

**AD-754 458**

# **Environmental Impact Study**

**Ocean and Atmospheric Science, Inc.**

**prepared for**

**Office of Naval Research  
Advanced Research Projects Agency**

**NOVEMBER 1972**

**Distributed By:**

**NTIS**

**National Technical Information Service  
U. S. DEPARTMENT OF COMMERCE**

# DISCLAIMER NOTICE

THIS DOCUMENT IS THE BEST  
QUALITY AVAILABLE.

COPY FURNISHED CONTAINED  
A SIGNIFICANT NUMBER OF  
PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.

AD754458

# OAS

Environmental Impact Study

Available at  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
U.S. Department of Commerce  
Springfield, VA 22161

DDC  
RECEIVED  
JAN 23 1975  
RECEIVED  
C

CONTINUATION STATEMENT A

OCEAN & ATMOSPHERIC SCIENCE, INC.  
145 PALISADE STREET  
DOBBS FERRY, NEW YORK 10522  
914-693-9001

# OAS

OCEAN & ATMOSPHERIC SCIENCE, INC.  
145 PALISADE STREET  
DOBBS FERRY, NEW YORK 10522  
914-693-9001

TR 72-116

## Environmental Impact Study

Prepared for and funded by:

Defense Advanced Research Projects Agency  
Arlington, Virginia 22209 - ARPA Order No. 2195

Research conducted under Office of Naval Research  
Contract Number N00014-72-C-0425, Task Number  
NR 089-090.

The views and conclusions contained in this document  
are those of the authors and should not be interpreted  
as necessarily representing the official policies,  
either expressed or implied, of the Defense Advanced  
Research Projects Agency or the U.S. Government.

(DISTRIBUTION UNLIMITED)

Principal Investigator:

Julius Woolf

November 8, 1972

I

# OAS

**OCEAN & ATMOSPHERIC SCIENCE, INC.**  
145 PALISADE STREET  
DOBBS FERRY, NEW YORK 10522  
914-693-9001

## FINAL TECHNICAL REPORT

Form Approved Budget Bureau No. 22-R0293

Sponsored by  
Advanced Research Projects Agency  
ARPA Order #2195

ARPA Order Number:	2195
Program Code Number:	2F10
Contract Number:	N00014-72-C-0425
Principal Investigator and Phone Number	Julius Woolf (914) 693-9001
Name of Contractor:	Ocean & Atmospheric Science, Inc.
Effective Date of Contract:	April 14, 1972
Contract Expiration Date:	October 31, 1972
Amount of Contract:	\$59,942.00
Scientific Officer:	Director, Field Projects Earth Sciences Division Office of Naval Research Department of the Navy 800 North Quincy Street Arlington, Virginia 22217
Short Title of Work:	Environmental Impact Study

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by ONR under Contract No. N00014-72-C-0425.

*III* Preceding page blank

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Ocean & Atmospheric Science, Inc. 145 Palisade Street Dobbs Ferry, New York 10522		2a. REPORT SECURITY CLASSIFICATION Unclassified	
		2b. GROUP	
3. REPORT TITLE Environmental Impact Study.			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
5. AUTHOR(S) (First name, middle initial, last name)			
6. REPORT DATE November 1972		7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO. N00014-72-C-0425		9a. ORIGINATOR'S REPORT NUMBER(S) TR 72-116	
b. PROJECT NO. NR 089-090		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c.			
d.			
10. DISTRIBUTION STATEMENT DISTRIBUTION UNLIMITED			
11. SUPPLEMENTARY NOTES Research conducted under Office of Naval Research Contract (See Item 8)		12. SPONSORING MILITARY ACTIVITY Defense Advanced Research Projects Agency	
13. ABSTRACT <p>The ARPA Environmental Impact Program is directed toward identifying those scientific and technical areas necessary to achieve satisfactory evaluation and abatement of the environmental impacts of DoD activities. The effort is directed toward high technology problems for which there are current voids not being adequately addressed by others and for which the environmental evaluations require considerable inter-service and inter-agency participation.</p> <p>Several areas were identified and appear to be germane for additional efforts by DoD and ARPA.</p> <p>These include:</p> <ul style="list-style-type: none"><li>• Sensors and Instrumentation</li><li>• Critical Materials</li><li>• Environmental Impact Prediction Facility</li><li>• Model Base</li><li>• Environmental Management</li></ul>			

DD FORM 1 NOV 55 1473

- v -

UNCLASSIFIED

Security Classification

Preceding page blank

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
ARPA Net						
Atomic Absorption Analysis						
Chromatography						
Critical Materials						
Data Management						
Electronic Spectrophotometry						
Energy Resources						
Environmental Impact Prediction Facility						
Environmental Impact Statements						
Hazardous Materials						
Infrared Spectrometry						
Ion-Selective Electrodes						
Mass Spectrometry						
Polarography						
Pollution Sensors						

## Summary

The ARPA Environmental Impact Program is directed toward identifying those scientific and technical areas necessary to achieve satisfactory evaluation and abatement of the environmental impacts of DoD activities. The effort is directed toward high technology problems for which there are current voids not being adequately addressed by others and for which the environmental evaluations require considerable inter-service and inter-agency participation.

The topic areas identified are:

1. An Environmental Impact Prediction Facility to assist DoD in evaluating impact on the environment and to provide a data base for an accurate assessment of an activity's impact.

Four areas essential to this Facility are discussed: Standards, Sensors/Instrumentation, Numerical Modeling, and Data Management. The interaction of these areas is illustrated using the high flying aircraft as an environmental impact prediction sample.

2. Implementation of a model base facility in which all the environmental factors and natural resources could be well controlled. The emphasis was concentrated on techniques which could be implemented within the next ten years. Energy resources, in particular, are detailed.
3. Development of sensor and instrumentation techniques for environmental monitoring. Sensors and instrumentation techniques are considered in great detail with emphasis on sophisticated chemical analysis techniques such as ion-selective electrodes, polarography, chromatography, etc. The basic principles

and theory of operation of each of the instruments have been investigated to gain insight into the existing and future limitations.

4. Study of critical materials to assure a DoD supply. This study considers the environmental aspects of the metallurgical processes involved from the mining to the finished products.
5. Environmental management so that DoD's pollution efforts in detection, control, and abatement will be recognized by the civilian community.
6. Pilot project to achieve insight and know-how prior to the start of the actual Environmental Impact Prediction Facility. The project proposed is the study of an estuary closely tied to a DoD facility. Details are enumerated so that one can gain insight into the environmental problem, the tasks necessary to resolve the situation, and the final product result from the pilot study.

The effort was also directed toward identifying research needed to support future environmental impact statements. Assessment and evaluation of current impact statements were used to determine potential difficulties. For each Environmental Impact Statement, an abstract was prepared together with a summary of the environmental factors involved and future study areas.

## Table of Contents

	<u>Page</u>
1.0 Introduction	1-1
1.1 Study Objectives	1-1
1.2 Recommended Research	1-2
1.2.1 Environmental Impact Prediction Facility	1-3
1.2.2 Model Base Facility - Resource Depletion - New Base Facilities	1-4
1.2.3 Sensors/Instrumentation	1-5
1.2.3.1 Air Pollution - Solids	1-5
1.2.3.2 Air Pollution - Hydrocarbons of Volatile Organics	1-6
1.2.3.3 Water	1-6
1.2.4 Critical Materials/Sole Source Suppliers	1-7
1.2.5 Recommendations for Environmental Pilot Study	1-9
2.0 Environmental Impact Prediction Facility	2-1
2.1 General Description	2-1
2.1.1 Intermediate Objectives	2-1
2.1.2 Final Objectives	2-4
2.2 Standards Section	2-7
2.2.1 History of Standards	2-8

## Table of Contents

	<u>Page</u>
2.2.1.1 Standards for Water	2-8
2.2.1.2 Standards for Air	2-13
2.2.2 Sources for Standards	2-17
2.2.3 Standards Research	2-21
2.3 Sensors/Instrumentation Section	2-23
2.3.1 Introduction	2-23
2.3.2 Objectives	2-24
2.3.3 Hydrological and Meteorological Sensors	2-25
2.3.3.1 Salinity	2-26
2.3.3.2 Water Temperature and Depth	2-26
2.3.3.3 Current Measurements	2-27
2.3.3.4 Wind Velocity and Direction	2-28
2.3.3.5 Satellite Data	2-29
2.3.4 Physical Parameter Instrumentation	2-29
2.3.4.1 pH	2-30
2.3.4.2 Turbidity	2-31
2.3.5 Organic/Inorganic Chemical and Biological Instrumentation	2-33
2.3.5.1 Photosynthetic Rate Measurements	2-34

## Table of Contents

	<u>Page</u>
2.3.5.2 Periphyton/Chlorophyll	2-35
2.3.5.3 Biological Oxygen Demand (BOD)	2-38
2.3.5.4 Chemical Oxygen Demand (COD)	2-39
2.3.5.5 Total Organic Carbon	2-40
2.3.5.6 Heavy Metals	2-40
2.3.5.7 Organic Contaminants	2-41
2.3.6 Instrument Evaluation (Example)	2-42
2.3.6.1 Dissolved Oxygen (DO)	2-42
2.3.6.2 Measurement Techniques	2-43
2.3.6.3 Instrument Comparison	2-47
2.4 Numerical Modeling Section	2-49
2.4.1 Introduction	2-49
2.4.2 Technological Support Required	2-51
2.4.2.1 Numerical Models	2-51
2.4.2.2 Computing and Input/Output Facilities	2-55
2.4.2.3 Verification Data	2-56
2.4.2.4 Update Data	2-57
2.4.2.5 Source Data	2-58
2.4.3 Current Numerical Modeling Efforts	2-58

## Table of Contents

	<u>Page</u>
2.4.3.1 Ocean Modeling	2-59
2.4.3.2 Atmospheric Modeling	2-60
2.4.3.3 Smaller-Scale Water Circulation Models	2-60
2.4.3.4 Smaller-Scale Atmospheric Circulation Models	2-61
2.5 Data Management Section	2-62
2.5.1 Introduction	2-62
2.5.2 The ARPA Net	2-63
2.5.2.1 Network Facilities	2-64
2.5.2.2 Network Interconnection	2-66
2.5.2.3 Network Utilization	2-67
2.5.3 Data Management Section Configuration	2-68
2.5.3.1 Data Collection Group	2-68
2.5.3.2 Data Evaluation Group	2-69
2.5.3.3 The Data Bank	2-71
2.5.3.4 Remote Monitored Facilities	2-73
2.6 Environmental Impact Prediction Example, High-Flying Aircraft	2-77
2.6.1 Introduction	2-77
2.6.2 Procedure of Impact Assessment	2-80
2.6.3 Effects (Known and Unknown) of Some Individual Contaminants	2-81

## Table of Contents

	<u>Page</u>
2.6.4 Research Programs	2-82
2.6.5 Proposed Effort for the High-Flying Aircraft Impact Program	2-85
2.6.6 References	2-87
3.0 Model Base/Energy Resources	3-1
3.1 Introduction	3-1
3.2 Electrical Generating Power Plant	3-2
3.3 Nuclear Generators	3-4
3.4 Proposed Future Energy Sources	3-6
3.4.1 Tidal Energy	3-6
3.4.2 Wind Power	3-8
3.4.3 Solar Farms	3-8
3.5 House and Building Construction	3-9
3.6 Waste Disposal and Sewage	3-10
3.7 A Combined Waste Removal and Supplementary Power Generation Process	3-12
3.8 Sewage	3-14
3.9 Transportation	3-16
3.10 Recommendations	3-18
3.11 References	3-19

## Table of Contents

	<u>Page</u>
4.0 Sensors	4-1
4.1 Introduction	4-1
4.2 Atomic Absorption Analysis	4-2
4.2.1 Theory of Operation	4-2
4.2.2 Special Features	4-2
4.2.3 Detection Capabilities	4-3
4.2.4 Instrumentation Sources	4-5
4.3 Chromatography	4-6
4.3.1 Gas Chromatography (GC), Theory of Operation	4-6
4.3.1.1 Operation of a GC	4-7
4.3.1.2 GC Detectors	4-9
4.3.1.3 Interfacing with Mass Spectrometer or Infrared	4-11
4.3.1.4 GC Manufacturers	4-11
4.3.2 High Performance Liquid Chromatography (HPLC)	4-13
4.3.2.1 Applications	4-15
4.3.2.2 Instrumentation and Manufacturers	4-15
4.3.3 References	4-17

## Table of Contents

	<u>Page</u>
4.4 Electronic Spectrophotometry (Absorption & Fluorescence)	4-19
4.4.1 Theory of Operation	4-19
4.4.2 Sampling Methods	4-22
4.4.3 Spectrophotometry Instruments	4-23
4.4.4 Fluorescence, Theory	4-25
4.4.5 Spectrofluorometer Instruments	4-27
4.4.6 References	4-29
4.5 Infrared Spectrophotometry	4-30
4.5.1 Theory of Operation	4-30
4.5.2 Instruments and Manufacturers	4-32
4.5.3 Specialized IR Techniques	4-35
4.5.4 References	4-36
4.6 Ion-Selective Electrodes	4-37
4.6.1 Theory of Operation	4-37
4.6.2 Selectivity and Sensitivity	4-38
4.6.3 Instruments and Manufacturers	4-42
4.6.4 References	4-43
4.7 Mass Spectrometry	4-44
4.7.1 Theory of Operation	4-44
4.7.1.1 Magnetic Analysis	4-45

## Table of Contents

	<u>Page</u>
4.7.1.2 Electrostatic Analysis	4-47
4.7.1.3 Time of Flight Analysis	4-48
4.7.2 Operation of Simple Mass Spectrometer	4-49
4.7.3 Sources	4-50
4.7.4 Ion Detectors	4-51
4.7.5 Applications	4-52
4.7.6 Instruments and Manufacturers	4-52
4.7.7 References	4-55
4.8 Polarography	4-56
4.8.1 Conventional Polarography	4-56
4.8.2 Derivative Polarography	4-58
4.8.3 Cathode Ray Polarography	4-58
4.8.4 Alternating Current Polarography	4-59
4.8.5 Applications	4-60
4.8.6 Manufacturers	4-60
4.8.7 References	4-62
4.9 Recommendations: New Instruments and Methods	4-63
4.9.1 Air Pollution - Solids	4-63
4.9.2 Air Pollution - Hydrocarbons and Volatile Organics	4-64
4.9.3 Water	4-65
4.9.4 References	4-68

## Table of Contents

	<u>Page</u>
5.0 Critical Materials	5-1
5.1 Stockpiling of Critical Materials	5-2
5.1.1 Introduction	5-2
5.1.2 Stockpile Objectives	5-2
5.2 Materials and Their Impact on the Environment	5-3
5.3 Critical Materials and Environmental Factors	5-11
5.4 Conclusion	5-22
5.5 References	5-23
6.0 Management for Environmental Impact	6-1
7.0 Support Requirements for Future Environmental Impact Statements	7-1
7.1 Air Quality	7-2
7.2 Economic	7-4
7.3 Electromagnetic	7-4
7.4 Hazardous Materials	7-5
7.5 Land Use	7-6
7.6 Noise	7-7
7.7 Waste Disposal	7-9
7.8 Water Quality	7-10

## Table of Contents

	<u>Page</u>
8.0 Environmental Impact Statements	8-1
8.1 History	8-2
8.2 Issued Environmental Impact Statements	8-5
8.3 Environmental Impact Statements	
Appendix A Persons and Agencies Visited	A-1
Appendix B.0 Pollution Abatement Efforts	B-1
Appendix B.1 History of the Environmental Impact Statement	B-1
Appendix B.2 The Role of the Environmental Protection Agency	B-10
Appendix B.3 The Environmental Impact Statement and the Department of Defense	B-15
Appendix C Tabulation of Issued Environmental Impact Statements	C-1

## List of Figures

	<u>Page</u>
Fig. 2. 1:      The ARPA Network	2-65
Fig. 2. 2:      Data Bank Configuration	2-72
Fig. 2. 3:      The Regional Monitoring Network	2-74
Fig. 4. 1:      Gas Chromatograph	4-8
Fig. 4. 2:      Magnetic Analyzer	4-46
Fig. 4. 3:      Electrostatic Field Analyzer	4-48
Fig. 4. 4:      Typical Polarographic Curve	4-57

## List of Tables

	<u>Page</u>
Table 2. 1: Parameters Used in Evaluation of Water Quality	2-3
Table 2. 2: Regional Offices of the EPA	2-10
Table 2. 3: Ranges of Values for Effluent Quality in Waste Water Treatment Processes	2-12
Table 2. 4: National Ambient Air Standards	2-13
Table 2. 5: Motor Vehicle Exhaust Emission Standards	2-14
Table 2. 6: Atmospheric Areas	2-16
Table 2. 7: Federal Agencies Concerned with Pollution Control	2-18
Table 2. 8: State Agencies Concerned with Pollution Control	2-19
Table 2. 9: Maximum A-Weighted Noise Levels at Residential Boundary	2-20
Table 2. 10: Comparison of Commercially Available Dissolved Oxygen (DO) Instrumentation	2-48a
Table 4. 1: Air Pollutant/Sensor	4-1a
Table 4. 2: Water Pollutant/Sensor	4-1b
Table 4. 3: Pollutant and Minimum Detectable Limit for Atomic Absorption	4-4
Table 4. 4: Gas Chromatograph Detectors	4-9a
Table 4. 5: Commercial Instruments for Spectrophotometry	4-24
Table 4. 6: Properties of Commercially Available Solid-State or Diffusion Electrodes	4-40
Table 4. 7: Properties of Commercially Available Electrodes with Liquid and Glass Ion Exchange Membranes	4-41

List of Tables (continued)

	<u>Page</u>
Table 4.8: Mass Spectrometry Instrument Manufacturers and Representatives	4-54
Table 4.9: Selected Polarographic Methods of Trace Analysis	4-61
Table 5.1: Basic Stockpile Materials	5-4 to 5-6
Table 5.2: "Major Mineral Materials - U. S. Statistics for 1971"	5-7
Table 5.3: "91 Mineral Materials Extracted from the Earth"	5-8

## 1.0 Introduction

The ARPA Environmental Impact Program is directed toward identifying those scientific and technical areas necessary to achieve satisfactory evaluation and abatement of the environmental impacts of DoD activities. The effort is directed toward high technology problems for which there are current voids not being adequately addressed by others and for which the environmental evaluations require considerable inter-service and inter-agency participation.

The need for these efforts is evident if one considers the legal constraints which are imposed by the current legislation and Executive Directives. For example, all Federal agencies, including DoD, whose activities may have a significant impact on the environment, must prepare a detailed report of the action and the probable environmental effects prior to the start of the activity. This is required by Section 102(2)(c) of the National Environmental Policy Act of 1969 [Public Law 91-190].

### 1.1 Study Objectives

The objectives of this study contract are to conduct a study which will include, but not be limited to:

1. Conducting a review of existing DoD Environmental Impact Statements furnished by ARPA to determine the weaknesses of current theory and technology.
2. Attending selected conferences and symposia on pollution detection, control, and abatement.
3. Within the limits of time and funding imposed by this contract, conducting a review of the environmental effects programs of other DoD, and other Federal agencies.
4. Using the information derived from (1) through (3) above and information obtainable from other sources, identifying the principal environmental considerations of importance to the DoD.
5. Formulating a recommended research plan for an advanced research program to be conducted by ARPA.

#### 1.2 Recommended Research

As a result of this contract study, several topics/areas were identified and appear to be germane for additional study and work efforts by DoD and ARPA.

These include:

1. The establishing of an Environmental Impact Prediction Facility to assist DoD in evaluating impact on the environment and to provide a data base for an accurate assessment of an activity's impact.
2. The implementation of a model base facility in which all the environmental factors and natural (energy) resources could be well controlled.

3. The further development of sensor and instrumentation techniques so that the environment can be readily monitored and quantified.
4. The study of critical materials so that DoD's source will always be available.
5. The organization of environmental management so that DoD's pollution efforts in detection, control, and abatement will be recognized by the civilian community and the techniques adapted to non-DoD needs if warranted.
6. A pilot study and project to achieve insight and know-how prior to the start of the actual Environmental Impact Prediction Facility.

#### 1.2.1 Environmental Impact Prediction Facility

To obtain predictions of the environmental impact of DoD activities and to properly complete future Environmental Impact Statements, a data network, a centralized high-speed digital computer, and an Environmental Impact Prediction Facility are essential. The ARPA Net and the ILLIAC IV computer appear to be ideally suited for the first two job tasks. To function properly, this Environmental Impact Prediction Facility must have a data base, "in-situ" sensors and instrumentation expertise, legal knowledge pertaining to legislation and standards and modeling capability.

Efforts must be directed toward the mechanics of establishing this facility. This entails identifying:

1. The customer.
2. The format of the end product/service to be provided.
3. The data collection and analysis facilities of other agencies, both Federal and non-Federal.
4. The applicable standards and regulations.
5. The program participators and the extent of participation.

1.2.2 Model Base Facility  
Resource Depletion - New Base Facilities

The ever decreasing supply of natural resources and energy emphasized the need to conduct studies into the development of a model new base military facility. The objective of a total facility is to minimize total energy consumption. A system approach is being utilized for this objective. The approach is to consider the facility in the same context as a submarine or space vehicle. A model community optimizes functional requirements, costs, and energy considerations. To accomplish this objective, new components of power generation, heat exchangers, and insulating materials are being examined. Once again the multi-agency and tri-service nature of this task is readily apparent.

### 1. 2. 3 Sensors/Instrumentation

The study has emphasized the need for state-of-the-art, reliable and sensitive instrumentation techniques and sensors that can effectively monitor the environment.

#### 1. 2. 3. 1 Air Pollution - Solids

A major need is for reliable solid state sensors for detection and measurement of particulates. The technology is available and is starting to be employed. An example of a newly developed solid-state method is the application of energy dispersive X-ray fluorescence spectroscopy to direct analysis of particulates collected on filter paper by Hi-Vol samplers. Extension of this technique to most of the metal particulates should be possible. The method is rapid and sensitive.

Linkage with a mass spectrometer/computer is a logical extension that would multiply the power of the method. Less accurate but still acceptable analyses for organic air particulates could be achieved by solvent extraction of the paper and subsequent GC/MS or TLC/scan. TLC/scan methods can involve IR reflectance, UV absorption, or spectrofluorometric techniques. The last technique has seen rapid improvement. However, HPLC methods may be preferable to the above in some instances.

### 1. 2. 3. 2 Air Pollution - Hydrocarbons and Volatile Organics

Methods for determining very low levels of hydrocarbons (including olefins) are desirable. By preconcentrating on chromatographic column materials, such as porapak Q, at very low temperatures (liquid N<sub>2</sub>) and subsequently isothermally distilling into a GC gas sampling inlet or by other methods, such as carrier gas sweeping at elevated temperature, input into a gas chromatograph or GC/MS or GC/IR combination can be achieved. This method could be adapted to automated sampling and analysis.

In general, the applications of GC/MS/computer systems should be explored exhaustively, particularly since many inorganics can be handled by GC by conversion to volatile stable complexes. The development of completely automatic GC/MS/computer systems, including automatic sampling, should be feasible, particularly with simple, rugged instruments such as the rf/quadrupole types.

### 1. 2. 3. 3 Water

The application of pyrolysis GC to aqueous pollutants, such as surfactants and other non-volatile organics, is a method with great potential. Automatic sampling and extraction-concentration techniques should be improved.

Continuous monitoring of water pollutants of many types is possible with the newly developed multiple internal reflection probe which dips into the sample to be analyzed. Some type of masking or correlation technique may be possible to enhance the method. Ion selective electrodes are very useful for monitoring waters but are susceptible to interferences. It may be possible to develop a container into which the sample flows, is masked by automatic addition of an appropriate reagent to remove interferences, and measurement is made. Upon achieving a stable reading the container opens, is flushed by the aqueous environment, and is ready to read again at a preset interval.

The continuous improvement in detectors for GC and HPLC suggests that these methods will be among the most generally useful for handling all types of organic pollutants. Specific detectors, such as electron capture and phosphorus and microionometric detectors, are extremely sensitive for specific types of pollutants, while the continuing development of phase transformation detectors greatly enhances the utility of HPLC methods for organics.

#### 1.2.4 Critical Materials/Sole Source Suppliers

DoD needs to identify the critical materials and sole-source manufacturers which are essential for their operation and programs.

At the present time, if any supplier or manufacturer is labelled a polluter by the U.S. Environmental Protection Agency or any other cognizant government agency, the imposition of legal action based upon current legislation or Presidential directives could have a serious impact on DoD's efforts.

However, if single source manufacturers and critical materials are known, DoD will be able to avoid difficulties by providing technological help and expertise before judicial restrictions are imposed.

This initial contract study has identified the need of DoD to be assured of materials which are critical for their activities. Not only must the total supply and location of the natural resource be known, but the material must be handled/processed in a manner which will comply with all Federal, State, and local ordinances and standards.

Thus, a study should be initiated to positively identify the critical materials, to determine the total environmental impact of their refinement, to identify the necessary instrumentation to be assured of non-polluting processes and compliance with all applicable standards, and to ascertain the void in the instrumentation/monitoring or the metallurgical process itself so that improved state-of-the-art technology can be applied to correct any deficiency.

### 1.2.5 Recommendations for Environmental Pilot Study

#### A. Introduction

One of the conclusions of the contract study has led to the suggestion to create an Environmental Impact Prediction Facility. The greatest cost-effectiveness can be achieved if the program to formulate the structure of the Facility were simultaneously conducted with a pilot project which will typify the tasks that will be the mandate of the Facility. By combining the planning of the Facility and a pilot study in one program, the interaction between the two efforts will result in significantly higher productivity.

The pilot project will be a complete investigation of all the phases of the impact of one DoD installation on an estuary. It will include:

1. An inventory of pollutants introduced into the estuary by the DoD installation and by the bordering community;
2. A field study of the estuary's fluid dynamics, and thermal and salinity structures;
3. The collection of topographical, geological, and sedimentation data;
4. A survey of instruments available for the hydrological study and sensors of water-borne pollutants;
5. An extensive field program of biological and chemical measurements;

6. A review of local, state, and federal laws, and of extra-legal quality standards, which relate to the introduction of pollutants into the estuary;
7. The implementation and use of a numerical model of the estuary's dynamic, thermal, and salinity properties and of the dispersion of pollutants in the estuary;
8. Recommendations for increasing the environmental sensitivity of the installation's operations, for future environmental studies of the estuary, and for the elimination of gaps in the technological capabilities in estuarine pollution studies; and
9. The formulation of an Environmental Impact Statement for the installation as related to this estuary.

The obvious objectives of the combined program will be the planning of the Environmental Impact Prediction Facility, and the successful completion of the pilot project as outlined above. The successful achievement of these objectives, alone, is sufficient justification for the program's efforts. However, by combining these two tasks in one program, additional and equally important objectives will be achieved at no extra cost. One is the pre-testing of the managerial and technological structure of the Environmental Impact Prediction Facility by applying its planned structure to the pilot project; this will enable the Environmental Impact Prediction Facility to be planned with foresight which will result in tremendous savings in time and direct cost. A second additional objective to be achieved will be a critical evaluation of the existent technology applicable to environmental

problems--including sensor technology; data acquisition, storage, and retrieval, numerical modeling; ecological field methods; etc.

B. Technical Tasks

1. An inventory will be made of all material introduced by the installation into the estuary. Such material may include inorganic chemicals, organic chemicals, nutrients, microorganisms, or thermally treated water. Similar inventories will be made for other pollution sources which affect the same region of the estuary. During the field measurement period, continuous records will be kept of the disposal rates for each separate pollutant.
2. A hydrological survey of the type which is common for oceanography will be carried out. Measurements will be made of the water current and direction, temperature, and salinity at various positions and depths, during different phases of the tidal cycle. Another useful measurement is the diffusion rate, which can be obtained from a dye diffusion experiment.
3. Topographical and geologic data will be obtained from U.S. government sources, if available. In addition, sediment thickness must be measured and sediment samples from different depths analyzed. Depositional and erosional processes will be observed, as well.
4. A survey and evaluation of sensors and instruments will begin early in the project, leading to a selection of sensors and instruments to be used in the actual measurement phases of the project. These will include oceanographic instruments (current meters, salinometers, thermometers, dye diffusion apparatus, turbidity meters, etc.); sensors and quantitative analysis apparatus for both organic and inorganic chemicals (including dissolved  $O_2$ , dissolved  $CO_2$ ,

mercury, heavy metals, BOD, COD, pesticides, etc.); sensors and quantitative analysis equipment for nutrients such as organic-N and soluble-P; microbiological measurement equipment (for coliform and salmonella, for example); and equipment for the observation of flora and fauna in the estuary.

5. The sensors, instruments, and equipment selected after the survey will be deployed at various stations and depths in the estuary, as continuously as possible for a one-year period. The measurements will be sufficiently dense in space and time to show spatial patterns caused by the estuary's dynamics and the distribution of sources, and temporal variations associated with the estuary's dynamics and variations in disposal rates. The measurements will include physical, chemical, and biological indices of pollution and will be taken concurrently with the hydrological survey.
6. A review will be made of relevant local, state, and federal laws, for comparison with the source and field data. In addition, extra-legal environmental quality standards advocated by DoD, EPA, or other agencies and organizations will be reviewed and compared with source and field data.
7. A numerical model capable of simulating the estuary's dynamics, its thermal and salinity regimes, and the spatial and temporal variations of pollutant concentrations, will be developed or adapted and implemented on a digital computer. The simulated estuary will be required to agree closely with all the field measurements when the source data is used as the input.

Once operating, the numerical model will be used to predict the effects of hypothetical changes in the estuary itself and in the pollution sources. For example, it will predict the effect of restricting pollutant disposal to certain tidal phases, to certain depths, or to certain

combinations of positions. It will predict the effect on the dispersion of pollutants by changes in the estuary's dynamics caused by piers, bridges, or other structures.

Estuarine modeling by numerical methods has received considerable attention in recent years. It is expected, therefore, that the pilot project will not be required to develop a numerical modeling scheme, but will be able to adapt existing models to its problem in one man year.

This last technical task, the numerical modeling, is the culmination of all the preceding tasks. It will be the basis of the pilot project's conclusions and recommendations. Without the numerical model, the entire project's efforts would be without substantive results; but without the other tasks, a dependable numerical model would be impossible to develop.

### C. Conclusions and Recommendations

The pilot project will produce a detailed analysis of the environmental impact of the DoD installation on an estuary. This will comprise the direct objective of the pilot project.

In addition, as a result of the interaction between the pilot projects' efforts and the Environmental Impact Prediction Facility's planning efforts, the program will produce an extensive critique of the

environmental prediction capability of existing technology, including sensors, data handling and analysis, and numerical modeling. A further significant product of the interaction of the two efforts will be an evaluation of the planned managerial and technological structure of the Environmental Impact Prediction Facility, based on its application to the pilot project. This evaluation will result in time- and cost-saving foresight in the eventual implementation of the Environmental Impact Prediction Facility.

The recognition of the important accomplishments which can be achieved by combining a pilot project with the Environmental Impact Prediction Facility's planning effort, as outlined above, motivates the recommendation that the program should include both these efforts. Such a program will be a highly productive, cost-effective means for DoD to comply with and exceed local, state, and federal requirements and standards for the protection of the environment.

## 2.0 Environmental Impact Prediction Program

### 2.1 General Description

Environmental Impact Statements already written for several DoD activities contain several instances of conclusions drawn from inadequate technical information. This is not due to intentional obfuscation. On the contrary, it is necessitated not only by the scientific community's insufficient data and incomplete basic understanding of the environment, but also by the lack of a central source of scientific expertise and data available to the DoD. It is the purpose of the Environmental Impact Prediction Program to fill this information gap, with the objectives of enabling the DoD to predict the environmental impact of its own activities, and to predict the effects on DoD programs of environmental interactions and limited natural resources.

#### 2.1.1 Intermediate Objective

The intermediate objectives of the Environmental Impact Prediction Program are the development and coordination of capabilities in the following four areas.

##### A. Standards

The program must develop a competence in the evaluation and documentation of the various standards which are applicable to the DoD facilities. This section must:

1. Categorize the standard vs the pollutant vs locality.
2. Identify the work being done to evaluate the standards.
3. Identify significant enforcement or legislative proceedings which might have a significant impact on DoD's activities.
4. Identify where research is required to validate the standard and to determine that the specified limit is safe to the populace, not only for short term but for long term effects.

B. Sensors/Instrumentation

Instrumentation is required for the measurement, under various climatic and environmental conditions in situ, of pollutant concentrations and of environmental parameters which affect the dispersion of pollutants. As an example, parameters which are useful in the evaluation of water quality are:

1. Hydrological and meteorological
2. Physical
3. Chemical, Inorganic
4. Chemical, Organic
5. Nutrients
6. Microbiological
7. Biological

Some of the specific items within each of these categories are presented in Table 2.1. Thus, the quantity of instrumentation and analysis which

Table 2.1\*

PARAMETERS USED IN EVALUATION OF WATER QUALITY

Hydrological & Meteorological	Physical	Chemical, Inorganic	Chemical, Organic	Nutrients	Microbiological	Biological
Volumetric Flow Rate	Temperature	Dissolved Oxygen	Trace Elements:	BOD (Immediate, 5 Day Long-Term)	Organic-N	Plankton
Velocity	Specific Conductance	Dissolved Carbon	Aluminum	COD	NH <sub>3</sub> -N	Periphyton
Time of Flow	Turbidity	Dioxide	Arsenic	Chlorine Demand	NO <sub>2</sub> -N	Benthos
Depth	Light Penetration	Hydrogen Sulfide	Barium	Total Organic Carbon	NO <sub>3</sub> -N	Fish
Tide Variation	Color	Minerals:	Beryllium	MBAS	Total-P	Waterfowl
Wind Speed & Direction	Odor	Acidity	Boron	CCE	Soluble-P	Wildlife
Solar Radiation	pH	Alkalinity	Cadmium	CAE	Organic-P	Vascular Plant
Intensely	Total Solids (Volatile & Fixed)	Calcium	Chromium	Cyanide	Orthophosphate	
Air Temperature & Humidity	Suspended Solids (Volatile & Fixed)	Magnesium	Copper	Pesticides	Polyphosphates	
	Floating Solids	Bicarbonate	Fluoride	Oil & Grease		
	Particle Size	Carbonate	Iron	Phenolics		
	Bed Load	Hydroxide	Lead			
		Hardness	Manganese			
		Chlorides	Potassium			
		Sulfates	Selenium			
		Dissolved Solids	Silver			
		Radiochemical	Sodium			
			Zinc			

are required to monitor and evaluate water quality is correspondingly long. (Mercury compounds and pesticides are missing from the list.)

Air, noise, radiation, and solid waste matter have not been considered and these environmental pollution factors require additional instrumentation in many instances.

To effectively monitor and derive meaningful results, instrumentation, sampling methods, and analysis procedures must be standardized. Once established, data from various sectors of the country can then be compared and meaningful conclusions can be reached.

\* "Water Pollution Analyzers: A Changing Market",  
H. W. Porterfield, Oceanology International, October 1970,  
p. 22-24.

### C. Environmental Monitoring and Data Bank

A network of continuous, long-term measurements of pollutant concentrations and meteorologic and oceanographic parameters will be required for environmental warning, for environmental prediction, and for the development of parametric and dynamic environmental prediction methods. The data collected by the network and any other data required by the other efforts in the program will be stored in a digital form rapidly accessible by computer.

### D. Environmental Prediction

Computer-based numerical methods for environmental prediction will be developed and, where available, adapted for DoD use. They will include both parametric and dynamic (Eulerian or Lagrangian) models of oceanic, atmospheric, coastal, water, urban atmospheric, estuarine, or river phenomena. The term "environmental prediction", as used here, refers to the prediction of pollution concentrations and of induced changes in the normal environment (climate, ocean circulation, sea ice, river flow, etc.).

#### 2.1.2 Final Objective

Capabilities in various aspects of environmental prediction have been developed by many government, industrial, and university research groups. In order to apply the capabilities of these research groups to the needs of DoD effectively and efficiently, a center of environmental expertise responsible to the DoD -- the Environmental

Impact Prediction Facility -- will be established.

Relying heavily on the ARPA computer network, the Facility will work towards the four intermediate objectives. Wherever possible, this will be accomplished by adapting the accomplishments of existing research groups. Where information gaps exist, funds must be applied to further research in government, industrial, and university research groups. The need for further research will be determined by DoD requirements.

Thus, when established and operating normally, the Environmental Impact Prediction Facility will be able to:

Predict the environmental effects of the addition to the environment of contaminants by DoD activities.

1. Waste disposal of land-based personnel support systems.
2. Waste disposal of ocean-going personnel support systems.
3. Aircraft emissions.
4. Munitions testing and disposal.
5. Industrial processes related to military procurement.

Predict limitations imposed by DoD activities by the environment and resource availability:

1. Fossil fuel availability.
2. Climatological effects of fossil fuel combustion.

3. Nuclear fuel availability.
4. Solar energy use.
5. Critical material availability (e. g., beryllium),  
etc.

## 2.2 Standards Section

An integral and highly necessary section of the Environmental Impact Prediction Facility is the Standards Section. It will be the duty of this section to:

1. Be cognizant of the existing standards for the various pollutants.
2. Be cognizant of the pending legislation before the Federal, state, and local authorities which could alter the existing standards.
3. Inform the Sensors/Instrumentation Section and Data Management Section of the prediction facility of any change in an existing standard so that the instrumentation and data analysis capabilities can be updated accordingly.
4. Provide technical and quasi-legal advice to any customer concerning the level of pollutant allowed and the applicable standard.
5. Provide tabulation of all applicable standards to any customer. This tabulation will vary depending upon the action or activity involved, the scope, type, and extent of equipment involved, and the geographical location of the activity or action. (Needless to say, for complete and accurate tabulation, the Standards and Sensors/Instrumentation Sections must work in harmonious accord with each other.)

Thus, the Standards Section, when established within the Environmental Impact Prediction Facility, will provide a quasi-legal service to members of the Prediction Facility and to DoD and any other customer.

### 2.2.1 History of Standards

Standards define the tolerance of man or the environment to a detrimental influence, a pollutant. Primary standards are to protect man, the public health. Secondary standards are to protect the environment, the soil, sea, and scenery. At present, standards are set according to the best knowledge, both technical and medical, available and may change as the ability to monitor and control the pollutant and evaluate the effects of the pollutant advances.

The need for legislative standards was recognized as early as the 19th century when the Refuse Act (Rivers and Harbors Act of 1899) was enacted. Later, in 1969, this act was used for the Great Lakes and in 1970, President Nixon's Executive Order 11574 directed strict enforcement of the permit program of the Refuse Act.

The harmful effects of pollution probably first came to notice in the efforts of the Public Health Service under the Public Health Service Act of 1912 (P. L. 62-265). Research was conducted into the health effects of water pollution and a data base was established which led to the virtual elimination of waterborne disease in the United States.

#### 2.2.1.1 Standards for Water

The Water Pollution Control Act of 1948 (P. L. 80-845) specifically recognized the primacy of the States in the abatement of water pollution.

The Federal Water Pollution Control Act of 1956 (P. L. 84-660)

as amended in 1961 (P. L. 87-88), 1965 (P. L. 89-234), 1966 (P. L. 89-753) and 1970 (P. L. 91-224), is the legal basis for all U.S. water pollution abatement. The legislation generally refers to research programs, construction grants and enforcement procedures.

The 1965 amendment (Water Quality Act of 1965) set up the Federal Water Pollution Control Administration, renamed the Federal Water Quality Administration by the amendment of 1970 (Water Quality Improvement Act of 1970). The FWQA has participated with all the States and territories in formulating water quality standards for interstate waters.

P. L. 89-234 (1965) specified that the State's criteria which are Federally acceptable and have a means for implementation and enforcement, for the quality of waters which become interstate in character are the Federal water quality standards for that state.

The Department of the Interior published "Guidelines for Establishing Water Quality Standards in Interstate Water" in 1966. It clarified and emphasized the objective of the Water Quality Act, to improve water quality. This objective became highly controversial later when the Department of the Interior insisted on secondary treatment of all sewage, even if the degraded water had still exceeded established water quality standards.

The FWQA was transferred intact to the Environmental Protection Agency (EPA) as a result of President Nixon's "Reorganization Plan No. 3" of July 9, 1970. The EPA has the responsibility of enforcing State water quality standards if the State, who has the first responsibility, does not do so. The EPA now approves State water quality standards, and also the

type of standards that apply to the waterway.

There is no uniformity in the state water quality laws because of the diversity of water types in the natural scene and the diversity of the use to which the waterways are put. A continuing development of the standards is being accomplished in a joint effort between the states and the ten regional offices of the EPA (see Table 2. 2).

**UNITED STATES  
ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460**

<b>Regional Offices</b>	<b>Phone</b>	<b>States covered</b>
Boston, Massachusetts 02203	617-223-7210	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
New York, New York 10007	212-254-2525	New Jersey, New York, Puerto Rico, Virgin Islands
Philadelphia, Pa. 19106	215-597-9151	Delaware, Maryland, Pennsylvania, Virginia, West Virginia, D.C.
Atlanta, Georgia 30309	404-526-5727	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
Chicago, Illinois 60606	312-353-5250	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
Dallas, Texas 75202	214-749-2827	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
Kansas City, Missouri 64106	816-374-5493	Iowa, Kansas, Missouri, Nebraska
Denver, Colorado 80203	303-837-3895	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
San Francisco, Calif. 94102	415-556-4303	Arizona, California, Hawaii, Nevada, American Samoa, Guam, Trust Territories of Pacific Islands, Wake Island
Seattle, Washington 98101	206-442-1200	Alaska, Idaho, Oregon, Washington

Table 2. 2 Regional Offices of the EPA

Some time and effort will be spent by the Standards Section to verify and validate the standards which are being developed by the EPA and other agencies, to ascertain their relevance to DoD facilities and activities. In addition, the Standards Section will categorize pollutant vs standard vs locality. An example of the range of values for effluent quality which is used in the development of waste water treatment processes is presented in Table 2.3.\*

---

\* H. W. Porterfield, "Water Pollution Analyzers: A Changing Market" *Oceanology International*, 5, no. 10, p. 22-24 (1970)

RANGES OF VALUES FOR EFFLUENT QUALITY TO BE USED IN THE DEVELOPMENT  
OF WASTE WATER TREATMENT PROCESSES

Constituent or Measurement	Detectable Limit	Desirable Level (for Public Water Supply)	Permissible Level (Surface Water for Public Water Supply)	Body Contact (Recreation)	Fisheries Use	Alternative Uses			
						Farmstead Supply	Irrigation Uses	Industrial Uses	Discharge to Groundwater
Turbidity	0.1 JTU	0.1 JTU	30.0 JTU	25.0 JTU	25.0 JTU	25.0 JTU			
Color	2 Units	3 Units	15 Units			20 Units		1,200 Units	
Odor (At 25°C.)	0 Threshold	0 Threshold							
pH	0.1	7.0-8.5	6.0-8.5	6.5-8.3	6.5-9.0	6.0-8.5		3.5-9.1	6.5-8.5
Total Residue	1.0 mg/l	500.0 mg/l	1,000.0 mg/l						
Filtrable Residue	1.0 mg/l	200.0 mg/l	500.0 mg/l						
BOD	0.5 mg/l	2.0 mg/l	4.0 mg/l				100.0 mg/l		
TOC	1.0 mg/l	5.0 mg/l	10.0 mg/l						
CCE	0.001 mg/l	0.04 mg/l	0.1 mg/l					106 mg/l	0.4 mg/l
MBAS	0.05 mg/l	<0.25 mg/l	0.5 mg/l					1.3 mg/l	1.5 mg/l
Alkalinity	1.0 mg/l	250.0 mg/l	400.0 mg/l					500.0 mg/l	
Aluminum	0.01 mg/l	0.05 mg/l	0.1 mg/l					3.0 mg/l	
Ammonia as N	0.005 mg/l	0.01 mg/l	0.05 mg/l	1.0 mg/l	1.0 mg/l			1.0 mg/l	
Arsenic	0.01 mg/l	0.01 mg/l	0.05 mg/l						0.1 mg/l
Barium	0.4 mg/l	0.5 mg/l	1.0 mg/l						2.0 mg/l
Boron	0.02 mg/l	0.025 mg/l	1.0 mg/l						
Cadmium	0.001 mg/l	0.005 mg/l	0.01 mg/l						0.02 mg/l
Chloride	1.0 mg/l	25.0 mg/l	250.0 mg/l						
Chromium (hexavalent)	0.01 mg/l	0.02 mg/l	0.05 mg/l	1.0 mg/l	1.0 mg/l	0.05 mg/l	5.0 mg/l	500.0 mg/l	500.0 mg/l
Copper	0.004 mg/l	<0.01 mg/l	0.2 mg/l	0.2 mg/l	0.2 mg/l	0.05 mg/l	0.2 mg/l	0.5 mg/l	0.1 mg/l
Dissolved Oxygen	0.1 mg/l	8.0 mg/l	<5.0 mg/l	5.0 mg/l	7.0 mg/l				0.4 mg/l
Fluoride	0.1 mg/l	1.0 mg/l	1.2 mg/l			1.2 mg/l		TRACE	3.0 mg/l
Hardness as CaCO <sub>3</sub>	1.0 mg/l	80.0 mg/l	250.0 mg/l					1.2 mg/l	
Calcium	0.1 mg/l	15.0 mg/l	43.0 mg/l					850.0 mg/l	
Magnesium	0.1 mg/l	10.0 mg/l	29.0 mg/l					162.0 mg/l	
Iron	0.005 mg/l	0.05 mg/l	0.3 mg/l					108.0 mg/l	
Lead	0.01 mg/l	0.01 mg/l	0.05 mg/l			0.3 mg/l		80.0 mg/l	0.6 mg/l
Manganese	0.001 mg/l	0.01 mg/l	0.05 mg/l			0.05 mg/l			0.1 mg/l
Nitrates & Nitrates as N	0.1 mg/l	0.1 mg/l	2.0-4.0 mg/l			0.05 mg/l	2.0 mg/l	10.0 mg/l	0.6 mg/l
Phosphorus	0.01 mg/l	0.01 mg/l	0.1 mg/l			45.0 mg/l		30.0 mg/l	20.0 mg/l
Selenium	0.004 mg/l	<0.01 mg/l	0.01 mg/l					4.0 mg/l	
Silver	0.001 mg/l	0.001 mg/l	0.05 mg/l			0.01 mg/l			0.2 mg/l
Sulfate	1.0 mg/l	50.0 mg/l	250.0 mg/l						0.1 mg/l
Total Dissolved Solids	1.0 mg/l	200.0 mg/l	<500.0 mg/l	500.0 mg/l	240.0 mg/l			680.0 mg/l	500.0 mg/l
Uranium Ion	0.005 mg/l	<0.5 mg/l	5.0 mg/l					1,000.0 mg/l	1,000.0 mg/l
Zinc	0.001 mg/l	0.05 mg/l	5.0 mg/l			5.0 mg/l	5.0 mg/l		0.6 mg/l
Cyanide	0.005 mg/l	0.01 mg/l	0.1 mg/l	0.02 mg/l	0.02 mg/l	0.02 mg/l			0.4 mg/l
Oil & Grease	<0.05 mg/l	<0.05 mg/l	0.05 mg/l						
INSECTICIDES									
Aldrin		<0.05 µg/l	<1.7 µg/l	<0.05 µg/l	<0.05 µg/l	<1.7 µg/l	<1.7 µg/l	<1.7 µg/l	<0.05 µg/l
Chlordane		<0.02 µg/l	<0.3 µg/l	<0.02 µg/l	<0.02 µg/l	<0.3 µg/l	<0.3 µg/l	<0.3 µg/l	<0.02 µg/l
DDT		<0.008 µg/l	<4.2 µg/l	<0.006 µg/l	<0.006 µg/l	<4.2 µg/l	<4.2 µg/l	<4.2 µg/l	<0.006 µg/l
Dieldrin		<0.003 µg/l	<1.7 µg/l	<0.003 µg/l	<0.003 µg/l	<1.7 µg/l	<1.7 µg/l	<1.7 µg/l	<0.003 µg/l
Endrin		<0.002 µg/l	<0.1 µg/l	<0.002 µg/l	<0.002 µg/l	<0.1 µg/l	<0.1 µg/l	<0.1 µg/l	<0.002 µg/l
Heptachlor		<0.002 µg/l	<1.8 µg/l	<0.002 µg/l	<0.002 µg/l	<1.8 µg/l	<1.8 µg/l	<1.8 µg/l	<0.002 µg/l
Heptachlor epoxide		<0.0002 µg/l	<1.8 µg/l	<0.0002 µg/l	<0.0002 µg/l	<1.8 µg/l	<1.8 µg/l	<1.8 µg/l	<0.0002 µg/l
Lindane		<0.002 µg/l	<5.6 µg/l	<0.002 µg/l	<0.002 µg/l	<5.6 µg/l	<5.6 µg/l	<5.6 µg/l	<0.002 µg/l
Methoxychlor		<0.004 µg/l	<3.5 µg/l	<0.004 µg/l	<0.004 µg/l	<3.5 µg/l	<3.5 µg/l	<3.5 µg/l	<0.004 µg/l
Organic Phosphates plus Carbamates		<0.0003 µg/l	<10.0 µg/l	<0.0003 µg/l	<0.0003 µg/l	<10.0 µg/l	<10.0 µg/l	<10.0 µg/l	<0.0003 µg/l
Toxaphene		<0.03 µg/l	<0.5 µg/l	<0.03 µg/l	<0.03 µg/l	<0.5 µg/l	<0.5 µg/l	<0.5 µg/l	<0.03 µg/l
HERBICIDES									
2, 4-D Plus 2, 4, 5-T plus 2, 4, 5-TP		10.0 µg/l	<10.0 µg/l	0.001 mg/l	10.0 µg/l	10.0 µg/l	2.0 µg/l		10.0 µg/l
Phenols	0.0005 mg/l	0.001 mg/l	0.005 mg/l	10.0 µg/l	0.01 mg/l				0.02 mg/l
RADIOACTIVITY									
Gross Beta	1.0 pc/l	100.0 pc/l	1,000.0 pc/l	11,000.0 pc/l	1,000.0 pc/l	1,000.0 pc/l	1,000.0 pc/l	1,000.0 pc/l	1,000.0 pc/l
Radium-226	0.05 pc/l	<1.0 pc/l	3.0 pc/l	3.0 pc/l	3.0 pc/l	3.0 pc/l	3.0 pc/l	3.0 pc/l	3.0 pc/l
Strontium-90	0.05 pc/l	<2.0 pc/l	10.0 pc/l	10.0 pc/l	10.0 pc/l	10.0 pc/l	10.0 pc/l	10.0 pc/l	10.0 pc/l
MICROBIOLOGICAL									
Coliform		100/100 ml	10,000/100 ml	1,000/100 ml	5,000/100 ml	5,000/100 ml	5,000/100 ml	5,000/100 ml	100/100 ml
Fecal Coliform		20/100 ml	2,000/100 ml	200/100 ml	1,000/100 ml	1,000/100 ml	1,000/100 ml	2,000/100 ml	20/100 ml

(These values are for planning of waste treatment projects only and do not represent optimum, desirable, mandatory, or permissible limits of the parameters whose values are given. From Federal Water Quality Administration.)

Table 2.3

### 2.2.1.2 Standards for Air

In contrast to the water quality standards, the basic standards for air quality are fixed at the Federal level. EPA Administrator, W.D. Ruckelshaus, stated that the standards are strict, can be met, and must be met. No alternatives exist in that the standards are a direct result of the provisions under the Clean Air Act Amendments of 1970 (P.L. 91-604). As an example, Table 2.4 presents the National Ambient Air Standards.

<u>Pollutant</u>	<u>Primary Standard</u>	<u>Secondary Standard</u>
Carbon monoxide	9 ppm max 8 hrs. (a) 35 ppm max 1 hr. (a)	same
Photochemical oxidants	0.08 ppm max 1 hr. (a)	same
Hydrocarbons	0.24 ppm max 3 hrs. (a)	same
Nitrogen oxides	0.05 ppm annual mean	same
Sulphur oxides	0.03 ppm annual mean 0.14 ppm max 24 hrs. (a)	0.02 ppm annual mean 0.1 ppm max 24 hrs. (a) 0.5 ppm max 3 hrs. (a)
Particulate matter	75 ug/cm annual mean 260 ug/cm max 24 hrs. (a)	60 ug/cm annual mean max 150 ug/cm max 24 hrs. (a)

(a) not to be exceeded more than once a year

ppm: parts per million

ug/cm: micrograms per cubic meter

Table 2.4 National Ambient Air Standards

Understandably, the air quality standards become more strict as the technology and the concern for cleaner air increases. This is clearly evident in the following example:

The motor vehicle exhaust emissions study and the air quality criteria study are the sources of Federal legislation which brought about the national air quality standards. The Motor Vehicle Pollution Control Act (Clean Air Act Amendments of 1965, P. L. 89-272) authorized the promulgation of standards applicable to motor vehicle exhaust emissions. These were adopted in March 1966 to apply to the 1968 vehicles. With the advances in technology of recent years and with the added strength of the Federal government in establishing standards and enforcing them (Clean Air Act, Amendments of 1967, P. L. 90-148 and Amendments of 1970, P. L. 91-604) the standards for motor vehicle exhaust emissions have become successively more stringent. Table 2.5 illustrates the change with automobile model years.

Table 2.5

Pollutant	Motor Vehicle Exhaust Emission Standards (Grams/Vehicle Mile)					
	Pre-1968 Vehicles	(Equivalent) 1968	Proposed 1970	Actual 1970	1975	1976
Carbon Monoxide	71.0	33.0	23.0	34.0	3.4	3.4
Hydrocarbons	9.7	3.2	2.2	4.1	0.41	0.41
Nitrogen oxide	4.0	-	-	-	3.0	0.4

To establish uniformity of measurement and monitoring techniques, the National Air Pollution Control Administration, which was replaced by the EPA, published several volumes on the criteria necessary to achieve and meet the standards. These are:

1. "Air Quality Criteria for Carbon Monoxide",  
March 1970.
2. "Air Quality Criteria for Hydrocarbons", March 1970.
3. "Air Quality Criteria for Nitrogen Oxides",  
January 1971.
4. "Air Quality Criteria for Particulate Matter",  
January 1969.
5. "Air Quality Criteria for Photochemical Oxidants",  
March 1970.
6. "Air Quality Criteria for Sulphur Oxides", January 1969.

Some agency must establish the necessary criteria for the common ambient air pollutants. The Standards Section will be intimately concerned with the establishment and enforcement of standards for militarily unique pollutants.

The Air Quality Act of 1967 (P. L. 90-148) further required the designation of an atmospheric area which is set out on the basis of those conditions which affect the interchange and diffusion of pollutants in the atmosphere. The conditions are the frequency, persistence and height variation of stable (inversion) layers of air, and speed and direction of the winds. Collectively, these parameters assess the pollutant dilution of an area. The 14 Atmospheric Areas designated are listed in Table 2.6.

Table 2.6 Atmospheric Areas

1. California - Oregon Coastal Area
2. Washington Coastal Area
3. Rocky Mountain Area
4. Great Plains Area
5. Great Lakes - Northeast Area
6. Appalachian Area
7. Mid-Atlantic Coastal Area
8. South Florida Area
9. Hawaiian - Pacific Area
10. Alaskan Pacific Maritime Area
11. Alaskan Bering Maritime Area
12. Alaskan Arctic Maritime Area
13. Alaskan Continental Area
14. Southern Florida - Caribbean Area

In order to establish realistic air quality standards, these Atmospheric Areas are subdivided by the States into Air Quality Control Regions. If interstate or major intrastate regions are logical, then the Administrator of EPA can designate them.

### 2.2.2 Sources for Standards

It is very important that the Standards Section of the Environmental Impact Prediction Facility be cognizant of all Federal, State, and Local agencies that are concerned with pollution. The list of agencies identified to date for the Federal and State level are given in Tables 2.7 and 2.8, respectively. It should be noted that these tables are quite lengthy even though the local agencies are not included.

In addition, the Standards Section will update and maintain files for the various geographical areas of CONUS and format the appropriate data for input to the computer. Thus the latest information will always be in the computer and DoD's facilities will be evaluated for the level of pollution which is the most current and applicable to the particular action. This will not only insure compliance with the law but also compel the Sensors/Instrumentation Section of the Environmental Impact Prediction Facility to maintain their monitoring instrumentation in proper working order and to effectively train the men on each facility who will be taking the samples and readings.

An example of the wide range of standards to which a pollutant can be specified is given in Table 2.9. [The pollutant considered is noise and the table is for the maximum A-weighted noise levels at residential boundaries.] The range of maximum acceptable level is spread over almost 20 dB (a 10:1 ratio) from a low at Beverly Hills of 43 dBA to a high of 62 dBA at Chicago.

Table 2.7\*

FEDERAL AGENCIES CONCERNED WITH POLLUTION CONTROL

- Atomic Energy Commission—James R. Schlesinger, Chairman, Washington, D.C. 20545
  - Atomic Safety and Licensing Board Panel—Biles, Director
  - Division of Operational Safety—Martin B. Biles, Director
  - Division of Radiation Protection on Standstads—Lester R. Rogers, Director
  - Division of Reactor Licensing—Dr. Peter A. Norris, Director
  - Case Director Standards—Edson G. Henry, A. Nowak, Director
  - Division of Waste and Scrap Management—Henry A. Nowak, Director
  - Health Protection Branch—Dr. Donald M. 2355, Chief
  - Health Protection—Robert J. Galin, Assistant Director
  - Licensing and Regulations—Ralph G. Page, Director
  - Office of Environmental Affairs—Joseph J. DiMunno, Director
  - Operations—John A. E. Hewitt, Assistant General Manager
  - Pollution Control Branch—Arthur A. Schoen, Chief
- Delaware River Basin Commission—Rogers C. B. Morton (Secretary of the Interior), Federal Member
  - Paul N. Vaniver, U.S. Commissioner
  - Secretary of Agriculture—Earl L. Butz, Secretary, Washington, D.C. 20250
  - Agricultural Research Service—G. W. Irving, Jr., Administrator, Washington, D.C. 20250
  - Washington, D.C. 20250, Chief
  - Soil Conservation Service—Kenneth E. Grant, Administrator, Washington, D.C. 20250
- Department of Commerce—Maurice H. Stans, Secretary, Commerce Building, Washington, D.C. 20230
  - Economic Development Administration—Robert A. Podesta, Assistant Secretary
  - Environmental Affairs—Dr. Sidney R. Galler, Deputy Assistant Secretary
  - Ferguson, Coordinator, Quality—Dr. Robert E. Measurements Int. Air Quality Program—Dr. James R. McNesby, Manager
  - National Bureau of Standards—Dr. Lewis M. Branscomb, Director
  - National Oceanic and Atmospheric Administration—Dr. Robert M. White, Administrator, 501 Securities Bldg., Rockville, Md. 20852
  - Office of Public Works—George T. Norris, Director
- Department of Defense—Address to Land Management Programs—Washington, D.C. 20330
  - Army Corps of Engineers—J. G. Parsons, Director, 3701 15th St., Washington, D.C. 20315
  - Environmental Affairs—Baker—Chief
  - Regulation, Construction—20315
  - Washington, D.C. 20315
  - Headquarters—20315
  - Headquarters—20315
  - Headquarters—20315
- Institute for Water Resources—Bryl. Cem. Richard H. Groves, Director, 20th N. Washington St., Alexandria, Va. 22314
- Department of Health, Education and Welfare—Elliott Richardson, Secretary, 330 Independence Ave., S.W., Washington, D.C. 20201
  - Bureau of Community Environmental Management—Robert E. Norton, Director
  - Bureau of Radiological Health—John C. Villforth, Director, 5600 Fishers Lane, Rockville, Md. 20852
  - Food and Drug Administration—Dr. Charles G. Edwards, Commissioner, 2021 Jefferson Building, Washington, D.C. 20205
  - National Institute of Environmental Health Sciences—Dr. Paul Klotz, Director, P.O. Box 122739, Research Triangle Park, N.C. 27709
- Department of Housing and Urban Development—George Romney, Secretary, HUD Building, 451 Seventh Street, S.W., Washington, D.C. 20410
- Department of Interior—Rogers C. B. Morton, Secretary, Interior Building, Washington, D.C. 20240
  - Bureau of Land Management—Boyd L. Rasmussen, Director, Interior Building, Washington, D.C. 20240
  - Osborn, Director, Interior Building, Washington, D.C. 20240
  - Bureau of Outdoor Recreation—G. Douglas Lore, Jr., Director, Interior Building, Washington, D.C. 20240
  - Bureau of Reclamation—Ellis L. Armstrong, Commissioner, Interior Building, Washington, D.C. 20240
  - Fish and Wildlife Service—Spencer Smith, Director, Interior Building, Washington, D.C. 20240
  - Geological Survey—Vincent E. McKelvey, Director, Interior Building, Washington, D.C. 20240
  - National Park Service—George B. Harting, Jr., Director, Interior Building, Washington, D.C. 20240
  - Office of Coal Research—George Fumich, Jr., Director, Interior Building, Washington, D.C. 20240
  - Office of Saline Water—J. W. O'Meara, Director, Interior Building, Washington, D.C. 20240
  - Water Resources Research—M. Garland Hershey, Director, Interior Building, Washington, D.C. 20240
  - Department of Justice—Richard Hendler, Acting Attorney General, Washington, D.C. 20530
    - Land and Natural Resources Division—Shim Ashwa, Assistant Attorney General, Washington, D.C. 20530
  - Department of State—William P. Rogers, Secretary, 2201 C Street, N.W., Washington, D.C. 20520
    - Office of Environmental Affairs—Christina A. Miller, Jr., Director, 2201 C Street, Room 7819, Washington, D.C. 20520

- Department of Transportation—John A. Voise, Secretary, 400 7th Street, S.W., Washington, D.C. 20590
  - Coast Guard—Adm. Willard J. Smith, Commandant, 400 7th Street, S.W., Washington, D.C. 20591
  - Federal Aviation Administration—John H. Swaffler, Administrator, 800 Independence Avenue, S.W., Washington, D.C. 20590
- Environmental Protection Agency—William D. Ruckelshaus, Administrator, Waterside Mall, 20460
  - Advanced Water Research Laboratory, Robert A. Tall Water Research Center—Or F. M. Middleton, Director, 4676 Columbia Parkway, Cincinnati, Ohio 45226
  - Alaska—University of Alaska, College, University of Alaska, College, Alaska 99735
  - Cincinnati Water Hygiene Laboratory—Gordon Koback, Director, 5555 Ridge Ave., Cincinnati, Ohio 45213
  - Citizens Advisory Commission—Rockville, Md. 20852
  - Environmental Quality—Russell E. Train, Chairman, 722 Jackson Place, N.W., Washington, D.C. 20006
  - Great Coast Water Hygiene Laboratory—1580 Hempstead, Director, P.O. Box 1580, Hampton, Va. 23628
  - National Marine Water Quality Laboratory—Dr. Clarence Farwell, Director, P.O. Box 227, West Kingston, RI 02892
  - National Water Quality Laboratory—Dr. Donald J. Moor, Director, 6201 Condon Blvd., Duluth, Minn. 55804
  - Northeast Water Hygiene Laboratory—Or. Marine, 1101, Director, South Ferry Rd., Northeastern Water Hygiene Laboratory—Dr. John Holt, Director, Rt. 4, Box 4129, G.G. Harbor, Wash. 98235
  - Office of Air Programs—Dr. John T. Middleton, Deputy Assistant Administrator, Parklawn Building, 5600 Fishers Lane, Rockville, Md. 20852
  - Office of Air Programs—David D. Dominick, Assistant Administrator, Office of Compliance, Atlanta—Graham McGowan, Director
  - Office of Enforcement and General Counsel—John Quines, Assistant Administrator
  - Office of Equal Opportunity—Norris W. O'Brien, Director
  - Office of Media Affairs—F. Hugh Green, Associate Administrator
  - Office of Noise Abatement and Control—Dr. Alvin Meyer, Director, 1129 20th St., N.W., Washington, D.C. 20460
  - Office of Pesticides Programs—William M. Uphoff, Deputy Assistant Administrator, 1129 20th St., N.W., Washington, D.C. 20460
  - Office of Planning and Management—Thomas Carroll, Assistant Administrator
  - Director of Public Affairs—Thomas Hart, Director of Radiation Programs—Dr. Joseph A. Lieberman, Deputy Assistant Administrator, Parklawn Building, 5600 Fishers Lane, Rockville, Md. 20852
  - Office of Research and Monitoring—Dr. Stanley Greenfield, Assistant Administrator
- National Academy of Sciences—Philip Handler, President, Washington, D.C. 20418
  - Environmental Studies Board—Oswald M. Gates, Chairman, Washington, D.C. 20418
  - National Research Council—Philip Handler, Chairman, Washington, D.C. 20418
- National Science Foundation—William D. McEvey, Director, 400 G Street, N.W., Washington, D.C. 20550
  - Division of Environmental Sciences—A. P. Gray, Director, 1800 G Street, N.W., Washington, D.C. 20550
- National Water Commission—Charles F. Luce, Chairman, 800 Quincy Street, Arlington, Va. 22203
  - Tennessee Valley Authority—Aubrey J. Wheeler, Chairman, Sprinkle Building, Knoxville, Tenn. 37902
- Water Resources Council—Rogers C. B. Morton, Chairman, 800 Quincy Street, Arlington, Va. 22203

\* from Clean Air and Water News, Index Volume, 31 March 1972.

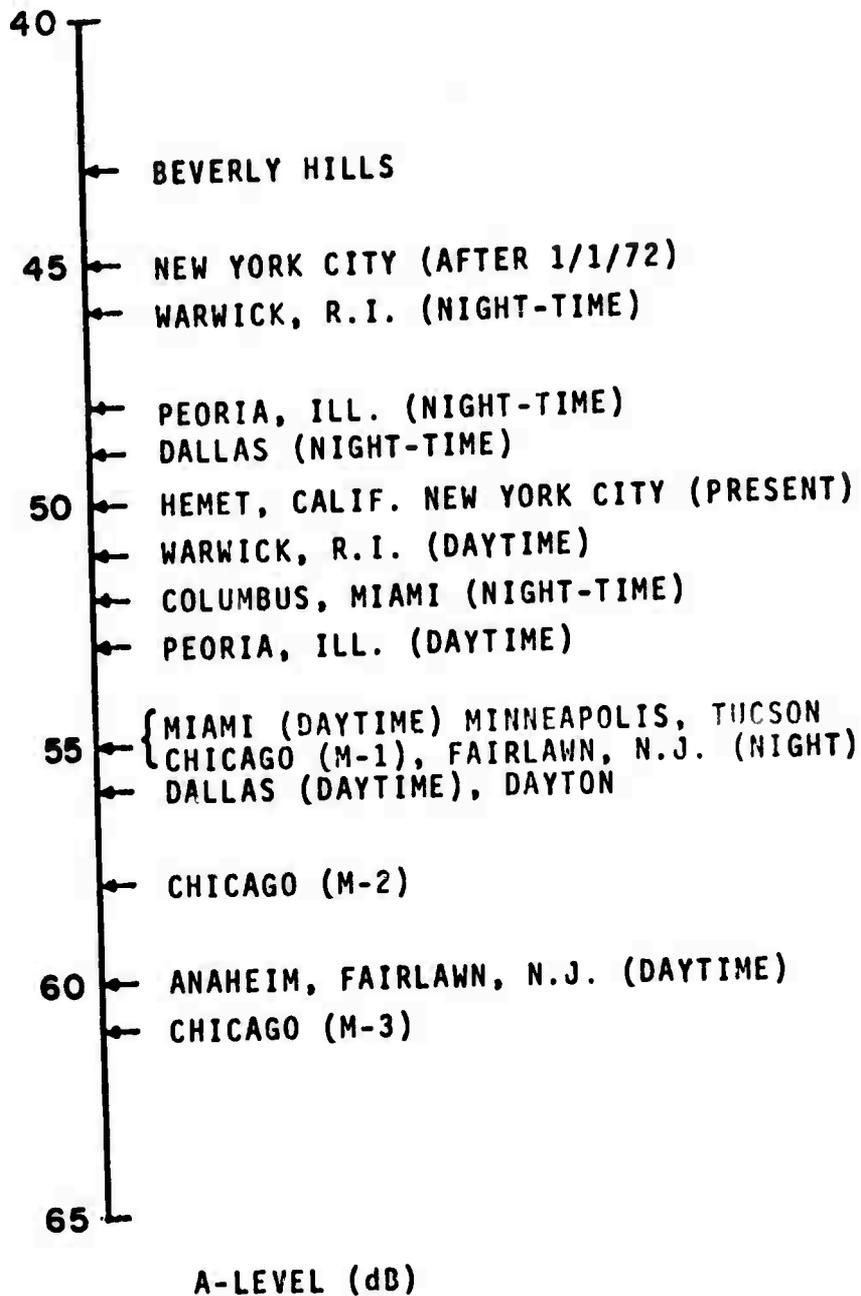
Table 2.8\*

**STATE AGENCIES CONCERNED WITH POLLUTION CONTROL**

<b>Alabama</b>	Air Pollution Control Commission—State Office Building, Montgomery, Alabama 36104 Water Improvement Commission—State Office Building, Montgomery, Alabama 36104
<b>Alaska</b>	Air Pollution Control Commission—Alaska Department of Health and Welfare, Pouch H, Juneau, Alaska 99801
<b>Arizona</b>	Air Pollution Control Division—Arizona State Department of Health, 4019 N. 33rd Avenue, Phoenix, Arizona 85017 Environmental Health Service, Department of Health, Hayden Plaza West, 4019 N. 33rd Avenue, Phoenix, Arizona 85017
<b>Arkansas</b>	Arkansas Pollution Control Commission—1100 Harrington Ave., Little Rock, Ark. 72202
<b>California</b>	California Air Resources Board—1108 14th St., Sacramento, Calif. 95814 State Water Resources Control Board—1416 Ninth St., Sacramento, Calif. 95814
<b>Colorado</b>	Air Pollution Control Commission—Department of Public Health, 4210 E. 11th Ave., Denver, Colo. 80220
<b>Connecticut</b>	Air Pollution Control Section—Environmental Health Services Division, State Department of Health, 79 Elm St., Hartford, Conn. 06115 State Water Resources Commission—Room 225, State Office Building, 165 Capitol Ave., Hartford Conn. 06115
<b>Delaware</b>	Division of Environmental Control—Department of Natural Resources and Environmental Control, P.O. Box 916, Dover, Del. 19901
<b>District of Columbia</b>	Division of Air Pollution Control—Department of Public Health, 1825 Connecticut Ave., N.W., Washington, DC 20009
<b>Florida</b>	Department of Air and Water Pollution Control—Suite 400, 315 S. Calhoun St., Tallahassee, Fla. 32301
<b>Georgia</b>	Occupational Public Health—47 Trinity Ave., S.W., Atlanta, Ga. 30334 State Water Control Board—47 Trinity Ave., S.W., Atlanta, Ga. 30334
<b>Hawaii</b>	Department of Health—P.O. Box 3378, Honolulu, Hawaii 96801
<b>Idaho</b>	Air Pollution Control Section—Environmental Improvement Division, State House, Boise, Idaho 83707

\* from Clean Air and Water News, Index Volume, 31 March 1972.

<b>Illinois</b>	Air Zoning and Compliance Division—117 W. 19th St., Springfield, Ill. 62761 Water Pollution Board—P.O. Box 134, Joliet, Ill. 61701
<b>Indiana</b>	State Department of Health—Columbus Building, Indiana State Capitol, Indianapolis, Ind. 46204 Water Pollution Control—Department of Health, Laboratory Building, Indiana State Office Building, Indianapolis, Ind. 46204
<b>Iowa</b>	Department of Environmental Health—State Office Building, 500 S. Grand St., Des Moines, Iowa 50319
<b>Kansas</b>	Bureau of Environmental Health—Division of Health, Department of Health, Building and Health Station, 290 S. 10th St., Topeka, Kan. 66602
<b>Massachusetts</b>	Air Pollution Control Commission—100 State St., Boston, Mass. 02109 Water Pollution Control—Department of Health, 88 State St., Boston, Mass. 02109
<b>Michigan</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Lansing, Mich. 48906
<b>Minnesota</b>	State Department of Health—615 Spring St., St. Paul, Minn. 55101
<b>Mississippi</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Jackson, Miss. 39201
<b>Missouri</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Jefferson City, Mo. 64501
<b>Montana</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Helena, Mont. 59601
<b>Nebraska</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Lincoln, Neb. 68501
<b>Nevada</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Carson City, Nev. 89401
<b>New Hampshire</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Concord, N.H. 03301
<b>New Jersey</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Trenton, N.J. 08646
<b>New Mexico</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Santa Fe, N.M. 87501
<b>New York</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Albany, N.Y. 12242
<b>North Carolina</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Raleigh, N.C. 27601
<b>North Dakota</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Bismarck, N.D. 58101
<b>Ohio</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Columbus, Ohio 43261
<b>Oklahoma</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Oklahoma City, Okla. 73101
<b>Oregon</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Salem, Ore. 97301
<b>Pennsylvania</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Harrisburg, Pa. 17120
<b>Rhode Island</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Providence, R.I. 02903
<b>South Carolina</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Columbia, S.C. 29201
<b>South Dakota</b>	Department of Health and Environment—Division of Health, P.O. Box 1343, Pierre, S.D. 57501
<b>Tennessee</b>	Air Pollution Control Board—727 Cordell Hall Building, Nashville, Tenn. 37219 Stream Pollution Control Board—727 Cordell Hall Building, Nashville, Tenn. 37219
<b>Texas</b>	Air Control Board—1100 W. 48th St., Austin, Tex. 78756 Water Quality Board—1103 Lavaca St., Austin, Tex. 78701
<b>Utah</b>	Division of Health—44 Medical Dr., Salt Lake City, Utah 84113 Water Pollution Control Committee—44 Medical Dr., Salt Lake City, Utah 84113
<b>Vermont</b>	Department of Water Resources—State Office Building, Montpelier, Vt. 05602 Industrial Hygiene Division—Department of Health, P.O. Box 607, 32 Spaulding St., Barre, Vt. 05841
<b>Virginia</b>	Air Pollution Control Board—Room 1106, 10th Street Office Building, Richmond, Va. 23219 Water Control Board—P.O. Box 11143, Richmond, Va. 23230
<b>Washington</b>	Department of Ecology—P.O. Box 829, Olympia, Wash. 98501
<b>West Virginia</b>	Air Pollution Control Commission—4108 Max Corns Ave., S.E., Charleston, W. Va. 25304 Division of Water Resources—Department of Natural Resources, 1201 Greenbrier St., Charleston, W. Va. 25305
<b>Wisconsin</b>	Division of Environmental Protection—Department of Natural Resources, P.O. Box 450, Madison, Wis. 53701
<b>Wyoming</b>	Division of Industrial Hygiene—Department of Public Health, State Office Building, Cheyenne, Wyo. 82001 Water Pollution Control—Department of Health, State Office Building, Cheyenne, Wyo. 82001



**CITY ANTI-NOISE ORDINANCES:**

**Figure 2.9** MAXIMUM A-WEIGHTED NOISE LEVELS (EXCEPT TRAFFIC) AT RESIDENTIAL BOUNDARY

From: Noise Assessment Guidelines/Technical Background, HUD Report TE/NA 172  
 U. S. Department of Housing and Urban Development, Washington, DC 20410

Thus, the Standards Section has quite a formidable task ahead as it must:

1. Categorize standard vs pollutant vs locality.
2. Identify the work being done to validate the standard.
3. Identify where research is required to substantiate the standard.

### 2.2.3 Standards Research

Identifying where research is required to validate the standard is, in itself, a monumental task. In order to specify a standard for the Sensors/Instrumentation Section and the Data Management Section, the Standards Section must be certain that:

1. A standard is based on criteria which establish the adverse effects of a particular pollutant on the environment or its deleterious effect on the public health.
2. A standard is instituted immediately if a hazard to public health exists.
3. A standard is enforceable (i. e., the instrumentation/sensor technology must exist to monitor the pollutant).
4. A standard is economically feasible (if there are no clear-cut indications that a public health hazard exists).
5. There are no feasible alternatives which may avoid the pollution problem.

In order to adequately prepare and evaluate standards for DoD facilities and activities, the Standards Section must have a research laboratory. With the laboratory, the Standards Section will be able to state that:

- a. the standard is realistic
- b. the standard is safe
- c. the standard is the best that could be measured and controlled at this time.

Without the Standards Section, the efforts of the other three parts of the Environmental Impact Prediction Facility (Sensors/Instrumentation Section, Data Management Section, and the Numerical Modeling Section) would not have an established in-house capability for evaluation of the common ambient pollutant standard and will not be able to determine the safe and measurable level for a militarily unique pollutant.

## 2.3 Sensors/Instrumentation Section

### 2.3.1 Introduction

Oceanographic and meteorological instrumentation is a vital part of environmental prediction in two ways. First, the physical state of the atmosphere, ocean, or smaller part of the environment must be known at the time of a pollution episode in order to prognosticate accurately. For example, in order to predict the concentration of SO<sub>2</sub> in an urban region, one must know not only the data relating to the source of the SO<sub>2</sub>, but also the wind speed, atmospheric stability, diffusion coefficients, humidity, precipitation, and other meteorological parameters. Indeed, the meteorological variables have no less profound an effect on the ultimate SO<sub>2</sub> concentrations than does the SO<sub>2</sub> emission rate itself.

The second way in which oceanographic and meteorological data are absolutely essential in predicting environmental changes is in verification of the numerical models which actually calculate the predictions. It can usually be assumed that the explicit physics and mathematics used to construct a numerical model are correct. However, there are generally several other aspects of a model which are ad hoc and must be verified by field data before calculations based on the model can be considered reliable. Included among such verifiable aspects of numerical models are the parameterization of implicit physical or chemical processes (for example, diffusion), the neglect of other physical or chemical processes

(for example, convergence and upwelling in many urban air pollution models), and approximations for other physical processes (for example, Newtonian cooling).

### 2.3.2 Objectives

The primary objectives of the Sensors/Instrumentation Section of the Environmental Impact Prediction Facility will be to provide expertise for the pollutant monitoring staffs of the various DoD facilities and to be responsible for obtaining accurate and meaningful data measurements, as required by the other sections of the prediction facility. Basically, this section's task will be to:

1. Test and use, in situ, various instruments and provide an instrumentation and technique evaluation based upon reliability, ease of operation, sensitivity, selectivity, etc.
2. Investigate DoD facilities to determine:
  - a. the overall pollution problem and the pollutants to be monitored
  - b. the number, type, and deployment of the instruments to effectively monitor the activity
  - c. the sampling procedures to be assured of obtaining meaningful data.
3. Train or provide technical advice to the facility's environmental pollution staff so that data throughout CONUS will be consistent and the monitoring instrumentation will be properly calibrated and maintained.

4. Provide technical backup for any facility/ activity that requests assistance.
5. Provide follow-up at regular intervals after the initial "setup" visit to determine the effectiveness of the endeavor, to re-evaluate the deployment of the instrumentation, and to update the facility's environmental protection staff with the latest techniques in instrumentation and analytical procedures.
6. Maintain effective communication links with other non-DoD agencies to be assured that DoD's instrumentation and analytical procedures are state-of-the art.

The Sensors/Instrumentation Section must not only be able to specify the necessary pollution monitoring sensors/instrumentation, but also the instruments that will adequately describe the hydrological and meteorological factors about the facility. Some of these instruments are briefly described in the following sections. The sophisticated chemical pollutant detection instrumentation, e. g., Gas Chromatograph, Ion Selective Electrodes, etc., are detailed in Section 4.0, Sensors.

### 2.3.3 Hydrological and Meteorological Sensors

A few of the more common instruments and sensors which are used to determine and parameterize the hydrological and meteorological features of an environment are described in the following sections.

#### 2.3.3.1 Salinity

Salinity may be determined at sea by collecting water samples in Nansen bottles at predetermined depths and measuring the samples' salinities in the shipboard chemistry laboratory. The measurement may be by the Knudsen method, by the electrical conductivity method, or by the induction salinometer method. Salinity may also be determined "in situ" by either of the latter two methods.

#### 2.3.3.2 Temperature and Depth

One common technique of measuring temperature as a function of pressure (approximately interchangeable with depth) at sea is by means of the bathythermograph, or BT. The BT is an instrument which senses both pressure and temperature and plots them as the ordinate and abscissa on a coated glass plate as the BT is lowered and raised by cable by the shipboard winch.

Another method which is gaining popularity lately, as it usually does not require the oceanographic vessel to slow down during the cast, is the use of the expendable bathythermograph or XBT. The expendable probe of the XBT uses a thermistor to measure temperature variations. The temperature signal is brought by a thin expendable wire to a shipboard recorder and the depth is determined by assuming that the probe descends at a constant rate.

The same pair of parameters is frequently measured in connection with a Nansen bottle cast by a pair of reversing thermometers. One of the two thermometers is sensitive only to temperature; the other is sensitive to pressure as well. They are, therefore, used together to measure both the "in situ" temperature and pressure at the time that they are reversed (inverted) by their tripping mechanism.

#### 2.3.3.3 Current Measurements

Ocean currents may be measured by a variety of devices. Several measure the motion of the water relative to the instrument by a physical interaction, such as a windmill-type action or a drag force; these instruments include the Richardson current meter and the thrust current meter. Other techniques, such as the electromagnetic probe method, determine water current speed relative to the probe by measuring the electric current induced when the (conducting) water flows through the magnetic field produced by the probe.

Lagrangian current measurements may be obtained by tracking a submerged buoy (neutrally buoyant float) with precise navigation techniques. Other measurements of this type have been made by precise navigation in a freely drifting deep-sea submersible research vehicle.

The geomagnetic electrokinetograph (GEK) measures the Faraday induction due to the drifting motion of a ship underway, together with the surface water, in the earth's fixed magnetic field. The reliability

of the inference of ocean currents from measurements of the electromagnetic induction, even if the latter are accurate, is dubious, particularly in shallow water.

#### 2.3.3.4 Wind Velocity and Direction

Wind velocity is conventionally measured by a vane anemometer which detects the wind speed by the turning rate the wind imposes on a propeller and determines the wind direction by the orientation of the freely pivoting vane, which also serves to orient the propeller's axis parallel to the wind.

The thrust anemometer is capable of considerably more resolution on time, space and wind velocity itself, over a wide range of wind speeds. Another recently developed device for measuring wind speed is the acoustic doppler anemometer.

Arrays of crossed-beam lasers can produce data from which wind velocities can be determined by correlation techniques. This method is very promising and offers the important advantage of measuring the winds aloft continuously with ground-based instruments. If perfected for high altitude measurements, it will represent an extremely important breakthrough in meteorological instrumentation.

#### 2.3.3.5 Satellite Data

Satellite measurements of the infrared radiation flux simultaneously in several bands can be used to infer the atmospheric temperature profile. These data have already been incorporated into several meteorological programs.

Satellite-based radar backscatter measurements from the sea surface can be used to calculate the capillary wave amplitude. From this information, the windfield over the ocean can be inferred. If perfected, this technique will lead directly to major improvements in atmospheric forecasting ability.

#### 2.3.4 Physical Parameter Instrumentation

As an example of current instrumentation, two of the physical parameters, pH and turbidity, have been selected from the group of ten features which are required to accurately describe water quality. The other features are:

Specific conductance

Light penetration

Color

Odor

Total solids (volatile and fixed)

Suspended solids (volatile and fixed)

Floating solids

Sediment

#### 2.3.4.1 pH

The pH of most American natural waters varies from 4 to 9; the former is characteristic of certain acidic swamps and runoff from some mines while the latter is characteristic of some western U. S. alkali marshes. Pure water is slightly basic (pH about 7.3) owing to the presence of carbonates and bicarbonates. Sea water has a pH varying from 7.8 to 8.3, the small range is characteristic of the buffering action of the carbonates. Contamination of sea water in the coastal zone or in estuaries may affect the carbon dioxide-carbonate system, directly or by means of alteration of the biological oxygen demand (BOD). At present, two methods exist for pH determination, colorimetric and electrometric.

The colorimetric method of pH determination, which uses the color change of certain solutions, when added to the sample, as an indicator, is generally not suitable for pollution studies. Severe interference with the color change is produced by the presence of free chlorine, various oxidants and reductants, unknown salinity, turbidity and colloidal matter. These influences are most likely to be present when coastal waters are contaminated.

The electrometric method of pH determination uses a glass electrode containing silver chloride and a potassium chloride saturated calomel electrode immersed in the water sample. It measures pH on the scale of a 59.1 millivolt per pH unit variation at 25<sup>o</sup> C and is

standardized against a solution of known pH. A temperature correction can be inserted in most instruments or calculated from the manufacturer's data to correct for the temperature variation of the calomel cell in the test sample. The hydrogen ion activity, which is the pH, is itself temperature dependent. Hence the water temperature must be measured at the sample depth; the pH can then be calculated from the measured pH. Accuracy in the field is generally to 0.1 pH units. Laboratory measurements can be made to an accuracy of 0.005 pH units. However, the sample cannot be more than two hours old or biological action will change the pH. Typical instruments are the Beckman Model G and the Fisher Scientific Accumet 220.

#### 2.3.4.2 Turbidity

Turbidity is an optical property of the suspended material in a water mass and is not related, quantitatively, to any biological measurement. It is important in pollution studies as turbidity affects photosynthesis (highly turbid waters are low in photosynthetic productivity). Turbidity can originate in natural erosion processes (clay and silt), wastewaters (organic and inorganic particles), and in local biological production (plankton).

The standardized method for measuring turbidity is rarely used as it is very difficult to perform and assess a sample. This technique is called the Jackson candle turbidimeter. Measurements are

based on the length of a light path through a water sample containing suspended material which just causes the image of a standard candle to become indistinguishable from the scattered background illumination. A table converts the light path length to Jackson turbidity units, which vary from 25 (clear water) to 1000 (turbid water). The table has been extrapolated to 0 (for distilled water) so that measurements can be taken of the unusually clear waters (e.g., streams, wells and treated water - range from 0 - 5).

Turbidity is almost universally measured by a nephelometric means. Light is transmitted into a clear glass tube which contains the sample and the scattered light is measured on a photoelectric detector which is located on an axis perpendicular to the incident light. The measurement is standardized to a solution of Formazin polymer which has been calibrated on the Jackson turbidimeter at 40 units. This is reasonably reproducible and permits scaling of the data.

There are two major difficulties with this technique. One, there is no physical relationship between the Jackson candle measurement and the nephelometric measurement; and two, the differences in optical systems between different commercial instruments produce results that do not correlate with one another, nor do the results agree with the Jackson measurements over a complete range of samples. Thus, a universally acceptable standard optical format is required.

Examples of commercially available nephelometric turbidimeters are the Central Scientific Helige model, Coleman model 9, and several models by Hach, such as 2100A and 1860 A. A portable device for "in situ" measurements is the Beckman EV 4. [The latter device utilizes a different optical format from the other instrumentation and appears to be a transmission measurement combined with a scattering measurement. The output is not readable in Jackson units.]

#### 2.3.5 Organic/Inorganic Chemical and Biological Instrumentation

Of the parameters mentioned in the table entitled "Parameters Used in the Evaluation of Water Quality" in Section 2.1.1B, several of the chemical, organic and inorganic, and biological factors are briefly described. These are:

Photosynthetic rate measurements

Periphyton/Chlorophyll

Biological Oxygen Demand (BOD)

Chemical Oxygen Demand (COD)

Total Organic Carbon

Heavy Metals

#### 2.3.5.1 Photosynthetic Rate Measurements

The rate of oxygen production by photosynthesis in the phytoplankton is an important measure of the net effect of pollution in coastal waters and estuaries. A series of measurements will indicate the extent and effects of pollution, including adverse effects on aquatic life, and the progress of the self-purification of the water.

Two methods of photosynthetic rate measurements are in use. The more common one is the measurement of DO content before and after incubation; the second method uses a radioactive carbon tracer.

The samples are acquired in the same way for both methods. Large (3 - 5 liter) free-flushing and non-metallic water sample bottles, such as the Niskin or VanDorn bottles, are lowered to predetermined depths to obtain water samples. Surface samples are usually taken one or two feet below the surface and the deepest sample should be near the bottom in shallow water or at the bottom of the euphotic zone in deep water. [This is the depth that receives 1% of the light at the surface waters and it can be measured with a photoelectric probe or photometer.] Following measurement, the data are plotted as a function of depth to produce a vertical photosynthetic rate profile. The integral of the curve is the total productivity per unit area of water column.

In the first determination technique, the water sample is placed in three clean BOD bottles (300 ml capacity), one of which is totally opaque. One of the clear BOD bottles and the opaque one are securely

stoppered and lowered to their original sample depths to incubate for several hours. The third bottle is used for an immediate DO measurement. Upon retrieving the "in situ" samples, the DO is measured immediately. The opaque bottle will have a DO loss owing to respiration, and the clear bottle will have a DO gain owing to photosynthesis. Then,

Net photosynthesis = clear bottle DO - initial bottle DO

Respiration = initial bottle DO - opaque bottle DO

Gross photosynthesis = clear bottle DO - opaque bottle DO

In the second method, two BOD bottles, one clear and one opaque, are used as before, but a solution of radioactive carbonate (carbon 14) is added to the samples before incubating. Following incubation "in situ", the plankton are removed from the retrieved samples by collection on a membrane filter, and then dried. The fraction of the radioactive carbonate taken up by the plankton is measured with a Geiger counter and is assumed to be a direct measure of the photosynthesis. Although more complex than the first method, the second method has the advantage of being available in a test kit.

#### 2.3.5.2 Periphyton/Chlorophyll

The periphyton include the communities of microorganisms growing on stones and other submerged surfaces (e.g., filamentous bacteria, attached protozoa, and algae) and certain free-swimming

microorganisms. The periphyton respond sooner and with greater sensitivity to changes in the water quality than do other life forms (e. g. , plankton, fish). An example is the variability in type and density of the slimes that are found in estuaries and coastal zones in the vicinity of a sewage outfall; the slimes change and disappear as the water quality improves with distance from the outfall, thus delineating "pollution zones".

Periphyton samples are obtained by suspending substrates, usually standard 1 x 3 inch microscope slides, in the water mass at the desired sample point for a period of at least two weeks. The periphyton growth is then removed from the slides, preserved in a formalin solution, and counted using standard microscope counting techniques. The two accepted counting techniques are arduous and costly. One requires visual counting of the periphyton in a fixed volume of solution (using a Sedgwick-Rafter cell, a microscope slide with an indented volume of 1 milliliter). The difficulty with this technique is that the microscope magnification is limited and the microscope depth of field is too small to permit counting of the floating and the bottom periphyton simultaneously. The second method, which is rapid and accurate, uses a television camera on the microscope barrel. A count is made by a computer analysis of the microscopic field using pattern recognition techniques so as not to lose count of periphyton that overlap each other. One commercial instrument is made by Millipore, Inc.

For most pollution studies, the biomass of the periphyton (such as algae) is the parameter of interest since it is an indication of both the organic contamination of the water and the ability of the water to purify itself. The chlorophyll content of the periphyton is an accepted measure of that biomass. All the methods of chlorophyll determination for the types a, b, and c are spectrophotometric. These methods, and the aforementioned counting methods, have the inherent disadvantage of not being adaptable to field techniques.

For determination of chlorophyll content, the substrate growth is dissolved in an acetone solution and a sample is placed in a cuvette in a narrow band spectrophotometer. Optical densities are measured at 7500 Angstroms (turbidity correction), 6650, 6450, and 6300 Angstroms (chlorophyll a, b, and c, respectively) and the original concentrations are calculated. Accuracy, at typical sample levels is  $\pm 0.26$  micrograms of chlorophyll a at the 5 microgram level,  $\pm 0.21$  micrograms of chlorophyll b at the 0.5 microgram level, and  $\pm 1.5$  micrograms of chlorophyll c at the 5 microgram level. Chlorophyll c determinations are particularly susceptible to positive error due to the presence of non-active pigments. This difficulty can be avoided by reading the optical density of the sample at 4500 Angstroms, before and after the addition of acid to the sample.

For details on spectrophotometers, refer to Section 4.4.

#### 2.3.5.3 Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) measurements are based on empirical tests using standardized laboratory procedures. The uniform interpretation of the data by different workers in the field depends upon the uniformity of the laboratory procedure. This is a major disadvantage.

BOD tests are useful in determining the waste loading and efficiency of sewage treatment plants and are acceptable tests for following the pattern of pollutant circulation and purification in natural waters. However, they are not very accurate and no standard exists. BOD reactions are delayed by the presence of free chlorine, abnormal pH, or certain toxic chemicals - all of these are characteristic of most industrial wastes. In the BOD laboratory procedure, a pre-treatment of the sample corrects for these conditions and also provides seed organisms for the oxidation of the organic matter if the natural biological population is deficient.

The laboratory procedure consists of making several dilutions of the water sample with distilled water saturated in DO, and filling standard 300ml BOD bottles with the test samples, in pairs. One of each pair is used for an immediate DO measurement, the other incubated for five days (most often) or thirty days (rare) in a dark room at 20° C. Following incubation, the DO is measured again. Corrections for dilution are made and the data are discarded where BOD is in excess of available DO. The five-day BOD is the generally accepted form of the data.

#### 2.3.5.4 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is a measure of that portion of the organic matter in the natural water which is oxidizable by a strong chemical oxidant. It is a parameter that can be measured in the field, although it does require removal of a sample and addition of chemicals. Sewer effluents and organic pollutants can be traced through an estuarine or coastal flow pattern. However, the data are highly susceptible to variation caused by contaminants such as cellulose, which are not immediately a demand on the DO.

The accepted procedure is to add known amounts of potassium dichromate and sulphuric acid to the sample. The amount of oxidizable organic matter measured as oxygen equivalent is proportional to the potassium dichromate consumed. This is determined by a titration with a ferrous ammonium sulphate standardized solution. The COD, which should indicate the total of oxidizable materials present in the water, is affected by temperature, concentration of the reagents, deviations of the test, and composition of the water sample. Consequently, measurement conditions must be precisely controlled to develop data useful for comparison.

#### 2.3.5.5 Total Organic Carbon

The relationship between BOD, COD and total organic carbon (TOC) has been rationalized such that the two oxygen demands are a fair measure of TOC. TOC can be measured directly by several laboratory procedures; however, no field procedure exists.

The most common procedure is to dilute or concentrate the water sample to a suitable working range, chemically eliminate non-organic carbon, inject a sample into an infrared combustion analyzer in which the organic carbon is oxidized to carbon dioxide, and then measure the height of the peak associated with the infrared absorption of the carbon dioxide. Comparison with similar tests on standardized solutions of sodium oxalate determines the original TOC content.

Typical commercial instruments for TOC measurement are the Beckman 915, Union Carbide 1212, and Coleman 33. Measurement accuracy is one part per million (ppm) of the injected sample, which is limited to the range of 1 to 100 ppm. Analyses using advanced laboratory spectrophotometers instead of the commercial TOC analyzer can attain much better accuracy.

#### 2.3.5.6 Heavy Metals

The presence of heavy metals in waterways is important as they present a long term toxicity to biological life. No suitable field procedure exists for a general determination of the concentration of heavy metals.

Atomic absorption analysis and polarography are accurate and reliable laboratory procedures for determining the concentration of heavy metals. However, the instrumentation is costly. Colorimetry is a less expensive, but complex laboratory procedure which requires a pre-treatment of the sample to destroy the organic carbon content (which holds heavy metals in complex bonds), and to eliminate interferences when more than one heavy metal is present. Standard procedures exist for the individual determination of the presence and quantity of cadmium, total chromium, hexavalent chromium, total copper, cuprous ion, total iron, ferrous ion, lead manganese, nickel, and zinc by colorimetric techniques. A standard polarographic technique is used to simultaneously identify and quantize cadmium, copper, lead, nickel and zinc.

#### 2.3.5.7 Organic contaminants

Insecticides, herbicides, agricultural chemicals, phenols, polychlorinated biphenyls, and the reaction products of phenols and chlorine are all persistent chemicals in the TOC content of a waterway, and are particularly objectionable because of their adverse effects on the living environment of the waterway. No simple procedures exist for determining the extent of their presence in natural waterways. [Chlorinated phenols have a recognizable taste even in very small concentrations. However, this is not a test.] Laboratory procedures utilize carbon adsorption to concentrate the organic contaminants and gas chromatography for identification. Quantitative data rely on comparison with standard solutions,

which is a time-consuming process. No field instrumentation exists for identifying or quantizing these organic contaminants.

#### 2.3.6 Instrument Evaluation (Example)

As previously mentioned, one of the objectives of the Sensors/Instrumentation Section of the Environmental Impact Prediction Facility will be to provide an evaluation of commercially available, on the shelf, and state-of-the-art instrumentation which is required to parameterize the environmental features of the DoD facility or activity or to measure the extent of the pollutant concentration in the various media.

Instrumentation for one of the inorganic chemical parameters, Dissolved Oxygen (DO), is evaluated. Although all of the instruments currently commercially available for the measurement of DO are not presented, this evaluation is provided as an example of what would be expected from the Sensors/Instrumentation Section.

##### 2.3.6.1 Dissolved Oxygen

Dissolved oxygen (DO) levels in the coastal waters and estuaries are a measure of the combined effect of photosynthesis, respiration, chemical and biological oxygen demands (COD and BOD) of sewage and other wastewaters entering the natural waters. Analysis of DO is a primary guide to pollution abatement. Two methods of DO measurement in common use are the Winkler (iodometric) method and the electrometric method.

### 2.3.6.2 Measurement Techniques

The expected range of DO measurements is from 0.005 to 8 milligram-atmospheres per liter (mg-at/l). The lower limit is essentially anoxic water while the upper limit is not fixed. At normal surface conditions, DO becomes supersaturated in the 8-9 mg-at/l region. Supersaturated DO is seasonally found in streams and estuaries. [If supersaturated DO cannot be measured directly, a water sample can be diluted with low DO water, and the measurement corrected.]

Any instrument measuring DO should compare with the standard chemical analysis for DO, called the Winkler method. This method exhibits the highest precision of any method adaptable to routine measurements. The expected error of a single determination is  $\pm 0.003$  mg-at/l at the 0.7 mg-at/l level for a well-controlled laboratory experiment. Routine analysis in pollution studies accept a  $\pm 0.050$  mg-at/l error for visual determination of the titration endpoint, and  $\pm 0.005$  mg-at/l error for an electrometric endpoint determination.

The water sample from the selected depth is taken with a non-metallic sampler such as the Kemmerer, Van Dorn, or Niskin bottle and transferred to a standard 300 milliliter BOD bottle, without entraining external air. [Sample temperature should be measured as soon as the sample reaches the surface.] Immediately, 2 ml of manganous sulphate reagent solution should be added to the BOD bottle, followed by 2 ml of alkaline iodide solution. The sample is then shaken. A precipitate

forms, which is redissolved by the addition of 1 ml of concentrated sulphuric acid.

Initially, the DO had been captured by oxidizing the manganous ion to a higher valence manganese ion. The latter now reverts to the divalent state in the presence of the iodide ions and the sulphuric acid, liberating an iodine equivalent to the original DO.

When convenient, the sample is titrated with a 0.5 N sodium thiosulphate solution using either starch as the endpoint indicator, or an electrometric endpoint determination. The DO in the original sample is then calculated from the quantity of titrant used. A correction must be made for the temperature change, and if a deep sample, the pressure change from the original state.

Since the water samples contain a variety of natural, sewage, and industrial contaminants, several modifications to the Winkler method exist to correct for their presence, as they would interfere with the iodometric determination. For example, oxidizing materials in the sample would change iodide to iodine thereby producing an apparent increase in DO, while the opposite is true for reducing materials. The following list summarizes the common modifications to the Winkler method.

<u>Modification</u>	<u>Purpose</u>
1. sodium azide addition	Removes interference caused by nitrite, which is common in sewage effluents and incubated BOD samples.
2. alum flocculation addition	Settle suspended solids which may consume appreciable quantities of iodine in acid solution.
3. copper sulphate-sulphamic acid flocculation	Used in addition to the azide modification to settle biological material which has a high oxygen utilization rate.
4. potassium permanganate addition	Eliminate ferrous iron interference.
5. potassium fluoride and azide addition	Eliminate ferric iron interference.
5a. use phosphoric acid instead of sulphuric acid for acidification step	

Although the chemical techniques are not convenient for field use, they remain the standard methods to which instrument performance is compared.

Two different principles are used in measuring DO in situ with the presently available instruments, polarographic, and galvanic. Both techniques have been demonstrated feasible for in situ measurements in lakes, rivers, oceans, industrial effluents, sewage effluents, and in activated sludge. They have an accuracy of  $\pm 0.05$  to  $\pm 0.1$  mg-at/l DO when calibrated with a fresh water or a salt water standard of known DO, (depending upon whether the measurement is to be made in fresh or salt water).

The DO can be measured using a conventional polarographic cell with a dropping mercury electrode, however the impurities in industrial waste and sewage cause unreliable electrode operation. DO meters which are commercially available use a special adaptation of the polarographic cell. It comprises a gold cathode, a silver anode, and a potassium chloride electrolyte. A polarizing potential of about 2 volts is used. The cell is isolated from the test sample by a plastic membrane, usually teflon or polyethylene. The membrane is permeable to oxygen and the flow through the membrane is linearly proportional to the DO and logarithmically proportional to the temperature. The current through the polarographic cell is directly proportional to the molecular oxygen activity in the electrolyte. Thus, a current measurement is a measure of the DO.

Some instruments use thermistors in the probe to sense the sample temperature and correct the DO for membrane permeability. However, this system loses accuracy when there is a wide difference between the test sample temperature and the standardized sample temperature. Consequently, some instruments are provided with graphs to make the correction from external temperature measurements.

The measurement of DO using a galvanic cell does not require an oxygen permeable membrane in that other constituents of the test sample, as commonly encountered, will not affect the DO determination. The sensor comprises a thallium anode and a saturated calomel glass reference electrode or a cathode. Oxygen is reduced at the cathode

causing an electric current to flow which is proportional to the DO content. The galvanic cell is temperature sensitive, hence requires correction either electronically, or by graphical means.

Both the polarographic and the galvanic type sensors are capable of operation in fresh and salt waters, in sewage effluents and in incubated BOD samples. They are also capable of operation to any water depth.

#### 2.3.6.3. Instrument Comparison

A comparison of instruments used for DO measurement should consider all of the following parameters:

1. Measurement range: some units do not measure very small levels of DO (0.1 to 1 mg-at/l), and some units have limitations in the super-saturated region (above 9 mg-at/l). (Note that 1 part per million = 1 milligram atmospheric/liter for samples measured at the surface of the sea.)
2. Temperature range: The range of operation is usually much larger than the range of automatic temperature correction.
3. Depth capability: In addition to a physical limitation, both the polarographic and the galvanic sensors exhibit a pressure effect in DO determination, which, if no calibration is available, becomes a loss in accuracy.
4. Accuracy of DO measurement at constant temperature.
5. Accuracy of temperature measurement and correction.
6. Response time of DO determination: This parameter is temperature sensitive, hence should be considered at the extremes of operation of the instrument.
7. Response time of temperature measurement.

8. Stability (drift) of DO measurement from a fixed calibration.
9. Stability (drift) of temperature measurement from a fixed calibration.
10. Resolution of DO measurement.
11. Resolution of temperature measurement.
12. Effects of variation in power supply voltage.
13. Effects of contaminants in the sample: Hydrogen sulphide, for example permeates a teflon membrane and contaminates the polarographic sensor. Magnesium ions in salt water contaminate the thallium anode of the galvanic sensor.
14. Repeatability of measurements.
15. Sensitivity of sensor to water flow direction and velocity.
16. Physical characteristics (size, weight, ruggedness)
17. Cost of instrument, cost of replacement sensors, sensor lifetime.
18. Toxicity of sensor materials: For example, thallium is poisonous.
19. Range of operating temperature for surface instrument (ambient air)
20. Application to BOD bottle samples: The sensor size and the provision of an agitator are meaningful considerations.
21. Mounting brackets: Some sensors are integral to the cable and do not allow for external mechanical suspension in waterways.

Table 2.10 compares some commercially available instruments on the basis of a few of the parameters which are considered most important.

TYPE	MEASUREMENT RANGE	DO ACCURACY	TEMP ACCURACY	DEPTH CAPABILITY	DO RESPONSE TIME	TEMP. RESPONSE TIME	FLOW CAPABILITY	RESOLUTION
POLARO-GRAPHIC	1. BECKMAN INSTRUMENTS 0-15 mg/l 0-10 mg/l	MINUS 3% OF READING OR 1% OF FULL SCALE INCLUDES TEMP. & DEPTH EFFECTS	3000 METERS	DO MONITOR 6 SEC.	6 SEC.	NOT LESS THAN 8 CM/SEC.	0.04 mg/l	
POLARO-GRAPHIC	2. HYDROLAB IIA WATER QUANTITY ANALYZER (PORTABLE) FRESH WATER ONLY SINCE SENSOR IS NOT COMPENSATED FOR SALINITY OR PRESSURE. 0-10 PPM 0-20 PPM	± 0.5°C	200 FEET	2-14 SEC.	2-14 SEC.	0.1 TO 5 KNOTS	0.04 PPM	
POLARO-GRAPHIC	3. BECKMAN INSTRUMENTS MODEL 735 0-5 PPM 0-10 PPM 0-20 PPM	1% OF FULL SCALE	DO ANALYZER 100 FEET	20 SEC.	20 SEC.	NOT LESS THAN 1.5 FT./SEC.	0.02 PPM 0.05 0.1	
GALVANIC	4. LEEDS AND NORTHROP 7070-08 MONITOR (FOR INDUSTRIAL USE) 0-5 PPM 0-15 PPM					HAS INTERNAL AGITATOR		
POLARO-GRAPHIC	5. HONEYWELL 2-25 mg/l	5550-5a 0.1 mg/l or 1% READING	DO MEASURING SYSTEM 100 FEET	1 MIN.	2 MIN.	1.5 TO 11 FEET/SEC.		
GALVANIC	6. IONICS INC. MODEL 1131 DO ANALYZER (FOR FRESH WATER) 0.5 TO 15 PPM	0.3 PPM OF 3% READING	25 FEET	15 SEC.	10 MIN.	1 TO 5 KNOTS	0.1 PPM	
GALVANIC	7. DELTA 85 OXYGEN METER 0-20 mg/l	0.2 mg/l	10 FEET OR 100 FEET			NOT LESS THAN 1 FT./SEC.		

TABLE 2.10: COMPARISON OF COMMERCIALY AVAILABLE DISSOLVED OXYGEN (DO) INSTRUMENTATION

## 2.4 Numerical Modeling Section

### 2.4.1 Introduction

In order to predict the effects of DoD activities on the environment and to assess the impact on DoD activities on environmental changes caused intentionally or unintentionally, it is not sufficient merely to collect data on the normal state of the environment and on the activities themselves. It is essential to have access to predictive models of the environment. One vital part of a successful Environmental Impact Prediction Facility must therefore be a Numerical Modeling Section whose function it is to develop, maintain, and apply a collection of dependable, efficient models of the environment.

There is, at present, no single agency or facility from which DoD can procure a rapid analysis of an environmental problem, including all phases of the problem from input data through analyses of physical, chemical, and biological processes to a quantitative environmental prediction, for problems in all parts of the environment from deep-sea pollution, to urban pollution, to stratospheric modification. While it is the mandate of the Environmental Impact Prediction Facility to provide DoD with this essential capability, it is the purpose of the Numerical Modeling Section to provide within the Facility the expertise necessary for its central objective -- the environmental prediction itself.

The capability necessary to achieve the Facility's goals requires

an efficiency possible only within a program which combines expertise on all phases of environmental prediction, from the design of instruments to measure trace chemicals in the oceans and atmospheres, to data display technology. For this reason, the Facility cannot rely on interfacing with the existing institutions which have developed numerical models in one or two of the many types of numerical models which will be needed. On the other hand, it would be extremely wasteful of time, money, and expertise to attempt to duplicate all the relevant modeling developments which have already been achieved. The Numerical Modeling Section will satisfy these requirements by:

- a. accomplishing the tasks of reviewing the state-of-the-art in numerical modeling.
- b. implementing on the ARPA computer programs for all existing models relevant to DoD environmental prediction needs.
- c. using this computing capability to provide rapid, dependable answers to questions posed by DoD personnel.
- d. updating the models continuously.
- e. advising other sections of the Environmental Impact Prediction Facility of their need for research or data for the verification or improvement of the models.

#### 2.4.2 Technological Support Required

The Numerical Modeling Section will require access to several types of technological information and capabilities. These include the numerical models themselves, computing facilities with various types of input/output peripheral equipment, data for verification of the numerical models, data for updating the numerical models, and data describing the activities whose environmental impact is to be predicted. These are discussed separately in the subsections which follow.

##### 2.4.2.1 Numerical Models

In concept, the Numerical Modeling Section might be able to work only with a single model encompassing the entire global environment from the earth's sedimentary covering to the upper atmosphere, and modeling the environment in sufficiently fine detail to include local phenomena such as urban or estuarine pollution. Practical considerations -- mainly available computer size and speed -- make this concept impossible to implement at least for a decade. Furthermore, it is unnecessary for one interested in the pollution of a stream to explicitly consider the dynamics of all the world's oceans and the atmosphere; and it is unnecessary to include such fine detail as the dynamics of each and every stream in a study of the effects of increasing water vapor in the stratosphere on the world climate. It is therefore necessary for the Numerical Modeling Section to work with a number of models, each

representing different scale phenomena. These are described briefly below:

a. Combined Ocean/Atmosphere Model

This will be the largest scale, coarsest grid model used. Its purpose will be to predict global-scale effects, such as the dispersion of radioactive strontium climatological changes, and sea-level fluctuations, which might result from activities such as the injection into the stratosphere of waste products by high-flying aircraft or the construction of an inter-ocean canal. The grid size will probably be on the order of 100 km. The model will therefore be unable to consider explicitly a single city or river. It will, however, encompass all the world's oceans, and the entire atmosphere.

b. Single-Ocean Models

The Numerical Modeling Section will have a separate model for each of the world's oceans and seas. This will require topographical data, temperature and salinity data, and runoff data (i. e., river discharge and chemical content). The grid size will be no greater than 100 km. These models will ignore ocean-atmosphere interactions explicitly modeled by the combined ocean/atmosphere model; the atmosphere will be assumed to behave independently of any changes which the model might predict in the oceans. These models will be useful in the distribution of a pollutant injected into the ocean. It would be advantageous to have separate models (or a two-option model) for studies of passive pollutants, such as mercury, and active pollutants, such as heat. (The distinction between passive and active is made, here, with respect to the ocean circulation.

c. Global Atmospheric Model

This model will include the dynamics of the entire globe's atmosphere, up to and including the stratosphere. Conversely with the single-ocean models, the oceans will be assumed by this model to behave independently of any variations which might occur in the atmosphere. This model will rely on temperature and wind data, continental topography, albedo, ocean surface temperatures, and atmospheric chemical composition data. As in the case of the single-ocean models, separate algorithms will be available for studying the dispersion of passive and active pollutants, such as strontium and CO<sub>2</sub>, respectively. The model will also be able to predict effects of climate, winds, the distribution of clouds and rainfall, etc., which might result from chemical pollution by CO<sub>2</sub> or water vapor, for example, or from man-made changes in the earth's albedo.

d. Estuarine Model

A generalized estuarine model will be implemented for the purpose of predicting the dispersion of pollutants (thermal or chemical) in an estuary, and circulation changes caused by modification of the shoreline by piers, bridges, or other structures. The model will rely upon topographic data collected by another section of the Facility. The dynamics will include tidal effects, river discharge, wind stress, temperature and salinity stratification, and boundary layer friction.

e. Urban Air Pollution Models

Several urban air pollution models will be included in the inventory. Each will utilize a different combination of data, and will be applied to a problem depending on the data available from the site. The types of data will include surface wind speed and direction, wind speed and direction at various altitudes, the Kolmogoroff structure function, eddy diffusivity tensor, topography, thermal structure

(with particular regard to the vertical stability and inversions), humidity, radiative fluxes, meteorological prognoses, cloud types and altitudes, cloud types and altitudes, and source data. These models will be capable of predicting the dispersion of passive and active pollutants, and of predicting the dynamical effects of active pollutants. For example, estimates may be provided of the heat island effect, orographic precipitation effects, etc.

f. River and Stream Models

Generalized one-, two-, and three-dimensional river models will be available to predict the dispersion of waterborne pollution of chemical, biological, or thermal type. Of these pollution types, only the latter may be considered to be active with respect to flow and stratification. The models will include not only the usual advective and diffusive processes, but also biochemical processes significant on the same time scale as the river flow. The models will depend on another section of the Environmental Impact Prediction Facility for topographic data. A further application of the model will be to problems of sediment deposition, erosion, and river course variations induced by shoreline structures or changes in the discharge rate.

g. Ground Water Model

A model will be required to predict the dispersion of pollutants in which ground water has a significant role. The model will include underground rivers, soil seepage, and percolation through porous rock strata. Ground water phenomena affect the dispersion of pollutants such as agricultural fertilizers and pesticides, and radioactivity from underground nuclear tests. The support of the section of the Environmental Impact Prediction Facility responsible for collecting geologic subsurface data and rock porosity data will be essential to the successful application of this model to DoD problems.

#### 2.4.2.2 Computing and Input/Output Facilities

It is anticipated that the physical location of the Numerical Modeling Section personnel responsible for assimilating existing numerical models of the environment and implementing them will be together with the entire Environmental Impact Prediction Facility at the site of a computer with access to the ILLIAC IV, part of the ARPA computing network. The large memory and high speed required for global atmospheric and oceanographic prediction calculations are not available even on relatively large conventional computers. The ILLIAC IV will be one of the few machines in the world capable of the computations necessitated by the Numerical Modeling Section's responsibility.

Access to the models, however, will not be limited to programmers at the ILLIAC IV site. The ARPA network makes it possible for a programmer or scientist at any of the network computers to transmit pollution source data to the Numerical Modeling Section, specify the relevant model and options, and receive output data. The program will actually run on the ILLIAC IV, and utilize oceanographic, meteorologic, topographic, and geologic data stored by the storage facility. The user will have the options of using annual average, seasonal average, or current oceanographic and meteorologic data, and of requesting dynamic predictions or passive dispersion predictions.

In a typical application, one computer will transmit pollution source data and computing instructions to the ILLIAC IV, which will

request and receive current meteorological data from a magnetic tape stored at another computer site. The ILLIAC IV will execute the necessary computations, and transmit the output data to an X-Y plotter (or intermediate magnetic tape) at the initial computer.

#### 2.4.2.3 Verification Data

Numerical models are the only available means of predicting the short-term and long-term, small-scale and global-scale, effects of man's activities on the environment. However, it is the subject of considerable discussion among scientists as to whether the models and data available today provide sufficient accuracy and dependability. While we have arrived at some understanding of the efficacy and limitations of numerical calculations possible today, a more nearly satisfactory understanding will be reached only by the acquisition of more global-scale oceanographic, meteorologic, and pollution data with which the models can be verified. These same verification data can then be used to improve the models, where necessary.

The exact nature of the verification data and the experiments necessary to acquire them is being determined and will continue to be determined by scientists familiar with the numerical models. As such determinations are made by the Numerical Modeling Section, the data-collecting section of the Environmental Impact Prediction Facility will be informed.

One example of the need for verification data arises from the uncertainty concerning vertical transport processes in the lower thermocline. Various combinations of vertical velocity (upwelling) and vertical diffusion account equally well for salinity and temperature data. Only one such combination, of course, is accurate. To distinguish among the accurate and inaccurate combinations, further data are required. It has been determined by numerical models that the data concerning chemical trace elements in the deep ocean, which the GEOSECS experiment intends to collect, will remove enough degrees of freedom from the numerical models to verify the validity of their representation of vertical transport processes in the lower thermocline.

It is anticipated that chemical trace elements will be a most important source of verification data for oceanographic and meteorologic models. The instrument/sensor section, the data section, and the Numerical Modeling Section of the Environmental Impact Prediction Facility, will have as their focal point of interaction and interdependence the vital problem of numerical model verification.

#### 2.4.2.4 Update Data

In addition to the verification data, the ILLIAC IV will require for its numerical model computations, rapid access to current oceanographic and atmospheric data. Data of this type are used routinely for weather prediction, and are collected by the National Oceanographic and Atmospheric Administration. The Numerical Modeling Section

will therefore require a data link with NOAA. There will, of course, be access to the pollution data collected by the Facility's global pollution monitoring network.

#### 2.4.2.5 Source Data

Source data -- data concerning the type and quantity of pollution emission, or the type, extent, and concentration of a locally-dispersed pollutant -- will be acquired routinely by the global monitoring network, or will be supplied to the ILLIAC IV by the computing center requesting the computations. The actual instrumentation used for pollution measurements, and the collection of pollution data, is the concern of another section of the Environmental Impact Prediction Facility, with which the Numerical Modeling Section must interface efficiently.

#### 2.4.3 Current Numerical Modeling Efforts

While numerical modeling is currently being attempted or in progress at many research centers today, there is no one organization which has numerical computation capabilities for models representing all scales of environmental phenomena, from urban to global, which is concerned mainly with predicting the environmental impact of human activities, and which has the mandate to supply DoD with the expertise needed to develop Environmental Impact Statements. However, there are many research centers which do have capabilities in part of the area.

As explained above, the Numerical Modeling Section of the Environmental Impact Prediction Facility will assimilate these capabilities and apply them to DoD needs. An outline of some of the more important research centers active in numerical modeling follows. (This outline does not purport to be an exhaustive listing.)

#### 2.4.3.1 Ocean Modeling

The outstanding institution in large-scale ocean modeling is the Geophysical Fluid Dynamics Laboratory, of the National Oceanographic and Atmospheric Administration, Princeton, New Jersey. The director of this laboratory is Dr. J. Smagorinsky. "In charge" of ocean modeling is Dr. K. Bryan. (Part of the laboratory is devoted to atmospheric modeling, discussed below.) Dr. Bryan has been one of the world's leading figures in the development of numerical modeling of the oceans. The model which has been developed by his group uses the "rigid lid" approximation, and an ad-hoc parameterization of the thermocline. It is felt that verification of the model is essential, and may be forthcoming from GEOSECS data, as well as from conventional oceanographic measurements such as MODE will make. Regions requiring verification most may be the deep sea near-bottom currents, and thermocline vertical-transport phenomena.

Dr. W. Holland, at the Geophysical Fluid Dynamics Laboratory, has been involved in the application of numerical models to ocean tracer distributions. This work will be most useful to the Numerical Modeling Section.

Other institutions doing important work in numerical modeling of the oceans include the University of California at Los Angeles, the National Center for Atmospheric Research in Boulder, Colorado, and Yale University, in New Haven, Connecticut.

#### 2.4.3.2 Atmospheric Modeling

The Geophysical Fluid Dynamics Laboratory is also a leading institution in numerical modeling of the atmosphere. Dr. Manabe is "in charge" of the atmospheric modeling. He and Dr. Bryan work closely together, and are presently developing a coupled ocean-atmosphere model.

The National Center for Atmospheric Research has done pioneering work in numerical modeling of the atmosphere, and is also concerned with coupled ocean-atmosphere models.

#### 2.4.3.3 Smaller-Scale Water Circulation Models

Studies of numerical modeling of coastal upwelling have been made at Florida State University, the University of Connecticut, and New York University. Estuarine and river studies have been made by the Environmental Protection Administration, Oregon State University, the Federal Water Quality Agency, and Johns Hopkins University.

#### 2.4.3.4 Smaller-Scale Atmospheric Circulation Models

Studies of urban and local dispersion of air pollution have been made by the Environmental Protection Agency, Pennsylvania State University, New York University, and many others.

## 2.5 Data Management Section

### 2.5.1 Introduction

The development of an Environmental Impact Prediction Program includes the development of a facility which can collect, process and evaluate environmental data which are obtained from DoD facilities and activities. This information is used to evaluate the environmental impact of existing facilities and to establish numerical models to predict the impact of future facilities and activities. This facility, termed the Data Management Section, will work in close coordination with the Numerical Modeling Section and the Sensor/Instrumentation Section to obtain the most reliable and up-to-date data on environmental pollution factors.

As a functioning entity, the main goals of the Data Management Section will be:

Data Collection. Collection of pollution data from sensors at DoD facilities; assimilation of pollution data from non-DoD sources such as EPA and NOAA when these sources contain information which relate to DoD activities; and assimilation of data comprising state and federal standards and regulations which relate to the pollutants under observation.

Data Evaluation. Evaluation of the environmental impact of existing and future DoD facilities; notification to DoD facilities of available methods to improve or correct their pollution endeavors; and evaluation of pollution abatement procedures, both short-term and long-term.

Data Processing. Standardization of collected data; storage of data required for evaluation and updating of environmental models; and dissemination of data to interested parties.

As discussed in Section 2.4, the goals of the Numerical Modeling Section are met by use of the ILLIAC IV computer as accessed through the ARPA Net. Extending this idea, the ARPA Net will handle data communications between the sensors deployed by the Sensor/Instrumentation Section and the data collection group. This technique will take advantage of the long distance reliable data links that are already in existence in that net. Furthermore, storage of data in the data bank facility, which is required for model evaluation by the Numerical Modeling Section, can also take place over the ARPA Net.

#### 2.5.2 The ARPA Net

The ARPA Net is a nationwide network of computers connected so that any program available to a user at one location is also available at any other remote location which is connected into the net. Thus, a user may access any computer in the net and execute a program on that computer as if it were at the user's own location.

This concept is not restricted to program usage. Data files may be transferred between locations over the net. Thus, a user at Location A can access the computer at Location B to execute a program using data stored in a computer at Location C. The results/output of

the program are then transmitted back to the user at Location A.

#### 2.5.2.1 Network Facilities

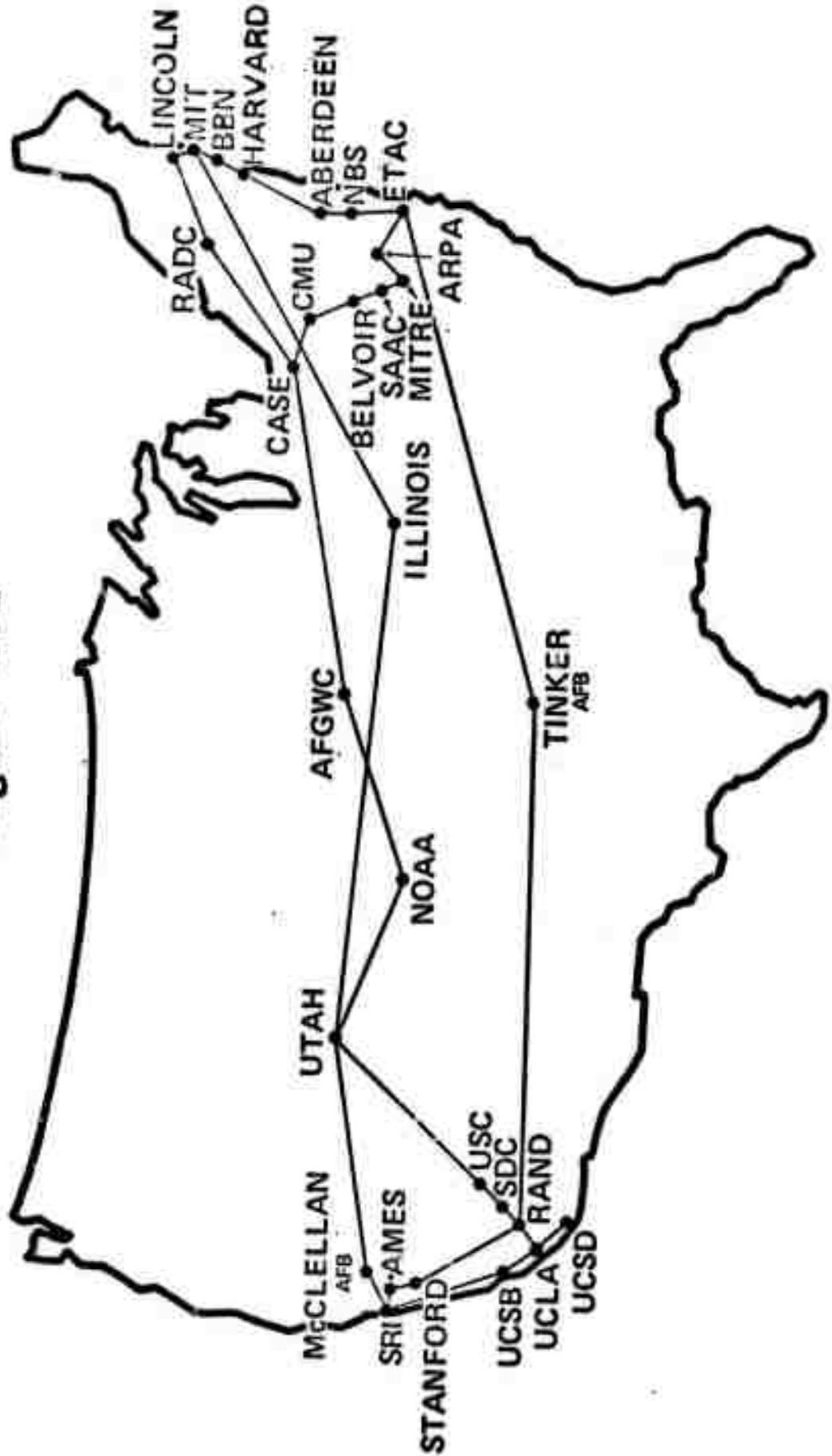
At present, there are 29 operational facilities connected to the net. Seven of these facilities intend to offer computing services to the other users. These are:

1. Massachusetts Institute of Technology -  
Honeywell 645
2. Stanford Research Institute - PDP-10
3. University of California at Los Angeles -  
IBM 360/91
4. University of California at Santa Barbara -  
IBM 360/75
5. Bolt Beranek and Newman - PDP-10
6. Lincoln Laboratories - IBM 360/67
7. Ames Air Force Base - ILLIAC IV

Figure 2.1 indicates the present configuration of the ARPA Network.

Of all these facilities, the ILLIAC IV promises to be the most useful for the purposes of the Environmental Impact Prediction Facility. First, the ILLIAC IV has been specially designed for processing large matrices/arrays of data such as those found in meteorology, oceanography, etc. Secondly, the ILLIAC IV will eventually contain a one trillion bit mass storage capability using laser techniques. Eventually, this storage capability will serve as both storage for programs being

# THE ARPA NETWORK August 1972



executed on the ILLIAC IV as well as an archive storage for the users of the ARPA Net. This tremendous storage capability now brings into the realm of possibility the execution of complex models for wide area oceanographic, atmospheric, or other natural phenomena heretofore rendered impossible by existing limitations on computer size and speed.

#### 2.5.2.2 Network Interconnection

To provide the reliable data link needed for computer-to-computer communication, a store-and-forward concept was implemented. The data communication process is handled by a number of devices called Interface Message Processors (IMP). Each of the network computers, termed a HOST, is connected directly to an IMP located at the HOST's site. Each IMP is connected to two or more IMPs through 50 kilo bit/second dedicated leased lines. To transmit a message from one HOST to another, the HOST sends its message to its IMP. The IMP then breaks the message into smaller pieces termed packets.

Each packet is transmitted through the network from IMP to IMP along the path that is the least busy. Then, the packets are re-assembled at the destination IMP and presented to the destination HOST as a complete message. In this manner, operation of the communications net is basically invisible to the HOST computers. Conversely, any IMP can function independently of its HOST, thereby rendering the communications net immune to a HOST computer's inoperability.

Furthermore, by requiring each IMP to be connected to two or more IMPs, the failing of one IMP does not seriously impair the functioning of the NET as the redundancy provides at least two separate paths between every pair of IMPs.

In addition to the IMP, there exists a device called a Terminal Interface Processor (TIP). Up to 64 terminals and various I/O equipment can be connected to the TIP. A TIP is used in those locations that do not have a HOST computer.

#### 2.5.2.3 Network Utilization

Of prime importance in any computer system is the ability of the software to facilitate the utilization of that system. In the case of the ARPA Net, such utilization implies software development which can facilitate the sharing of computer systems and the transfer of data and commands throughout the network. The ultimate goal is to make the net seem invisible to the user.

The software developed to date for the ARPA Net is reflected in the generation of a number of protocols; i. e., a set of specified rules or commands which computers and/or programmers must utilize when conversing with each other. The highest level protocol under development is the TELNET which allows users to directly access any of the HOST serving computers in the net. Such connection is first preceded by use of an ICP (Initial Connection Protocol) which establishes

a connection with the desired HOST computers. In addition, two other high level protocols exist. These are the Data Transfer Protocol and File Transfer Protocol, and they allow the transfer of structured data and/or programs between HOST computers.

### 2.5.3 Data Management Section Configuration

The Data Management Section comprises three basic areas: a centralized data collection and evaluation group; a data bank; and the data transmission facilities required for remote monitoring. By utilizing the ARPA Net for data transmission and interactive processing, these three areas may be conveniently tied together into a cohesive system.

#### 2.5.3.1 Data Collection Group

Centrally located with the other sections of the Environmental Impact Prediction Facility, the Data Collection Group will coordinate efforts of procurement of pollution data from all sources including:

1. Data from DoD facilities and activities.
2. Data from non-DoD facilities (NOAA, EPA) which reflect DoD's impact.

The collection of data from non-DoD agencies will be linked to these facilities by a high speed reliable data transmission network. Indeed, NOAA is already linked to the ARPA Net. The collection of

data from DoD facilities will also use the ARPA Net as the reliable high speed data link for long distance transmission to the Data Collection Group. Since a large number of DoD facilities will be monitored, each facility will not be an additional node in the ARPA Net. A number of such facilities will be concentrated, possibly by geographic location, and controlled by a single HOST in the ARPA Net. Discussion of this configuration is presented in Section 2.5.4.

#### 2.5.3.2 Data Evaluation Group

For this facility to be of any use to DoD, an accurate evaluation of the monitored data must be made to determine if:

1. Pollutant levels are within the existing standards for the locality of the DoD site being monitored.
2. Predicted pollutant levels for planned facilities or activities will fall within existing standards for the locality.

In Item 1, the direct monitoring of pollutants, whenever possible, yields straightforward comparison with allowable levels for the locality. However, when direct monitoring is not possible (air pollution near jet-ports) or when more than one source may be contributing (airplanes and automobiles) to the overall pollution level, a more complex approach is required to determine the amount of the pollutant which is contributed by the DoD facility.

For a given pollutant being emitted into a medium (e. g. , the atmosphere), a model representing the dynamics of the medium for the region of interest can be devised. Based on actual monitored values of the medium, the dispersion of the pollutant can be determined and its value at any given point, space or time, calculated.

As an example, consider gaseous emissions due to aircraft at a jetport. A model of the atmospheric dynamics in the surrounding region can be evaluated by using monitored parameters of the locality, e. g. , local terrain configuration, wind velocity and direction, temperature, humidity, local dispersion/diffusion characteristics, etc. Based on the characteristic properties of the pollutants, the quantity which is emitted per aircraft, the number of planes taking off and landing in a given time period, and the atmospheric parameters which are pertinent to the jetport, the resultant pollution levels at the jetport can be determined for any point on the ground and a pollution contour map calculated and plotted.

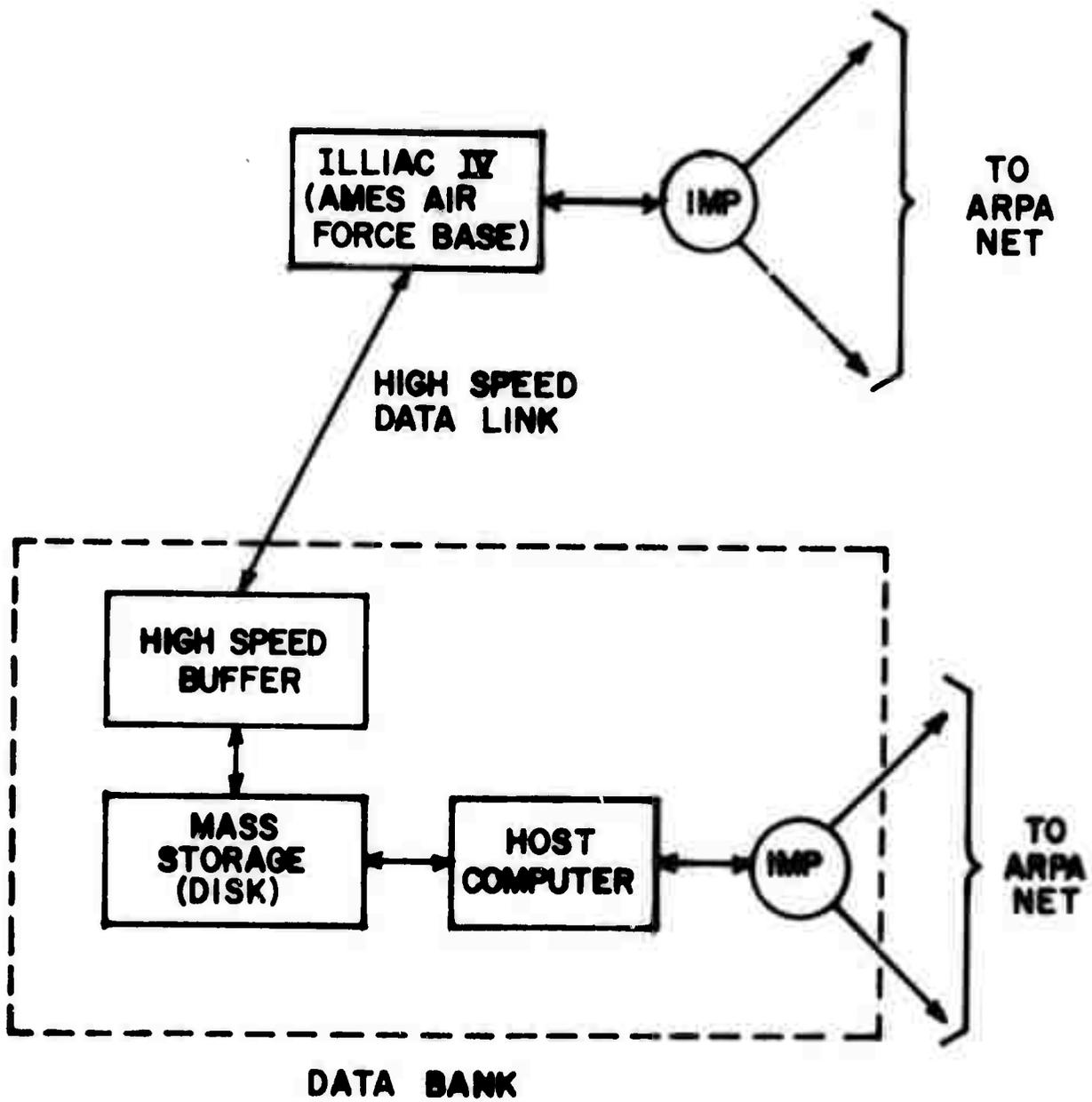
The same procedure can also be used to predict pollution levels for planned or future facilities or DoD activities. The expected environmental impact would then be based on evaluation of a model which uses data from a similar activity or facility. Thus, with a constant update of data from following operations, the numerical model for the facility/ activity can be improved so that, with each succeeding action, the numerical model's prediction is more accurate and thus can more readily predict the total environmental impact.

### 2.5.3.3 The Data Bank

Of utmost importance in evaluating the environmental impact of various activities is the accurate modeling of the processes involved and the resultant predictive capability which is obtained from the numerical model. The accuracy of these models is due, in small part, to the goodness of the data used in verifying the model's behavior.

Thus, all sections in the Environmental Impact Prediction Facility will evaluate the data for accuracy, will assist in formatting and analyzing the data for use in programming, and will submit the data to the data bank for use in the modeling effort.

The size, speed and location of the data bank are dependent on the modeling processes to be undertaken. For modeling of entire ocean basins or global atmospheric models, a large computing complex is required. The ILLIAC IV has been designed just for such applications. Eventually, the ILLIAC IV is to have a one trillion bit mass storage capability. A small portion of this capacity could probably serve as the data bank required for the Environmental Impact Prediction Facility. In the interim period, a mass storage device using discs and associated high speed magnetic core or solid state buffers could serve. This storage device, see Fig. 2.2, is tied directly through high data rate leased lines to the ILLIAC IV processor. In addition, a conventional computer system, acting as a HOST, is connected to the ARPA Net. This serves as the intermediary between the mass storage facility and the ARPA Net.



**FIG. 2.2 DATA BANK CONFIGURATION**

Control of the linked operation between the mass storage facility and the ILLIAC IV can also be handled by this HOST.

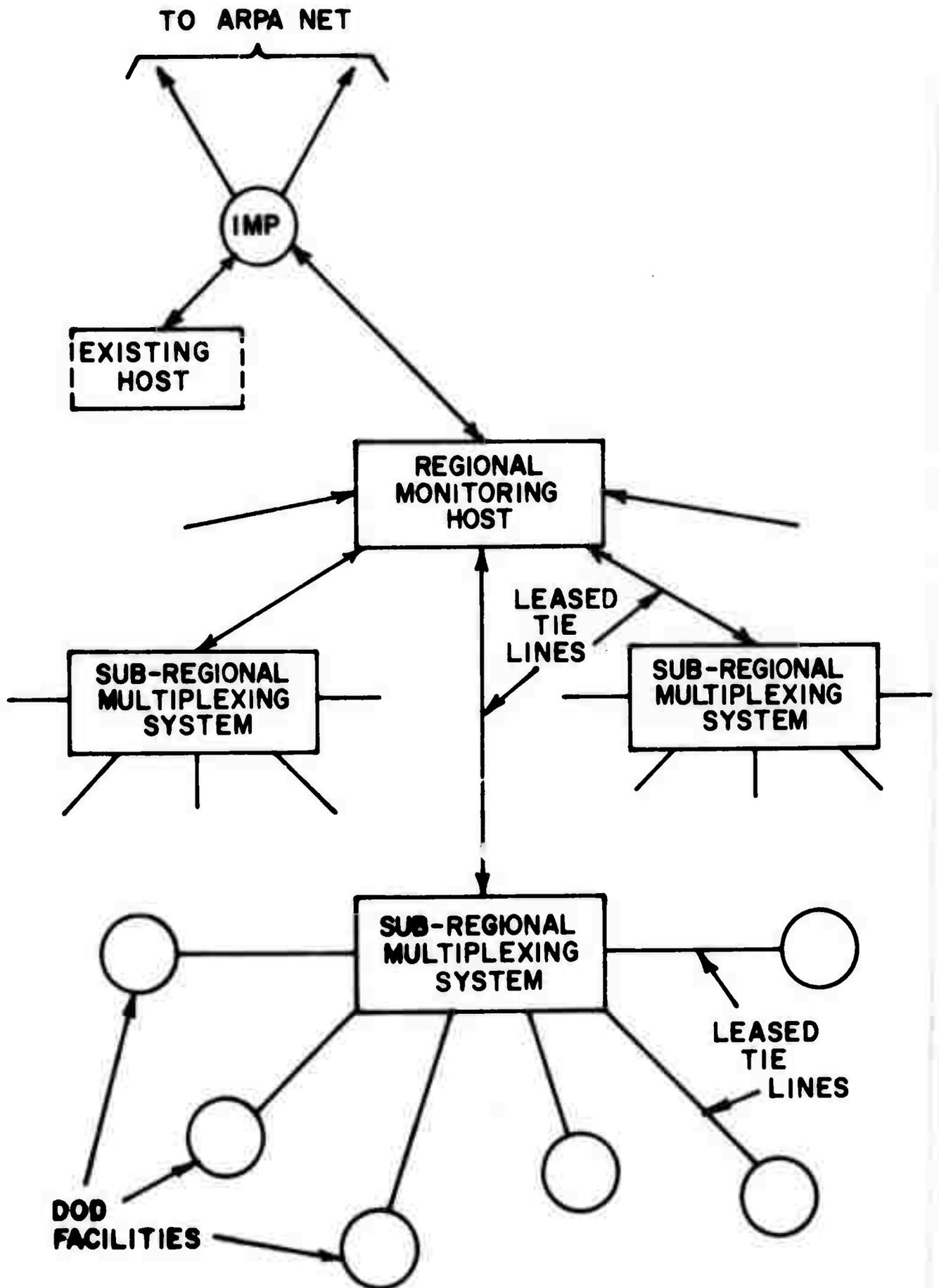
Clearly, three modes of operation are possible.

1. The ILLIAC IV utilizes the mass storage for large scale modeling efforts.
2. New data for the mass storage are sent along the ARPA Net to the HOST in the data bank and then to the mass storage.
3. Data in the mass storage facility can be accessed anywhere in the ARPA Net through the HOST. Thus environmental problems which can be handled by other computers in the ARPA Net can use data stored in the mass storage facility.

The software for implementing Items 2 and 3 for the ARPA Net already exists in the form of the Data Transfer Protocol.

#### 2.5.3.4 Remote Monitored Facilities

Assuming that a large number of DoD facilities will be monitored, these facilities must be serviced by the ARPA Net without substantially increasing the number of nodes. The low sampling rate required for most pollution sensors implies that a large number of sensors can be concentrated into one high speed data link. Therefore, a typical concentration scheme is shown in Fig. 2.3.



**FIG. 2.3 THE REGIONAL MONITORING NETWORK**

Referring to Fig. 2.3, for a given regional area (e.g., Northeast, Middle Atlantic), a special purpose computer is connected to the ARPA Net as a HOST through an existing IMP, if possible\*, or by adding an additional node to the net. This computer, termed a Regional Monitoring HOST, serves as a temporary data storage area and data concentrator. The data inputs to the Regional Monitoring Host are leased tie lines emanating from subregions within the region being serviced. At a central location within this subregion, the tie line branches out at a multiplexing station to a number of short leased tie lines. These are connected to all the DoD facilities being monitored within the subregion.

The actual configuration is dependent on a number of parameters including the number and type of sensors being deployed, sampling rates required, area distribution and total number of DoD facilities being monitored within a given geographical configuration, etc. Clearly, a study would be required to determine the optimum configuration in terms of reliability and cost.

A standard mode of operation of the Remote Monitoring Network would be to periodically sample the sensors at all facilities at predetermined sampling rates consistent with the process being monitored. The Regional Monitoring HOST can act as the main control in this mode by

---

\* Existing IMP designs can handle up to four HOST computers.

selecting the appropriate facility and sensor, when required, and transferring the data to their own storage area. The schedule listing all facilities and sensors along with associated sampling rates or times would be stored in this HOST. The HOST notifies the Data Collection Group when a block of data has been compiled and is ready for transfer. The data are then transferred over the ARPA Net using the standard Data Transfer Protocol.

Another mode of operation would be a more intensive monitoring of selected facilities or sensors. Thus, the Data Collection Group specifies the desired facility or facilities, the sensors to be monitored, the sampling time, rate and total sampling interval required. These parameters are sent as commands via the ARPA Net to the Regional Monitoring HOST in command of the facility or facilities in question. This HOST then assembles the data as requested. The data can be retransmitted either as they become available or at the end of the specified sampling interval.

The Remote Monitoring Network can also be extended to include temporary monitoring of facilities or regions. By configuring the multiplexing system to include additional channels, the facility to be monitored can be connected to an unused channel of the nearest multiplexing system. The facility would then be monitored through commands from the Data Collection Group.

## 2.6 Environmental Impact Prediction Example - High Flying Aircraft

The possibility of environmental modification resulting from the long-term operation of fleets of high-flying aircraft has been a subject of wide interest.<sup>1,2,3</sup> However, we are not yet able to assess in detail what consequences, if any, to the environment might accompany such operations. While many programs are now underway to study this question, considerable additional effort will eventually be required to settle the issues definitively. This effort must include instrumentation, data collection and numerical models of atmospheric photochemistry, radiation and dynamics.

### 2.6.1 Introduction

The regions of the atmosphere in which most high-flying jet aircraft, both conventional and supersonic, cruise are the upper troposphere and the stratosphere. The troposphere,<sup>4</sup> which is the region of the atmosphere that reaches to an altitude of about 11 km in the polar regions and about 15 km in the tropics, is characterized by a relatively high concentration of water vapor. This region exhibits a rapidly decreasing temperature profile with altitude. This temperature profile is primarily the result of the solar heating of the earth's surface combined with the infrared radiation cooling of the upper and middle layers of the troposphere. The heating of the troposphere from below often creates a buoyant instability which enhances vertical mixing processes.

This is the region of the atmosphere in which most of our weather occurs. The stratosphere, which is the region of the atmosphere directly above the troposphere (the transition zone from troposphere to stratosphere being called the tropopause), is characterized by a relatively low water vapor concentration but exhibits a high ozone concentration.<sup>5</sup> Ozone which absorbs radiation in the ultra-violet part of the solar spectrum is primarily responsible for producing a vertical temperature profile that increases with altitude. Thus, the stratosphere is a region of stable density stratification and therefore, mixing processes are much slower than in the troposphere. This, combined with the absence of any precipitation processes to cleanse the air, means that any trace substances introduced into the stratosphere will remain there for a much longer time than in the troposphere. The residence time of a trace gas or aerosol introduced just above the tropopause varies from about six months at high latitudes to a year at low latitudes; and at 20 to 30 km the residence time is two to three years, increasing to about five years at 50 km.<sup>6,7</sup> Thus, a contamination of the stratosphere will be more long lasting than a corresponding contamination of the troposphere where effective removal processes are constantly at work. There are two important cases to consider: contamination by large volcanic eruptions, and contamination by high-flying jet aircraft. The first is a well-recognized natural phenomenon that has occurred many times, while the latter is now only a source of possible concern.

Another important consequence of the presence of ozone in the atmosphere is its ability to absorb a significant portion of the ultraviolet part of the incoming solar spectrum, since radiation at these frequencies has a significant effect on biological processes.<sup>8</sup> The concentration of ozone depends in a complex way on photochemical reactions among various atmospheric constituents such as O<sub>2</sub>, H<sub>2</sub>O, NO<sub>x</sub>, etc.<sup>9</sup> Since exhaust emissions from high-flying aircraft include some of these gases, it is essential that the photochemical and transport processes that determine the distribution of ozone be better understood.

Another widely debated consequence of atmospheric contamination by high-flying aircraft is the possibility of inadvertent modification to the climate. The climate of the earth is ultimately determined by the radiation balance of the earth-atmosphere system (by which we mean the atmosphere and underlying surface taken together).<sup>10</sup> This balance is between the incoming solar radiation and the outgoing terrestrial infrared radiation fluxes. These fluxes depend upon the optical properties of the atmosphere - which are related to the distribution of optically active gases (e.g., carbon dioxide, water vapor and ozone), suspended atmospheric dust particles, and clouds.

Clouds are extremely important factors in the earth's radiation balance, because they both reflect a large percentage of the incoming solar flux and also because they are efficient absorbers of terrestrial infrared radiation. Thus, a change in the long-term amount of cloud cover could have a significant effect on climate.<sup>11</sup> Observations of

cirrus cloud cover over certain American cities indicate that there may be a connection between the amount of cirrus clouds and the density of jet aircraft traffic.<sup>12</sup> However, the effect of changes in cirrus cloudiness on the surface temperature has not been predicted unambiguously with existing radiation models.

Atmospheric dust particles (or aerosols) can also affect the transfer of both solar and infrared radiation, and increases in atmospheric aerosols may have consequences on the surface temperature.<sup>13</sup>

The effect of increases in stratospheric dust loadings on the stratospheric heating rates and temperatures are suggested from our experience on the effect of volcanic dust injected into the stratosphere. However, modeling studies are still uncertain as to the magnitude and even in some cases, the sign of possible effects of increases in particle loading on radiative heating rates.<sup>14</sup>

Since exhaust emission from jet aircraft could involve changes in the levels of atmospheric water vapor, particle loading and cloudiness (particularly high cirrus clouds), it is again essential that the effects of changes in these constituents on the climate be well understood.

#### 2.6.2 Procedure of Impact Assessment

In order to ascertain the possible impact of high-flying jet aircraft on the environment, as outlined in the Introduction, we must first evaluate the projected exhaust emissions from various types of aircraft, based on estimates of fleet size, flight frequency and domain,

and emission levels for each class of aircraft. Then, the magnitude of projected injections of exhaust products (or changes in other constituents that interact with these products) must be compared with natural background levels of the relevant atmospheric constituents, on detailed spatial and temporal scales. The residence times and transport and removal processes for various contaminants must then be evaluated, so that numerical modeling studies of the possible effects of these contaminants can be made. These studies should include photochemical, radiative, and dynamical simulations.

### 2.6.3 Effects (known and unknown) of Some Individual Contaminants

In this section, we will summarize briefly what the effects of some of the individual contaminants might be on the composition, distribution, and optical properties of the atmosphere. More details on these effects can be found in references 1, 2, and 3.

The presence of water vapor has a direct effect on the radiation balance and also on the formation of clouds. Additional effects through stratospheric photochemistry involving the distribution and concentration of ozone are possible.

Oxides of nitrogen apparently have a negligible direct radiation effect, but their effect on ozone photochemistry is currently a subject of much controversy. An important indirect effect would be the conversion of these gases to particles in the form of nitrate salts which could

alter the optical properties of the atmosphere.

The addition of sulphur dioxide gas appears to have no significant direct radiation effect. However, the particle effect could be significant from photochemical conversion to sulphate particles.

Particle injection in the form of photochemically converted particles from unburned hydrocarbons and direct soot particle injections may affect the radiation field, and can also indirectly affect it through changes in cloudiness. This is because particles act as condensation nuclei or ice nuclei upon which cloud droplets or ice crystals are formed.

Additional carbon dioxide injected into the atmosphere from jet aircraft would have a direct radiative effect, but this is probably not significant since the concentrations appear to be small in comparison to the natural flux of CO<sub>2</sub> into the stratosphere through the tropopause.

#### 2.6.4 Research Programs

In order to implement the procedure outlined in Section 2.6.2, a large research effort is required. First, a detailed description of the exhaust emissions of each type of aircraft must be compiled, so that future projections of contaminant injections can be made.

Then, an in situ monitoring program should be implemented, to determine the natural background concentrations of constituents listed in the preceding section, with adequate spatial and time resolution. At the same time, monitoring of radiation fluxes, the optical properties of certain constituents, and atmospheric motions should be conducted to:

- a. improve our understanding of the relationships between the radiation energy input and atmospheric motions
- b. improve our knowledge of stratospheric transport processes
- c. determine if any long-term trends in atmospheric radiation or dynamics will accompany any observed long-term trends in the concentration of atmospheric constituents related to high-flying aircraft.

A program of laboratory measurements concomitant with the in situ atmospheric monitoring effort should also be pursued. The reaction rate coefficients for various chemical constituents involved in the processes of photochemical production or destruction of ozone are often poorly defined, or even unknown. In addition, the radiation absorption cross sections for ozone and related stratospheric constituents may need additional laboratory measurements to improve the reliability of the presently assumed values. Also, laboratory determination of the optical properties (i. e. , complex index of refraction and size distribution) of both dust particles and ice crystals in cirrus clouds would be useful to modeling studies.

The fourth area of basic research needed to assess the impact of high-flying aircraft on the environment is the computation of these possible effects by numerical models. First, a coupled set of chemical equations must be solved to simulate the photochemical processes in the stratospheric production of ozone. This photochemical model must then be coupled to a dynamical model of the atmosphere, to include the

important effects of atmospheric diffusion and transport processes on the distribution of ozone. The dynamical model will need realistic values of eddy diffusion coefficients in order to simulate the transport processes correctly. Such a combined model should first be able to predict the currently observed distribution of ozone. If this is possible, the combined model can subsequently be used to study the effects of the injection of various contaminants on the amount of ozone. Then a radiation model that determines the detailed effect of ozone on the transmission of ultraviolet radiation can be used to determine the effect of various contaminants on the ultraviolet radiation reaching the biosphere.

To study the possible climatic impact of high-flying aircraft, the effect of contaminant injections on the radiation fluxes, both solar and infrared must be computed. This effort should include calculations of both the direct effect of changes in CO<sub>2</sub>, water vapor, cloudiness and aerosols on the radiation field, as well as the possible indirect effects of particle contaminants on the cloud-forming microphysical processes per se. Modified radiative-convective models of the earth-atmosphere system can be used initially for such a study, where data on the optical properties of the radiation scatterers and absorbers should be taken from the latest available measurements. Finally, the effect of any possible changes to the radiation fields will have to be coupled to a large scale dynamical model of the atmosphere to determine what the ultimate effect, if any, on climate from the injection of exhaust emission products might be.

#### 2.6.5 Proposed Effort for the High-Flying Aircraft Impact Program

Various aspects of the research program outlined above are under way by many groups throughout the world. For example, since the development time for large scale dynamical models of the general circulation of the atmosphere is large, those groups already possessing such modeling capability are the logical places to develop the coupled photochemical-dynamical simulation of ozone production. However, there are still many important unanswered questions about the possible effects of increases in atmospheric dust or cirrus cloudiness on the temperature of the stratosphere and the temperature near the earth's surface that can be studied at smaller installations. These questions should be studied by using a radiative-convective model of the earth-atmosphere system to determine how increases in aerosols or cirrus cloudiness might affect the atmospheric heating rates. While some work has been done in the past in this regard,<sup>11,13</sup> these models were based upon global averages and assumed values of optical properties of aerosols and cirrus clouds. Thus, their results might not be applicable (1) for the mid-latitude regions where the bulk of high-flying jet aircraft operate, and (2) because the observational and experimental data for the optical properties of cirrus clouds and aerosols are being updated at this time. An existing radiative-convective model could be modified to study the effects on the atmospheric heating rates of increases in cirrus cloudiness and atmospheric aerosols as a function of geographic position

and season as well as for global averaging. This model should utilize the latest available data for the optical properties of cirrus clouds and stratospheric aerosols, and at the very least try to show what the effect on the atmospheric radiation fluxes from increases in cirrus clouds and stratospheric aerosols would be, for the range of uncertainty inherent in current observations of the value of the optical properties of these constituents. This sort of calculation can then be easily incorporated in a general circulation model to eventually assess the impact of possible changes in cirrus cloudiness or stratospheric aerosols on the earth's climate.

### 2.6.6 References

1. Study of Critical Environmental Problems (SCEP), 1970. Man's Impact on the Global Environment (M.I. T. Press, Cambridge, Mass.)
2. Study of Man's Impact on Climate (SMIC), 1971. Inadvertent Climate Modification (M.I. T. Press, Cambridge, Mass.)
3. International Conference on Aerospace and Aeronautical Meteorology, May 22-26, 1972, Washington, D. C.
4. Goody, R. M., 1964. Atmospheric Radiation (Oxford University Press, London).
5. Craig, R., 1965. "The Upper Atmosphere", Meteorology and Physics (Academic Press, New York and London).
6. Martell, E. A., 1971. Residence times and other factors influencing pollution of the upper atmosphere, Chapt. 35 in Man's Impact on the Climate, edited by W. H. Matthews, W. W. Kellogg, and G. D. Robinson (M.I. T. Press, Cambridge, Mass.)
7. Junge, C. E., 1971. The nature and residence times of tropospheric aerosols, Chapt. 23 in Man's Impact on the Climate, edited by W. H. Matthews, W. W. Kellogg, and G. D. Robinson (M.I. T. Press, Cambridge, Mass.)
8. Urbach, F., 1969. Geographic pathology of skin cancer, The Biological Effects of Ultraviolet Radiation (Oxford: Pergamon Press), pp. 635-661.
9. Chapter 9 of SMIC.
10. Sellers, W. D. 1965. Physical Climatology (The University of Chicago Press, Chicago and London).
11. Manabe, S., and Wetherald, R. T., 1967. Thermal equilibrium of the atmosphere with a given distribution of relative humidity, Journal of Atmospheric Sciences, 24, pp. 241-259.
12. Machta, L., and Carpenter, T., 1971. Trends in high cloudiness at Denver and Salt Lake City, Man's Impact on the Climate, edited by W. H. Matthews, W. W. Kellogg, and G. D. Robinson (Cambridge, Mass., The M.I. T. Press), pp. 410-415.

### References (cont)

13. Rasool, S.I. and Schneider, S.H. Science, 173, pp. 138-141 (1971).
14. Chapter 8 of SMIC.

### 3.0 Model Base/Energy Resources

#### 3.1 Introduction

A useful microcosm in which community energy supply and pollution control may be studied is the military base. The advantage is that, in addition to being a relatively isolated community, directives issued by the base commander regarding use of power resources will be obeyed. In such a situation it will be possible to specify optimum conditions for power use and pollution control.

The following assumptions are made concerning the model base:

1. The total personnel complement is approximately 1000 men.
2. The model base has its own power generating plant, waste disposal plant, and sewage disposal plant.
3. The fresh water for the model base is supplied from the nearest municipal facility.
4. All food supplies are delivered to the base.
5. The model base is geographically located near a river or other source of water for use in cooling of the power generator.
6. The base consists of administration buildings and private residences for the personnel.

Considerations of power usage and pollution control have been classified into four areas:

1. the power generator
2. the construction of buildings and the use of appliances
3. waste disposal and sewage disposal
4. transportation.

Each of these four areas is discussed.

### 3.2 Electrical Generating Power Plant

The electrical power necessary to supply the model base will be provided by a generating plant located on the base. Two different types of power plants will be considered: fossil fuel and nuclear reactors.

Fossil fuels are coal, oil, and natural gas. The cleanest fuel, from the standpoint of pollution, is natural gas. The reserves of natural gas, however, have been dwindling at an alarming rate in the U.S. Since 1968 (aside from the Alaskan discoveries), the U.S. has been using natural gas twice as fast as it has been finding it. In many parts of the country gas companies are forcing some industrial users to shift back to oil when home heating demand is high.<sup>1</sup>

Coal and oil deposits, like those of natural gas, are becoming increasingly difficult to locate. The demand for oil in the U.S. is such that ten billion barrels of proved reserves at Prudhoe Bay in Alaska

represent only two years consumption.<sup>1</sup> In addition, the combustion of fossil fuels releases relatively large amounts of carbon dioxide into the atmosphere. Carbon dioxide buildup could conceivably raise the atmospheric temperature through the greenhouse effect - the trapping of part of the sun's radiation that would otherwise be reflected to outer space.

Sulphur dioxide is also released in the combustion of coal. Buildup of sulphur dioxide in a concentration as low as 0.11 parts per million can cause damage to the health of the exposed population after three or four days.<sup>2</sup> Sulphur can be removed from gas and oil prior to burning, but methods of refining coal are still in the development stage. The problem of the removal of sulphur dioxide from stack emissions (after burning) has not, as yet, been solved. Thus, while coal deposits are more plentiful in the U.S. than are oil and natural gas deposits, many utilities have switched from coal to low sulphur oil in an effort to meet the requirements of the Federal Environmental Protection Agency set for 1975. Such use of petroleum aggravates the energy-resource problem.

A solution to the sulphur problem may be to convert coal to clean-burning sulphur-free gas. Assuming that methods are found to convert coal to "clean" gas, electric utilities have calculated that it would not pay to transport the gas over long distances. The coal could be transported by train and converted to gas at the generating plant itself. Emissions of fly ash and other particulate matter could be

reduced by as much as 99% by the use of electrostatic precipitators. However, these control devices are costly. In addition, the use of these devices consumes more than 5% of the generating capacity<sup>3</sup> and the cost of the power generation is proportionally higher.

Present day fossil-fuel plants function in the range of 40 - 45% efficiency.<sup>4</sup> Most fossil-fuel utilities make use of simple gas-turbine generators, which have relatively low thermal efficiencies. A combined cycle gas and steam generator is in the process of development and offers great promise for obtaining more electricity from fossil fuel. In view of the expected shortages of natural gas and petroleum, the most effective fossil-fuel generator may be one in which coal is converted to low-sulphur gas, and the gas used in a combined cycle gas and steam generator.

### 3.3 Nuclear Generators

Present-day nuclear reactors operate at a thermal efficiency between 20 and 34%.<sup>4</sup> Conventional reactors operate at a lower thermal efficiency than fossil-fuel generating plants and create about 50% more waste heat for every kilowatt hour produced. Thus, thermal pollution is a major problem in nuclear reactors. Large amounts of cooling water are required for use in nuclear reactors. For example, the temperature rise from a 500-MW nuclear plant in a river whose flow rate is 1000 ft<sup>3</sup> per second can be 8 to 10<sup>o</sup> C.<sup>4</sup> According to some marine biologists and ecologists, because of the reduced oxygen content of the heated water,

beneficial indigenous marine life can be killed or driven away from a river habitat. In the U.S. today, 30 states have temperature standards and the utility companies are attempting to meet the requirements by using cooling ponds and cooling towers. From the standpoint of overall efficiency, it is possible that the very high water temperatures generated in the nuclear reactors could be used to heat houses or buildings in close proximity to the power plant.

Of all the advanced sources of power, the fast breeder reactor is closest to realization. The fast breeder converts the U-238 isotope, which makes up 99.3% of uranium, into fissionable plutonium. Whereas the ordinary reactor produces less of this new fuel than it consumes, the fast breeder produces more. Development of the fast breeder reactor is proceeding rapidly in the U.S. under the auspices of the Atomic Energy Commission (AEC) and the electric utility industry. The type of breeder chosen by the AEC uses liquid sodium as a coolant to transfer heat from the reactor core to a steam-producing boiler. Since hot liquid sodium reacts violently on contact with air or water, it needs to be completely shielded with metal as an inert gas.

About 2% of the breeder reactor's waste, by weight, will consist of plutonium, a radioactive material with a half-life of 24,000 years. At present, the only safe method of containing the waste material is to store it in concrete vaults.

There has been great disagreement among the experts on the dangers of radioactive wastes to the environment. A respectable portion of scientific thought and opinion believes that radioactive waste is so potentially hazardous that there should be a moratorium on the construction of all nuclear fission generating plants, unless they are built underground with all the necessary operational precautions.

### 3.4 Proposed Future Energy Sources

At present, there are several energy sources still in the development stage and these are discussed in the following sections. All of these sources produce no environmental pollution and are therefore attractive alternatives to the power generators which are presently operational. The proposed sources make use of the energy which is potentially available in natural phenomena - e.g., the steady westerly winds that sweep over the Atlantic Ocean, solar radiation, and tides.

#### 3.4.1 Tidal Energy

In recent years there has been a resurgence of interest in tidal energy. Tidal energy is the cleanest energy of all and its production uses no land. There have been many ideas proposed for the harnessing of tidal energy.<sup>5</sup>

Recent studies of possible tidal schemes have led to the conclusion that the most economical energy will come from single-effect schemes. This is a scheme where the high tide waters fill up a basin

through large sluice gates and the turbine water passages. The water is retained at its highest level until the sea level beyond the barrier dam has fallen to around mean sea level. The water is then released and the generation of electrical power begins as the outrushing water churns the giant water wheels that activate electricity-generating turbines.

A tidal power plant generates energy for periods of limited duration and, naturally, at times related to the tides. This does not occur at the same time each day. The amount of energy per tide varies with the cyclic variation of tidal range between springs and neaps. In order to meet the demand for power, it is generally necessary to retime delivery of the major part of the tidal energy by some form of energy storage. One retiming facility presently being considered is an underground compressed air storage system for subsequent gas turbine generation.

There are differences of opinion as to when tidal power plants will be both operational and practical. Some scientists predict that tidal power generators will not be practical before the next century.<sup>6</sup> A pilot plant tidal power generator was built in Russia in 1968 in the Kislayaguba Inlet in the White Sea. In La Rance in 1966, the French constructed a pilot plant which is no longer operated as a power producer, but as an energy producer.

Despite difficulties and expenses, the potential advantages of tidal power generation warrant the large amount of research and development which is currently being conducted.

### 3.4.2 Wind Power

Proposals to harness the winds envision huge windmills located 10 or more miles off the coast of New England and New York.<sup>6</sup> The windmills would be fixed atop 150-foot steel towers rising from stationary floating platforms or anchored directly to the seabed of the continental shelf. The windmills, propelled by steady westerly winds that sweep over the Atlantic Ocean, would produce electricity that is used to convert ocean water into hydrogen. The hydrogen would be shipped ashore where it would be in fuel with readily available oxygen in a manner that produces electricity. Fresh water is a byproduct of the reaction. Proposal estimates are that the wind power generator would produce enough electricity to supply all of New England and New York.

### 3.4.3 Solar Farms

Proposals have been made for generating electricity on vast solar "farms" that would be located in unpopulated desert regions. The farms consist of thousands of acres of arid land covered with an array of hollow tubes which is coated with a special chemical film and filled with a heat exchange fluid. The tubes absorb the sun's radiation and retain most of it; the heat exchange fluid converts the radiation to heat which is used to produce electricity-generating steam.

Some work has been done on solar power plants; the National Science Foundation has awarded nearly half a million dollars for work

on a process that could achieve a conversion efficiency of 20%.<sup>7</sup>

One serious drawback is that solar power would require vast amounts of land. Even at 20% efficiency, solar farms capable of supplying the nation's current electrical needs would consume 6,000 square miles.

It is believed that a solar power plant pilot facility could be built before 1980.<sup>8</sup>

### 3.5 House and Building Construction

One of the great drains on the electrical power supply in any complex, even a base, is created by the use of air conditioners. The modern thin-walled glass and steel construction, which is so prevalent, has increased the demand for electrical power in order to pump out the sun's heat during the summer months. Conversely, in the winter, the amount of fuel consumption for heating has increased due to the fact that the modern buildings exchange heat readily with their surroundings.

Buildings which have thicker walls, proper insulation, and a reflecting top surface, use less power, both for heating and air conditioning. In addition, a saving of fuel might be effected, as mentioned in the section on power generation, by using the cooling water of power plants to heat homes. It is also possible that conversion of solar energy to electricity or conservation of solar heat might provide extra power for heating and air conditioning, thereby lowering the demand on the power generator.

Electrical power used in home appliances, such as refrigerators, might be reduced by more efficient design. In addition, a study of different types of air conditioning systems might indicate a more efficient method than the present cold air system. Heat exhausted from air conditioning might supply hot water instead of heating up the atmosphere.<sup>9</sup> Considering the expected limitations on the availability of power, the study of methods to use power more efficiently is quite important in the design of any future complex.

### 3.6 Waste Disposal

The problems caused by the generation of solid wastes are quite formidable. The complexity and cost of collecting these materials contributes to the difficulties. Two thirds of the cost of solid waste handling and disposal is incurred in the first fifty feet, or in the period of time from pickup to transfer in the collection vehicle.<sup>10</sup>

The composition of home refuse has changed in the last decade. There are less ashes and garbage, and more plastic and paper. Volume, rather than weight is becoming critical. Solutions to the waste problems must be considered either on the basis of volume reduction (elimination of void space) and/or rapid turnover - i. e., reuse of these materials from a salvage standpoint. Any system which is used to reclaim or reduce volume must be capable of handling an array of materials ranging from metals to garbage, to plastic and glass, etc.

For personnel on the model base, it will be possible to demand separation of types of waste material before the waste is collected. There are systems currently being investigated which involve coarse dry grinding of the total mass of solid wastes followed by air classification of the various material components. This method separates plastics from paper and metal from both paper and plastic.<sup>11</sup> Researchers at the University of Chicago are considering a process which involves coarse grinding and the ultimate incineration of the material in a fluid state. Incinerating at temperatures of 2200° F, a molten slag is produced which, when quenched in water, can be used to produce a glass-type material. The material can be turned into marketable items (fiberglass, highway aggregate, etc.). Another process, which has progressed to the pilot plant stage, is one in which dry grinding is followed by a liquid classification process, in which centrifugal force is used to segregate materials into various density classifications.

Wet grinding, or pulping of the solid wastes, is currently being investigated and has many attractive features. Metals can be recovered in a relatively pure state as well as glass and paper fibers. It has been estimated that the value of the metal recovered, and the glass and paper pulp, should make the process self-sustaining.<sup>11</sup>

### 3.7 A Combined Waste Removal and Supplementary Power Generation Process

A system for the recovery of thermal energy by burning shredded residential solid waste as supplementary fuel in boiler furnaces was initiated in 1970 under the auspices of the U.S. Environmental Protection Agency, the Office of Air Programs, the city of St. Louis, and the Union Electric Company.<sup>12</sup> The system was operational in April 1972.

Domestic solid waste, collected from residential areas of St. Louis, is ground up in a large hammermill. Magnetic materials are removed, and the remainder of the material is fired pneumatically to one or both of two existing boilers in the Union Electric Company system. The quantity of ground-up refuse used for fuel is only a small percentage (about 10%) of the fossil fuel normally fired to the boilers. At the 10% burning rate, each of the two moderate size boilers can consume about 300 tons of waste material per day. This tonnage is equivalent to the residential solid waste generated by 170,000 people.<sup>12</sup>

Residential solid waste, in its raw state, is heterogeneous in appearance. However, after milling, the refuse becomes more homogeneous, in both appearance and consistency. Within reasonable limits, the analyses of refuse from different parts of the country have been found to be consistent. Thus, the system will be applicable to areas other than the St. Louis region, such as a base facility in any part of the country.

The original investigations were confined to pulverized coal-burning boilers. However, the test boilers are fitted to burn natural gas as well as coal and are therefore capable of burning solid waste with gas.

The capability of existing suspension-fired boilers to consume municipal solid waste as supplementary fuel is great enough to permit the process to serve as a principal means of solid waste disposal for many metropolitan areas. Assuming that the supplementary fuel is fired as only 10% of the total fuel requirement, a 600-megawatt unit could, at full load, consume about 1200 tons of solid waste per day. By 1973, the suspension-fired boilers in the St. Louis area will have the potential capability of consuming over twice the amount of municipal solid waste which could be produced by a metropolitan area with a population of over 2,500,000.<sup>13</sup> Thus, the solid waste produced in a base facility of 1000 men could be easily disposed of by such a system.

The pollution generated by burning fossil fuels and milled refuse in combination has not yet been studied. It is expected that some increased particulate loading may occur in the boiler exhaust gases. Air pollution tests are to be conducted on the stack gases. It is expected that the combustion of refuse and coal, for example, will not produce discernible increases in either gaseous or particulate emissions when compared to burning coal alone. Whether the same statement will be valid for the combustion of refuse and natural gas has yet to be determined.

### 3.8 Sewage

The conventional sewage treatment plant, when properly designed and operated, can produce an effluent that places a marginally acceptable demand on the oxygen resources of the receiving water and generally results in some surface discoloration and turbidity. However, when such effluents are discharged into lakes, small streams and poorly flushed estuaries, the nutrients, phosphorous, nitrogen, and biostimulants, which contribute to the growth of green plants (especially algae), lead to eutrophication.

There are three types of treatment systems which are capable of meeting almost any reasonable effluent requirement:

- a. **Traditional or modified biological systems followed by tertiary treatment processes.** The conventional secondary treatment is augmented by appending physical and chemical processes. This approach is probably inappropriate and uneconomic for new or greatly expanded installations.
- b. **Chemical-physical systems without biological treatment.** The physico-chemical approach is increasing in popularity because of the greater reliability of such systems compared to the well-known instability of biological processes.
- c. **Integrated biological-chemical systems.** The almost unique capability of biological systems to separate simple organics from solution makes it attractive to consider them in combination with chemical precipitation and sorption processes. For example, by integrating a modified biological process

with phosphate precipitation, it is possible to achieve a high degree of degradable carbon, suspended matter, and phosphorous removal at a lower cost than with either system. Of the various sewage constituents believed to contribute to eutrophication, the several compounds of nitrogen may pose the most difficult removal problem. In some cases, only nominal nitrogen removal may be required; in others, biological or chemical or a suitable integrated combination of both may be necessary.

It is necessary to mention the extensive solids handling facilities required to stabilize, dewater, and in some instances reclaim the large volumes of organic-chemical sludge produced. Considerable progress is being made in this area and it is likely that chemical-physical processes will replace anaerobic biological digestion as the principal step in solids handling. In a conventional biological treatment plant followed by chemical processing, a lime precipitation unit is incorporated for phosphorous removal and ion exchange. Carbon columns are used for ammonia separation and further organics removal, especially color. Disinfection is by chlorination which may also serve the function of degrading organics, including color. Ozonation is showing promise in performing these functions.

A chemical-physical treatment system depends entirely on chemical precipitation and sorption for the removal of phosphorous, nitrogen, organic carbon and suspended matter. Here the principal burden of suspended solids removal is placed on a phosphorous precipitation unit. Again, disinfection is accomplished by chlorine.

Both biological and chemical processes have advantages as well as disadvantages. Combining the best of both systems should prove feasible.

Sewage facility loads can be reduced by the use of new concepts. For example, "Sanivac", a revolutionary new vacuum toilet, requires only a quart of water per flush (conventional units use five to seven gallons) and thus will reduce sewage facility loads, as well as conserve water.

### 3.9 Transportation

It is assumed that transportation on the base will be by means of piston engine automobiles, gas turbine or steam-driven automobiles, or electrical vehicles, in which the power is supplied by overhead wires or curbside electrical outlets.

In the conventional automobile, crankcase emissions represent 20% of the hydrocarbons emitted. These are the blowby gases, which pass from the engine cylinder into the crankcase of the engine. Evaporative emissions represent another 20% of the hydrocarbon emissions and are primarily from the carburetor and the fuel tank. The remaining 60% of the hydrocarbons come from the exhaust along with all of the carbon monoxide and oxides of nitrogen emissions. <sup>15</sup>

The emission control systems planned for automobiles should reduce hydrocarbons and carbon monoxide emission from all sources.

Exhaust control systems were first introduced nationwide in 1968. A carbon monoxide reduction of 65% has been achieved.<sup>15</sup> A system has been developed for control of emissions from used cars. The system involves a leaner carburetor idle mixture for reduced carbon monoxide, an increased idle speed for reduced hydrocarbons, ignition timing set to the manufacturer's specification, and an inoperative vacuum advance unit during normal operation to provide reduced hydrocarbon and oxides of nitrogen emissions. The system was used on 194 cars and it displayed an ability to control exhaust emissions with approximately a 50% reduction in hydrocarbons, a 30% reduction in carbon monoxide, and a 30% reduction in oxides of nitrogen.<sup>15</sup> Aside from the control systems, other changes, such as fuel modification, can be effective in reducing emissions. Fuel volatility can give a 50% reduction in evaporative emissions from uncontrolled cars. Removal of lead from gasoline can give a reduction of hydrocarbon emission.

Proposed Federal standards for automotive exhaust emissions call for strict control of hydrocarbons, carbon monoxide, oxides of nitrogen, and particulates. Future controls for the piston engine could take several forms. One promising method is a combination of electronic fuel injection to provide lean mixture operation for low carbon monoxide, recirculation of exhaust gas to provide low oxides of nitrogen, and an oxidizing catalytic converter which would further lower the hydrocarbons and carbon monoxide that escape from the engine.

One way of providing lean mixtures is through the use of gaseous fuels. Liquified petroleum gas and natural gas can provide very lean mixtures and low carbon monoxide emissions. When combined with other controls they can provide the control of all three major pollutants.

Alternate power sources have been considered to replace the piston engine. Some of these are gas turbines, steam engines, and electric systems. The gas turbine and steam engine have difficulty in controlling the oxides of nitrogen.

The electric car depends on the stationary power generator for its source of energy. Thus, the emission problem becomes one of controlling the sulphur dioxide emission level of the power (fossil-fuel) plant.

When comparing the most promising systems for controlling the present piston engine as well as the most promising alternate power sources, it appears that the proposed Federal requirements can be met by all of these approaches.

### 3.10 Recommendation

As a result of this initial contract study, the military base appears to be a useful model with which to evaluate the various pollutant abatement and energy resource conservation techniques. Thus, it is recommended that a small facility be operated as the model base and a pilot study be conducted to evaluate the aforementioned techniques, plus

others not yet specified, so that data will be available to ascertain the "ultimate" in pollution control and abatement.

### 3.11 References

1. Faltermayer, E., "The Energy 'Joyride' is Over", Fortune Magazine, September 1972, p. 100.
2. Bibbero, R. J., "Systems Approach Toward Nationwide Air Pollution Control", IEEE Spectrum, October 1971, p. 74.
3. Friedlander, G., "Power Pollution and the Imperiled Environment", IEEE Spectrum, November 1970, p. 43.
4. Ibid, p. 47.
5. Wilson, E. M., "Tidal Energy and its Development", Ocean, 1972, p. 48.
6. Carey, R., "Far Out Sources Probed", Journal News, Wednesday, October 11, 1972, p. 10 B.
7. Faltermayer, op. cit., p. 101.
8. Ibid, p. 102.
9. Ellis, H., "Energy and Environment in New York City", 1970.
10. Etzel, J. E., Pollution - Special Report, October 1970, p. 14.
11. Ibid, p. 15.

12. Horner & Shifrin, Inc., "Energy Recovery from Waste", U.S. Environmental Protection Agency, 1972, Publication (SW-36 d.i.), p. 2.
13. Ibid, p. 4.
14. Kaufman, W.J., Pollution - Special Report, October 1970, p. 12.
15. Niepoth, G.W., Pollution - Special Report, October 1970, p. 4.

## 4.0 Sensors

### 4.1 Introduction

Of prime importance to any environmental research and monitoring facility is the availability and proper use of sensors which can accurately and repeatedly detect the qualitative and quantitative nature of the pollutant. The following sections detail the theory, operation, sensitivity, availability, and cost of the pertinent sophisticated environmental pollution sensors.

The sensors and techniques which were investigated are:

Atomic Absorption Analysis

Chromatography

Electronic Spectrophotometry (Absorption and  
Fluorescence)

Infrared Spectrophotometry

Ion-Selective Electrodes

Mass Spectrometry

Polarography

The usefulness and application of these sensors to the various pollutants of both air and water are given in Tables 4.1 and 4.2, respectively.

Standard sensors to measure the physical and biological composition of pollution within the oceans, rivers, and estuaries, and the atmosphere are explored in Section 2.3, Instrumentation/Sensors.

TABLE 4.1 AIR POLLUTANTS / SENSORS

AIR POLLUTANTS	TYPICAL CONC. (PPM)		SENSORS															
	CITY	RURAL	RATED (G) PRESENTLY CAN MEASURE AT ALL EXISTING CONCENTRATIONS.															
			IR	UV	VIS	FL	GC	LC	MS	ES	AA	NAA	POL	ISE	XRF	OTHERS		
CO	5.0	0.1	G	G			G											
CO <sub>2</sub>			G				G											
SO <sub>2</sub>	0.2	0.002	G		G		G											
NO	0.2	0.002	W					W										ELECTRO-CHEMICAL (G)
NO <sub>2</sub>	0.1	0.001	W	G	G		W											
O <sub>3</sub>	0.3	0.01	G															
METHANE	3.0	1.4	G				G											
ETHYLENE	0.05	0.001	W				G											
ACETYLENE	0.07	0.001	W				G											
PAN	0.03	0.001	W				G											
HIGHER OLEFINS	0.02	0.01	W				G			W								
TOTAL HYDROCARBONS (EXCL. METHANE)	2.0	0.005	G				G			W								
NH <sub>3</sub>	0.01	0.01	W	W			W											
H <sub>2</sub> S	0.004	0.002	W		W	G	W											ELECTRO-CHEM
FORMALDEHYDE	0.05	0.001	W		W		G							G				
PARTICULATES (MUCH DEVELOPMENT NEEDED HERE IN CRITERIA & METHODS)																		
POLYNUCLEAR AROMATIC HYDROCARBONS			W		W	G	G	G										GC/MS
PCB							G	W										TLC/FI
Hg				W					W									GC/MS
Be										G	G							
Pb										G	W							G
Cd										G	G							
As					G								G					G
Ni										G	G							G
F																	W	NMR
V										G	G							G
Mn										G	G							G
Cr										G	G							G
Se						W												
Cl <sub>2</sub>																	W	W
HCl																	W	W
Cu					W					G	G						G	W
Zn										G	G							G
B							G											
Ba										G	G							
Sn										G								
P								W										G
AEROALLERGENS																		
REACTIVE ORGANICS			W	W			G	W										MICROSCOPY
PESTICIDES							G	W	W									GC/IR
RADIOACTIVE MATERIALS																		GC/MS

NOTES:

- IR=INFRA RED, UV=ULTRA VIOLET, VIS=VISIBLE, FL=FLUORESCENCE, GC=GAS CHROMATOGRAPH, LC=LIQUID CHROMATOGRAPHY, MS=MASS SPECTROMETRY, ES=EMISSION SPECTROSCOPY, AA=ATOMIC ABSORPTION (ALSO EMISSION AND FLUORESCENCE), NAA=NEUTRON ACTIVATION ANALYSIS, POL=POLAROGRAPHY, ISE=ION SELECTIVE ELECTRODE, XRF=X-RAY FLUORESCENCE.
- IR'S PROMISE WITH FIXED GASES IS LARGELY DUE TO DEVELOPMENT OF LASER TECHNIQUES. MOST AIR POLLUTION WORK EMPLOYS CORRELATION METHODS, NDIR SIMPLEST.

TABLE 4.2 WATER POLLUTANTS / SENSORS

I. WATER POLLUTANTS INCLUDES INDUSTRIAL WASTES, INDUSTRIAL CHEMICALS (INORGANIC & ORGANIC)

	IR	UV	VIS	FL	GC	LC	MC	ES	AA	NAA	DOL	ISE	XRF	OTHERS
PESTICIDES														
CHLORINATED					G	W								GC/MS
CARBAMATE					G	W								TLC
ORGANOPHOSPHORUS					G	W								TLC
SYNTHETIC DETERGENTS		W		W		G								TLC
HYDROCARBONS	G				G		W							GC/IR
AROMATICS		G			G									GC/MS
INDUSTRIAL WASTES														
PHENOLS		G	W	G	W									
INDUSTRIAL CHEMICALS														
POLYMERS					W	G								
SOLVENTS					G									
MINERAL ACIDS												G		REACTION TO SALT, ISE
HEAVY METALS														
Cu														G
As										G		G		G
Pb														G
Hg														G
PCB														
														SEE AIR POLLUTION SECTION
NITRATES														G
NITRATES														G
PHOSPHATES														G

II. SOIL

- PESTICIDES
  - Pb
  - Cu
  - AS
  - CHLORINATED
  - ORGANOPHOSPHORUS (MALATHION, ETC.)
  - CARBAMATE
- FERTILIZERS
  - NITRATES
  - PHOSPHATES
- PCB

ESSENTIALLY SAME AS ABOVE EXCEPT FOR SAMPLING METHODS

"FOR LEGEND NOTATION" - REFER TO TABLE 4.1

## 4.2 Atomic Absorption Analysis

Atomic absorption analysis is one of the best known instruments employed for the detection of chemical pollutants.

### 4.2.1 Theory of Operation

Basically, the principle of operation of an atomic absorption analyzer is the passage of a beam of light through an atomic vapor and into a monochromator and detector. This light contains frequencies which can be absorbed by the substance to be analyzed if its atoms appear in the vapor. When this absorption occurs, the intensity of the light at these frequencies is diminished, and this causes a decrease in detector output. The light beam is generated, usually, by a hollow cathode tube which emits the spectral lines of the atoms to be analyzed. An atomic vapor is produced by aspirating a solution into a burner flame or by vaporizing the substance from a hot surface. The monochromator reduces light noise by eliminating all frequencies except the absorption frequency. The detector is a photomultiplier tube with associated electronics and display.

### 4.2.2 Special Features

Reproducibility and reliability of results are excellent. However, the absolute determination of element concentration depends to some extent on the structure of the aspirated solution. Therefore,

calibration standards must be reasonably similar to the solution containing the unknown so that different investigations can obtain similar results.

Atomic absorption instruments have been considered off-line up to the present time because of the need for a flame for atomization purposes. However, in cases where the pollutant exists in a gaseous atomic state, such as mercury vapor, attachments are available in which in situ operation is feasible. Recently, other flameless AA techniques<sup>\*</sup>, such as the graphite rod method have been developed. This could make on-line use of the instrument possible.

In the case of most elements handled by atomic absorption, the detection sensitivity is greater than that of other methods. Therefore, pollution standards can be set as low as these levels as the minimum quantity of contaminant that can be introduced into the environment. To speak of even lower emissions would be meaningless since they would be undetectable.

#### 4.2.3 Detection Capabilities

Table 4.3 presents the minimum concentrations of pollutants which are measurable by atomic absorption. The sensitivity limits are

---

\* Mercury detection by flameless atomic absorption (utilizes the Hatch and Ott procedure). Instrument = Coleman MAS-50, approximate cost is \$900 - this is the best method available.

given in parts per million (ppm)

<u>Element</u>	<u>Limit (ppm)</u>	<u>Element</u>	<u>Limit (ppm)</u>
Aluminum	6.0	Mercury	0.1
Antimony	1.0	Molybdenum	1.5
Arsenic	0.2	Nickel	0.1
Barium	5.0	Niobium	250
Bismuth	1.0	Potassium	0.03
Cadmium	0.04	Rhodium	0.3
Calcium	0.1	Rubidium	0.1
Cesium	0.5	Ruthenium	0.25
Chromium	0.1	Scandium	5.0
Cobalt	0.1	Selenium	3.0
Copper	0.02	Silver	0.1
Gallium	3.0	Sodium	0.05
Gold	0.3	Strontium	0.2
Indium	0.05	Tellurium	1.5
Iron	0.04	Tin	1.0
Lead	0.1	Titanium	1.0
Lithium	0.07	Zinc	0.005
Magnesium	0.001	Beryllium	0.2
Manganese	0.005		

Table 4.3 Pollutants and Minimum Detectable Limit for Atomic Absorption

#### 4.2.4 Instrumentation Sources

Given below are several of the manufacturers that produce atomic absorption analyzers. Their instruments are available off-the-shelf in most cases.

Instrumentation Laboratory  
113 Hartwell Avenue  
Lexington, Massachusetts 02173

Bausch and Lomb  
Analytical Systems Division  
1108-28 Linden Avenue  
Rochester, New York 14625

Varian Techtron  
Walnut Creek  
California 94598

Perkin Elmer  
Main Avenue  
Norwalk, Connecticut 06851

Philips Electronic Instruments  
750 South Fulton Avenue  
Mount Vernon, New York 10550

Fisher Scientific Company  
711 Forbes Avenue  
Pittsburgh, Pennsylvania 15219

### 4.3 Chromatography

Various chromatographic techniques are useful in separating, identifying and quantitatively measuring pollutants of all types. Gas chromatography, including gas liquid partition chromatography and gas adsorption chromatography, and liquid chromatography, including adsorption, partition, ion exchange and gel permeation, are the most versatile and reproducible qualitative and quantitative chemical techniques. Thin layer<sup>1</sup> and paper chromatography are sensitive and extremely useful though not as amenable to automation or on-line operation.

Modern gas and liquid chromatography techniques are complementary in that heat sensitive and non-volatile materials that cannot be analyzed by gas chromatography can be handled effectively by liquid chromatographic methods. Also, there is a substantial overlap between the methods and there is considerable similarity in sampling, detection and recording techniques.

#### 4.3.1 Gas Chromatography<sup>2,3</sup>, (GC) Theory of Operation

In gas liquid chromatography (GLC), separation is obtained by a partitioning of the sample mixture between a non-volatile liquid coating (stationary phase) of the column packing and the carrier gas (usually helium or nitrogen). GLC is most frequently used with liquid and volatile solid organic compounds. The great number of stationary phases that can be employed allow optimum separation conditions to be

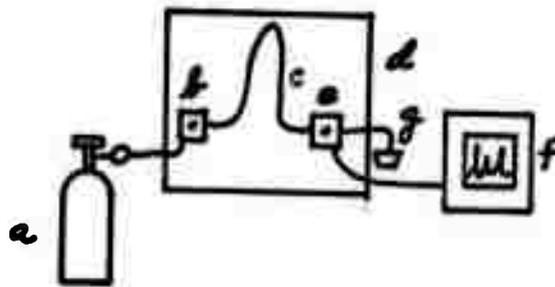
established for almost any sample mixture. In gas solid chromatography, the column is packed with a solid adsorbent material such as alumina, silica gel or molecular sieves. The separation is effected by differences in adsorption of the sample components by the column packing. This method is most widely used for the analysis of gas mixtures, such as air samples and engine exhausts. Often adsorption and partition columns are connected in series to effect analysis of complex samples, particularly in air pollution studies.

#### 4.3.1.1 Operation of a GC

Referring to Fig. 4.1, the gas chromatograph consists of:

- a. Gas source (multiple gas sources in the case of ionization detectors).
- b. Sample inlet (heated to ensure vaporization). Sample can be injected or valved in and can be automated.
- c. Column (usually stainless steel or glass). The column packing may consist of liquid-coated refractory material or of solid adsorbent. Special packing of fluropolymers and polar aromatic polymers are being used increasingly.
- d. Oven (necessary to maintain optimum temperature for specific separations). Temperature can be programmed in many instruments.

- e. Detector (many types in current use). Some have specific responses such as the electron capture detector which can be extremely useful in detecting halogenated pollutants (PCB, DDT, DDE, etc.)
- f. Recorder
- g. Exit port (gas and sample exits here). Sample can be collected for structure determination by IR, UV, mass spectrometry, NMR and for further chemical treatment. Direct interfacing with IR<sup>4</sup> and mass spectrometers<sup>5</sup> is possible.



**FIG. 4.1 - GAS CHROMATOGRAPH**

It may be instructive to follow a typical gas chromatograph separation:

A sample, suspected of containing a PCB<sup>6</sup>, is injected into the sample inlet through a silicone septum, using a microliter syringe. The sample is vaporized and swept onto the packed column by a stream of helium gas. A clean separation is effected by the successive dissolution

in the stationary phase and vaporization into the helium stream of the sample. Each component will be eluted at a different rate because of differences in volatility and solubility in the stationary phase. Each component passes through the detector where its presence and quantity are signaled to the recorder. The PCB can be identified by the elapsed time from injection to detection, by the volume of gas necessary to elute it, or by comparison with a pure sample of the same material. Alternately, the sample may be collected at the exit port and identified by the methods described previously.

#### 4.3.1.2 GC Detectors

While the temperature flow rate and type of column used determine the efficacy of a separation, the detector almost completely determines the selectivity, sensitivity, reliability and precision of any GC analysis. Table 4.4 presents the advantages, disadvantages, and special characteristics of most modern detectors.

For most analyses for pollutants, detectors such as Thermal Conductivity (TC), Flame Ionization (FID) and Electron Capture (EC) give comprehensive coverage. The TC detector is the most rugged and reliable and is therefore excellent for general purpose, off-line and "in situ" operation. For trace analyses of atmospheric pollutants, it may be necessary to use FID supplemented by a Helium detector for fixed gases. The entire range of pesticides and other related pollutants can be covered by Electron Capture and Alkali Flame down to trace quantities.

TABLE 4.4 GAS CHROMATOGRAPH DETECTORS

DETECTOR	OPERATION	SENSITIVITY (GM/SEC)	SELECTIVITY	LINEAR RANGE	MIN. QUANT. DETECTABLE GM	STABILITY	TEMP. LIMIT °C	CARRIER	REMARKS
THERMAL CONDUCTIVITY (TC)	MEASURES THERMAL CONDUCTIVITY OF GASES	$6 \times 10^{-10}$	UNIVERSAL RESPONSE	$10^4$	$10^{-5}$ GM CH <sub>4</sub> /ml EFFLUENT	GOOD	450°C	H <sub>2</sub> N <sub>2</sub> He	NON DESTRUCTIVE, SIMPLE, PLUGGED AND INEXPENSIVE - REQUIRES GOOD TEMP. AND FLOW CONTROL.
FLAME IONIZATION (FID)	H <sub>2</sub> O <sub>2</sub> FLAME IONS FORMED $\propto$ CONC.	$9 \times 10^{-13}$ FOR ALKANES	ORGANIC COMP. NO RESPONSE TO FIXED GASES & H <sub>2</sub> O	$10^7$	$2 \times 10^{-11}$ g (ALKANES)	EXCELLENT	400°C	He N <sub>2</sub>	NON RESPONSE TO FIXED GASES LIMITS IT IN SOME POLLUTION APPLICATIONS. HIGH SENSITIVITY IS A GREAT PLUS DESTRUCTIVE
ELECTRON CAPTURE ( <sup>3</sup> H, <sup>63</sup> N <sub>2</sub> (EC))	N <sub>2</sub> + $\beta$ → $\bar{e}$ → SAMPLE → LOSS OF CURRENT	$2 \times 10^{-14}$ CCL <sub>4</sub> ( <sup>3</sup> H) $5 \times 10^{-15}$ <sup>63</sup> N <sub>2</sub>	RESPONSE TO ELECTRON ABSORBING, HALO, NITRO & CONJUG. CARBONYLS	$5 \times 10^2$ ( <sup>3</sup> H) 50 ( <sup>63</sup> N <sub>2</sub> )	$10^{-13}$ g LINDANE $4 \times 10^{-12}$ LINDANE	FAIR FAIR	225°C 350°C	N <sub>2</sub> OR Ar +10% CH <sub>4</sub>	DETECTOR EASILY CONTAMINATED SENSITIVE TO WATER. CARRIES GAS, MUST BE DRY, NON DESTRUCTIVE, TREMENDOUSLY USEFUL FOR PCB AND PESTICIDE RESIDUES.
ALKALI FLAME (PHOSPHOROUS DETECTOR)	ALKALI MODIFIED FLAME IONIZATION	$4 \times 10^{-14}$	GREATLY ENHANCED RESPONSE TO PHOSPHORUS COMPOUNDS	$10^3$	$2 \times 10^{-12}$ g PARATHION	FAIR	300°C	N <sub>2</sub>	DESTRUCTIVE - REQUIRES FLOW CONTROLLER FOR H <sub>2</sub> AND AIR. VERY USEFUL FOR PHOSPHORUS CONTAINING PESTICIDES AND FOR TRACE NERVE GAS CONTAMINATION.
HELIUM	He + $\beta$ → He* He* + SAMPLE IONS → IONS	$2 \times 10^{-14}$ (CH <sub>4</sub> )	UNIVERSAL RESPONSE	$5 \times 10^3$	$10^{-12}$ g FOR FIXED GASES	POOR	100°	He	HIGH SENSITIVITY. CAN ONLY BE USED WITH NON COATED COLUMNS TO AVOID BLEED. NON DESTRUCTIVE BUT ONLY USABLE WITH FIXED GASES.
CROSS SECTION	$\beta$ + SAMPLE → IONS	$10^{-9}$	UNIVERSAL RESPONSE	$10^4$	$10^{-5}$	GOOD	225°C	H <sub>2</sub> OR He +3% CH <sub>4</sub>	
GAS DENSITY BALANCE	MOL. WT. DIFFERENCES MEASURED	VARIES CA. T.C. APPROX EQ. TO THERMAL CONDUCTIVITY	UNIVERSAL RESPONSE	$10^3$		GOOD	150°C	H <sub>2</sub> CO <sub>2</sub> Ar	NON DESTRUCTIVE. DIRECT CAN HANDLE CORROSIVE MATERIALS

Besides sensitivity, selectivity and reliability, price is an important consideration. While a basic research GC with TC detector costs \$4000 each, every additional detector adds \$500 to \$2000 to the price. The outstanding companies are Hewlett Packard, Perkin-Elmer and Varian-Aerograph. They all offer a full range of detectors and equipment options and will modify equipment for special applications. There are inexpensive GCs (approximately \$1000) that are reliable, effective and available.<sup>8</sup> All research GCs can be interfaced with mass spectrometers and computer systems resulting in extremely potent automated analysis of trace quantities of complex mixtures.<sup>9</sup>

A very important new development is the design of portable gas chromatographs with TC, EC or FID detectors that are completely self-contained for on-site work. Excellent results have been obtained in the field analysis of pollutants of various types.<sup>10,11</sup>

The time required for an analysis can vary from a few minutes to hours depending on the complexity of the mixture, the types of column, flow rate and temperature used. Multi-column and multi-detector instruments can be used to good advantage to cut overall times. Separations can be improved and total analysis time greatly reduced by temperature programming.

#### 4.3.1.3 Interfacing with Mass Spectrometer or Infrared

As previously indicated, more positive identification of sample components can be achieved by collecting the sample as it is eluted and subjecting it to various chemical, physical or spectral analyses. Of greatest utility is direct interfacing of the GC with a mass spectrometer or an infrared spectrophotometer. The GC/IR<sup>4</sup> combination is less successful than GC/MS<sup>5</sup> as the IR requires approximately 100 micrograms of sample and fairly high scan times. Mass spectrometers give good results with sub-microgram quantities and some have scan times < 0.1 second. Each separated component can be characterized by its molecular weight and fragmentation pattern. The entire procedure can be automated and the mass spectrometer can be interfaced with a computer, such as a PDP-8 or PDP-12, to process the GC/MS output.

#### 4.3.1.4 GC Manufacturers

The following is a tabulation of some manufacturers of Gas Chromatographs and the special features of their instruments.

- A. Hewlett Packard Co.  
Route 41  
Avondale, Pennsylvania 19311

Model 4750: medium price research gas chromatograph, approx. \$4000. - with Flame Ionization Detector (FID), temperature programming, dual column, etc.

Other models range from \$1500 to \$8000<sup>+</sup>.

B. Varian Aerograph  
2700 Mitchell Drive  
Walnut Creek, California 94598

Model 1420: Low cost, dual column, thermal  
conductivity detector (TC) - \$ 2000<sup>+</sup>

Model 2440: Low cost, dual column, flame  
ionization detector (FID) - \$ 2000<sup>+</sup>

Model 2700/2800: Moduline research gas  
chromatograph - \$ 4000<sup>+</sup>

C. Perkin-Elmer Corp.  
702-6 Main Avenue  
Norwalk, Connecticut 06852

Model 900: Full range research gas chroma-  
tograph - \$ 5000<sup>+</sup>

Mark II: Inexpensive, versatile - \$ 3000<sup>+</sup>

D. Carle Instruments Inc.  
1141 E. Ash Avenue  
Fullerton, California 92631

Model 6500: \$ 415<sup>-</sup>  
Flame Ionization Detector - \$ 800<sup>+</sup>  
(rugged, simple instruments)

E. Gow-Mac Instruments Co.  
100 Kings Road  
Madison, New Jersey 07940

69-100 rugged, simple TC and FID gas  
chromatographs from \$ 600 - \$ 1000.

#### 4.3.2 High Performance Liquid Chromatography (HPLC)<sup>12</sup>

High Performance Liquid Chromatography (HPLC) is a refinement of older column chromatographic methods. Its current development owes much to gas chromatography. As in GC, small sample sizes, long narrow columns and sensitive detectors are used in a highly automated procedure with a liquid mobile phase. For effective and rapid separations, finely divided homogeneous supports are used, making high operating pressures necessary (2 - 3000 psi). The mobile phase is generally a controlled mixture of solvents (gradient elution).

The four principal types of liquid chromatography are differentiated by the column packing used.

- |                   |                                                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------|
| A. Liquid-Liquid  | Separation by partition between mobile and stationary liquid phases. [Most frequently used and most useful for pollution work.] |
| B. Liquid-Solid   | Adsorption on solid adsorbent.                                                                                                  |
| C. Ion-Exchange   | Ionic sample components separated by selective exchange with ion-exchange resin support.                                        |
| D. Gel-Permeation | Separations with a permeable gel-based on molecular size.                                                                       |

While HPLC is not as versatile or as sensitive as GC, it is capable of treating heat sensitive and non-volatile compounds, not amenable to GC, as no elevated temperatures are required. High

molecular weight materials, biological compounds and polymers are readily handled. Another advantage is that by controlled polarity changes in gradient elution, an additional variable for improving separations is available. The key disadvantages of HPLC, relative to GC, are lower sensitivity and lower separating power for complex mixtures due to limited peak capacity.

A modern liquid chromatograph is similar to a gas chromatograph in many respects. The carrier gas source is replaced by solvent reservoirs, a mixing control (for gradient elution) and a high pressure pump. A pre-column is used to attain equilibrium between the moving and stationary liquid phases. As in GC, there is a wide selection of column packings used.

The most commonly used detectors<sup>13</sup> are the photometric (usually UV) and the differential refractometer types. The UV detector has an average sensitivity of about  $10^{-7}$  g/ml which makes it the most sensitive type presently used. Its disadvantages include possible interference from solvents having UV absorption and detection only of substances absorbing in the UV region.

The Differential Refractometer detector has a sensitivity of about  $10^{-5}$  g/ml and is quite rugged. However, it has the severe disadvantage of working poorly when gradient elution is being carried out.

The Phase-transformation or wire detector<sup>14</sup> is the most versatile and sensitive ( $10^{-10}$  g/ml). Its operation is complex, involving

evaporation, oxidation to  $\text{CO}_2$ , reduction to  $\text{CH}_4$ , and detection by a flame ionization detector. It is also, by far, the most expensive. Any solvent or mixture of solvents can be used, providing they are volatile. Very reproducible results are achieved.

#### 4.3.2.1 Applications

For studies of pollutants, HPLC's most important applications are where molecules are heat-sensitive, have a high molecular weight (including polymers), or possess a high polarity (including ionic materials). HPLC represents the only good way of carrying out these separations and identification. With the further development of the wire-detector, peak capacity can be improved to the extent that HPLC can be more competitive with GC.

Because of the liquid solvent, direct interfacing with a mass spectrometer is not possible.

#### 4.3.2.2 Instrumentation and Manufacturers

A basic HPLC instrument with UV detector costs about \$4000, a good part of which is the cost of the detector (\$1500 - \$2000). A Refractive Index (RI) detector costs about \$2000. The wire detectors are considerably more expensive. HPLCs are offered by most GC manufacturers (DuPont, Waters<sup>15</sup> and others). The elapsed time for an analysis can be as low as 45 seconds but limited peak capacity reduces the complexity of the mixtures that can be handled.

## LC Manufacturers

The following is a short tabulation of Liquid Chromatograph manufacturers and the special features of their instruments.

A. Waters Associates, Inc.

61 Fountain Street

Framingham, Massachusetts 01701

Good source for HPLC equipment and accessories, complete range of instruments.

B. Pye Unicam Ltd.

York Street

Cambridge, England

Only HPLC manufacturer with a commercial phase sensitive detector.

C. Tracor Inc.

6500 Tracor Lane

Austin, Texas 78721

Model UFC-1000: High performance (German-made). Six different detector options up to 3700 psi.  
Price range \$ 8000<sup>+</sup>

#### 4.3.3 References

1. For an introduction and descriptive survey of TLC and paper chromatography, see Bobbit, J., et al., "Introduction to Chromatography", Reinhold Publishing Co., New York, 1968.
2. An excellent introduction to GC is: Mc Nair, A. M. and Bonelli, E. J., "Basic Gas Chromatography", Varian Aerograph (1967).
3. A more technical and detailed book is Dal, Nogare, S. and Juvet, R. S., "Gas-Liquid Chromatography", Interscience, New York, 1968.
4. A description of interfacing techniques is in: Roboz, J., "Introduction to Mass Spectrometry", pp. 364-368, Interscience, New York, 1968.
5. A typical GC/IR system is offered by Wilks Scientific Corp., 140 Water Street, South Norwalk, Connecticut 06856. It scans a vapor sample, as eluted, in less than two minutes. Price, less the GC, is approximately \$6000.
6. Bonelli, E. J., American Laboratory 3, pp. 27-37, 1971.
7. Reference 2 p.
8. For example, Carle Instruments, Gow Mac, and other companies, manufacture low cost TC and FID models that are rugged and easy to operate.
9. Binks, R. et al., Chem. Britain 7, 8, 1971.
10. Debrecht, F. J. and Neel, E. M., American Laboratory 3, 39, 1971.

11. Debrecht, F. J. et al., American Laboratory 4, 47, 1972. Excellent potential for these instruments.
12. Scott, R. P. W., "Contemporary Liquid Chromatography", Analabs Research Notes 11, 2, 1971. Excellent review.
13. Fallich, G. J. and Waters, J. L., American Laboratory 4, 21, 1972. Excellent overall review.
14. Scott, R. P. W., J. Chromatography Science, February 1970.
15. Waters seems best in overall innovation, comprehensiveness, and reliability.

#### 4.4 Electronic Spectrophotometry (Absorption and Fluorescence)

##### 4.4.1 Theory of Operation

Electronic spectra result from the absorption and/or emission of radiation due to transitions between electronic energy levels of atoms and molecules. The energy absorbed or emitted is quantized and is related to the frequency of the radiation by Planck's equation:

$$E = h\nu = hc/\lambda$$

The transition energies involved give rise to radiation which ranges from the ultra violet to the beginning of the near infrared region. Most commercial instruments used in pollutant analysis cover the region 200-800 nm. (Below 200 nm, oxygen and water must be purged from the instrument.)

Two of the commonly used methods are absorption<sup>1</sup> and fluorescence spectrophotometry.<sup>2</sup> The techniques are related and complementary.

Each electronic energy level has associated vibrational energy levels that are also quantized. Excitation of an electron in the ground electronic state to a vibrational level of a higher electronic state follows absorption of radiant energy. This radiant energy is subsequently reemitted from the lowest vibrational level of the excited electronic state or by transfer to other vibrational and rotational

modes of the molecule before return to the ground state. The first type of emission is fluorescence; the second, phosphorescence. They are distinguished by the measurable time lag in phosphorescent emission.

In electronic absorption spectrophotometry (200-400) (400-800) nanometers, uv visible light is passed through a sample and the intensity difference between the incident and transmitted light is proportional to the concentration of the sample. The wavelength of the absorbed radiation is dependent on the molecular structure and the electronic spectrum is used for identification, as well as for quantitative determinations. The intensity of the transmitted light depends on the number of atoms, molecules, or ion in the light beam. Beer's Law (Beer-Lambert-Bouger) states that:

$$\log I_0/I = A = a b c$$

where

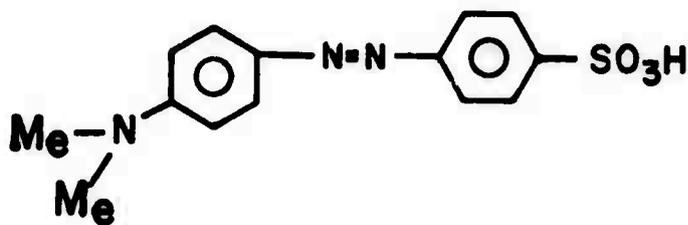
- A = absorbance
- a = absorption (extinction coefficient)
- b = cell length
- c = concentration

Generally, Beer's law holds well for low concentration ranges ( $<10^{-3}$  M); but it is subject to deviations due to reflection sample nonhomogeneities,

scattering, solution changes, fluorescence, etc. Therefore, it is important to check on conformity to Beer's law in new analyses or methods. Usually, the absorption of radiant energy by one species will be unaffected by the presence of other species. If two or more species are present, their absorbances will add to form a total observed value:

$$A = \sum a_i b c_i$$

Uv visible absorption spectrophotometry is applicable to the study of many organic and inorganic pollutants.<sup>3</sup> With organic material, it is most useful if the compound in question contains chromophores for uv or visible light (these are structural features, such as conjugated double bands or atoms with nonbonding electrons, that lead to excitation energies low enough to fall into the uv visible region). For example, alkanes such as methane, ethane, etc., do not have absorption maxima in the uv visible region due to lack of requisite chromophores. Aldehydes and ketones contain the carbonyl group where oxygen non-bonding electrons are excited by radiation of approximately 270 nm.(uv) to a higher electronic level. [ $n \rightarrow \pi^*$  transition].<sup>1</sup> In general, the greater the degree of conjugation, the longer the wavelength(s) of the absorbed radiation. An example of visible radiation absorption is an azo dye



such as methyl orange which possesses an extended conjugated structure. All aromatic systems including PCBs and polynuclear aromatics are analyzable by uv-visible spectrophotometry.

Inorganic pollutants, such as trace metals and various anions, are generally analyzed by methods which involve forming a complex that absorbs in the uv or visible region with a suitable reagent.<sup>3</sup> Care must be taken to exclude interferences from other metals or ions, depending on the specificity of the reagent. For example, mercury can be determined by the complex formed between the mercuric ion and the thiocyanate ion.<sup>4</sup> This complex has a maximum absorbance at 281 nm and can be utilized for parts per million determinations. Colored complexes used for analysis include the Cu(I) - 2, 2' - Biquinoline complex<sup>5</sup> which has a maximum absorption at 545 nm ( $\epsilon=3.2 \times 10^3$ ); detection limit of approximately 2 nanograms.

#### 4.4.2 Sampling Methods

Most commercial instruments are double beam and automatic recording, although quantitative work can be done very well at fixed wavelengths with instruments such as the work-horse, Beckman DU. Uv determinations require a uv source, such as a deuterium discharge lamp and quartz sample cells. For visible spectrophotometry, a tungsten lamp and glass sample cells are sufficient. For all work

at low levels, it is essential to use pure solvents, ultraclean glassware, and careful techniques. Contamination from glass and plastic sample containers can be an insidious factor. A calibration curve to check adherence to Beer's law should be run in any new circumstance.

#### 4.4.3 Spectrophotometry Instruments

Commercial instruments that can be used range from the very simple, inexpensive, but, surprisingly, reliable models to fairly complex research instruments. A few examples follow in Table 4.5. Shimadzu offers an interesting, self-zeroing, completely automatic instrument for \$4500 that should be very useful for on-line modification.

1. Perkin Elmer Corporation  
702-G Main Avenue  
Norwalk, Connecticut 06856

Many models including 356, 602, and 323

2. Coleman Instruments Division  
Perkin Elmer Corporation  
42 West Madison Street  
Maywood, Illinois 60153

Coleman (Hitachi) Model 101; inexpensive, rugged, uv visible; approximately, \$1700; simple to operate.

3. Bausch & Lomb  
128 Linden Avenue  
Rochester, New York 14625

Spectronic 20 work horse for simple, reliable operation; 340-950 nm range; cost, \$400; can adapt to fluorescence measurements.

Table 4.5: COMMERCIAL INSTRUMENTS FOR SPECTROPHOTOMETRY

	<u>Optics</u>	<u>Range (nm)</u>	<u>Resolution</u>	<u>Accuracy Absorption</u>	<u>Price</u>
Spectronic 20	Grating	340 - 950	Moderate	Moderate	\$ 400
Beckman DU2	Prism	190 - 1000	High	High	\$ 2,000
Cary 14*	Grating	186 - 2600 (includes NIR - near infra-red)	Very High	Very high ± 0.002 (0-1 range)	\$15,000

---

\* Now part of Varian Corporation  
Other models available

4. Varian Instrument Division  
611 Hansen Way  
Palo Alto, California 94303

Cary uv visible, including the Cary 14, Cary 17.

5. Beckman Instruments, Inc.  
2500 Harbor Blvd.  
Fullerton, California 92634

Many models besides the DU, including the DB-GT and the high performance Century ACTA series.

6. Cary Instruments  
A Varian Subsidiary  
2724 South Peck Road  
Monrovia, California 91016

(including the Cary 14 and Cary 17)

7. Shimadzu Seisakusho, Ltd.  
Foreign Trade Dept., 14-5  
Unchikanda 1 - Chrome  
Chiyoda, Tokyo, JAPAN

#### 4.4.4 Fluorescence,<sup>2</sup> Theory

A molecule in a higher vibrational level of an excited state quickly returns to the lowest vibrational level of that state by non-radiative energy transfer. Then, the molecule emits radiation to return to the ground state. The light emitted is of a longer wavelength than the incident light because some energy has been given up in the higher level before the fluorescent transition to the ground state. (Phosphorescence involves the excited molecule passing from

its lowest single excited state to a vibrational level of a triplet state. The triplet  $\rightarrow$  singlet ground state transition is forbidden and occurs after a time delay.

The fluorescence equation can be expressed as:

$$P = k P_o (1 - 10^{-abc})$$

where

- P = radiant power of the fluorescent light
- $P_o$  = radiant power of the incident light
- k = fraction of incident light absorbed
- a = constant dependent on the material
- b = path length
- c = concentration

For dilute solutions:  $P = 2.3k P_o a b c$

At constant excitation and emission wavelengths,  $P_a = K_c$  where  $P_a$  is the indicated fluorescence and  $K_c$  is a constant derived by calibration with standards.

A fluorometer consists of a source (usually uv) to excite the sample and a monochromator which allows only the emitted fluorescence to reach the detector. Hydrogen (or deuterium) lamps, mercury lamps, or xenon arcs are used. Photocells or photomultiplier detectors are used with dial, oscilloscope, or potentiometric recorder output.

Fluorescence techniques are very sensitive for several reasons. One is the dependence of sensitivity on the intensity of the excitation light source. Very intense excitation sources are used in fluorometers.<sup>6</sup> The main reason for high sensitivity stems from the direct measurement of the emitted fluorescent light by the detector. This can be amplified easier than in spectrophotometry, where the difference between incident and transmitted light is measured.

Commercial spectrofluorometers can be used with liquid samples, for the reflectance fluorescence of solids<sup>7</sup> (especially useful for direct measurements of thin layer chromatogram separated compounds) and for phosphorescence measurements.

An example of a fluorescence analysis is the determination of Selenium<sup>8</sup> by complexing with 2,3-diaminonaphthalene ( $\lambda$  max, 520 nm) in cyclohexane. The sensitivity is 0.1  $\mu$ g with EDTA as masking agent.

#### 4.4.5 Spectrofluorometer Instruments

Fluorescence attachments for the Cary Model 14, Beckman DU and other spectrophotometers, are available as well as several excellent spectrofluorometers (Aminco and Perkin Elmer). While fluorometric methods are generally more sensitive than photometric methods, they are more subject to error (5-10%).

1. American Instrument Company  
Division of Travenol Labs, Inc.  
8030 Georgia Avenue  
Silver Spring, Maryland 20910

Best source of entire range of fluorometers ranging from inexpensive fluoro/colorimeter to SPF 1000 spectrophotofluorometer in \$20,000 range.

2. Perkin Elmer Corporation  
702-G Main Avenue  
Norwalk, Connecticut 06852

Models 203, 204, and MPF-3; medium to high performance instruments; MPF-3 useful for TLC analysis.

#### 4.4.6 References

1. An excellent and simple introduction to uv visible spectrophotometry is given in Dyer, J. R., "Applications of Absorption Spectroscopy of Organic Compounds." Prentice Hall, Inc., NJ, 1965.  
Another excellent and comprehensive treatment is given in Jaffe, H. H. and Orchin, M., "Theory and Applications of Ultra Violet Spectroscopy," John Wiley, NY, 1962.
2. A useful introduction to fluorescence methods is given by White, C. E. and Weissler, A. in "Standard Methods of Chemical Analysis," Volume IIIA (edited by Welcher, F. J.), pp. 78-104, D. Van Nostrand Co., NJ, 1966.
3. Cheng, K. L., Chapter 5 in "Trace Analysis, Physical Methods," edited by Morrison, G. H., Interscience, NY, 1965.
4. Markle, G. E., Boltz, D. F., Anal. Chem., 28, p. 459, (1956).
5. Cheng, K. L. and Bray, R. H., Anal. Chem., 25, p. 655, (1953).
6. See references 2 and 3.
7. Aminco SPF 1000 and Perkin Elmer MPF-3 are very useful for TLC work.
8. Cukor, P., et al., Anal. Chem. Acta 30, p. 473, (1964).

#### 4.5 Infra-Red Spectrophotometry<sup>1</sup>

Infra-red spectrophotometry (IR) is a primary tool for identifying known pollutants.<sup>2</sup> While IR is most useful with pure samples, a great deal of information about the structures and functional groups of the components of a mixture can be obtained as well. Since the intensities of infra-red absorption bands vary widely and are often weak, IR is not as sensitive or reliable for quantitative determinations as ultra violet visible spectrophotometry. However, it does afford an enormous amount of structural information.

##### 4.5.1 Theory of Operation

The basis for IR spectroscopy is the quantization of the vibrational and rotational energy of molecules. The spacing of these levels is such that transitions between levels are promoted by the absorption of IR radiation. A complex molecule will absorb IR radiation of several different frequencies related to the transition energies of the allowed vibrational and rotational modes. The frequency of the radiation is related to the transition energy by Planck's Law:

$$\Delta E = h\nu$$

What makes IR a particularly powerful method is that functional groups, such as C=O, C=C, O-H, >CH<sub>2</sub>, etc., have fairly constant vibrational transitional energies which are largely independent of the rest of the

molecules to which they are attached. For example, the C=O stretching frequency is  $1720\text{ cm}^{-1}$  for cyclohexanone and  $1725\text{-}1700\text{ cm}^{-1}$  for acyclic ketones such as acetone. Relatively minor shifts are caused by conjugation and electronegative substituents. In many cases, the IR absorption spectrum alone can yield extensive structural information leading to positive identification of pollutants.

Pure samples can be obtained by Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), and Thin Layer Chromatography (TLC) and subsequently analyzed by IR. The most attractive technique is direct access from GC. Since the eluted vapor can be scanned directly, the limiting factor is scanning speed. These have been reduced to below 30 seconds in some new instruments,<sup>3</sup> leaving the relative large sample requirement (approximately  $20\text{ }\mu\text{g}$ ) as the major problem. However, this instrument technique should become very attractive in the near future.

The IR spectrum of a compound can be determined in the liquid, solid, or vapor state. The technique of preparing the sample varies with its state; for example:

1. Solid samples can be observed as melts between NaCl plates, as solutions in solvents such as carbon disulfide and carbon tetrachloride, as films (useful for polymers), dispersed in a mulling fluid (such as mineral oil or perfluorokerosene), and as dispersions in solid KBr pellets. Another option for solids is Attenuated Total Reflectance (ATR) or similar methods. ATR produces a reflectance spectrum and is useful for investigating samples of

crystals, fibers, viscous liquids, and surface coatings (including polymers) with little or no sample preparation.<sup>4</sup> Most IR spectrophotometers can be adapted to ATR measurements. Solutions are handled in sealed cells made of IR transparent materials such as NaCl, KBr, or AgCl. The cell plates are spaced between 0.05 - 2 mm apart. Compensation for solvent absorption is achieved by running a matched cell with pure solvent in a double beam instrument.

2. Liquid samples can be run as a film between two salt plates or in sealed, spaced cells for more precise measurements. In general, liquid samples are easiest to analyze.
3. Vapor samples must be run in cells having much longer optical paths than condensed phase samples. These "gas cells" have optical paths of several meters if low pressures or trace quantities are involved. The path length can be extended by multiple reflection of the radiation. Gas cells are extremely important in studying organic and inorganic gaseous pollutants of the atmosphere.<sup>5</sup> Inexpensive and effective gas cells for pollution work have been prepared from large polyethylene bags with salt plates at each end.

Microtechniques have been developed for handling very small gas, liquid, and solid samples. These techniques yield good spectra with less than 0.2  $\mu$ l of liquid, 0.1 mg solid, and very small gas samples. In addition, they are useful in examining components which have been separated by GC, HPLC, and TLC.

#### 4.5.2 Instruments and Manufacturers

The most useful and most widely studied region of the IR spectrum extends from 4000  $\text{cm}^{-1}$  to 625  $\text{cm}^{-1}$ . Most major bands fall within this region and can be handled using NaCl optics. The

far IR region,  $625\text{ cm}^{-1}$  to  $250\text{ cm}^{-1}$ , is being investigated intensively. (The grating spectrophotometer makes study of this region less expensive and more accessible.) This region includes sulfur, nitrogen, and phosphorus bonds to other atoms that are important in the study of pesticide residues and other contaminants.

The basic IR spectrophotometer contains: a source of IR radiation (covering the entire IR spectrum); a monochromator that disperses the radiation and isolates a narrow frequency range which is split into a double beam by a mirror arrangement; sample holders which position the sample and reference cells in their respective beams; and a detector that measures the difference in energy between the two beams thereby producing an electrical signal that is amplified and recorded. The frequency which is varied continuously, gives rise to a recorded IR absorption spectrum.

The usual sources are Nernst filaments or Globars (SiC rods) heated electrically. The detectors are usually thermopiles, thermocouples or Golay pneumatic detectors. Many refinements and optional attachments are available from commercial sources. Automatic recording IR double-beam spectrophotometers range in price from \$3000 for the basic, simplified models up to \$25,000 - \$30,000 for precision research instruments.

Simple models such as the Perkin-Elmer 137 (Infracord) are very reliable and easy to operate. They are useful for routine work

and have good potential for modification for trouble-free "in-situ" monitoring. The Beckman IR-20 grating spectrophotometer is a useful medium priced instrument that is fairly rugged, has excellent resolution, has considerable versatility, and can cover the IR range from  $4000\text{ cm}^{-1}$  to  $250\text{ cm}^{-1}$ . Comparable instruments are manufactured by Perkin-Elmer (Model 457). The Perkin-Elmer 621 and the Beckman IR-12 are expensive (\$20,000+), multipurpose precision instruments with wide capabilities.

The important criteria for IR spectrophotometers are maximum resolution, wave number accuracy and reproducibility, and percent transmittance accuracy and reproducibility.

1. Perkin Elmer Corporation  
702-G Main Avenue  
Norwalk, Connecticut 06852

Complete IR line from the inexpensive Model 727 (\$3000+) to the super high performance Model 180 at \$20,000+ ( $4000$  to  $180\text{ cm}^{-1}$  range).

2. Barnes Engineering Co.  
30 Commerce Road  
Stamford, Connecticut 06902

- a. Multispec IR analyzer; continuous analysis of gases, liquids, and mobile solids from  $1-20\ \mu$ ; multicomponent measurements.

- b. ATR and specular reflectance attachments among full line of accessories for commercial IR.

3. Beckman Instrument, Inc.  
2500 Harbor Blvd.  
Fullerton, California 92634

4. Wilks Scientific Corporation  
140 Water Street  
South Norwalk, Connecticut 06856

#### 4.5.3 Specialized IR Techniques

Specialized IR techniques are particularly useful for direct examination of gaseous atmospheric pollutants. They include dispersive and non-dispersive optical correlation methods. The dispersive technique uses a filter, whose transmission characteristics matches the spectrum of the compound to be detected, placed in the focal surface of the spectrometer. If the filter is a close match to the desired spectrum, the instrument will show high selectivity, even with complex mixtures. These instruments are highly sensitive, selective, and useful for continuous monitoring. Non-dispersive correlation instruments<sup>2</sup> use an absorption cell containing the gas to be measured as a matching filter.

The cross-correlating instruments<sup>2</sup> give good results in the open atmosphere and with short or long path cells. Standard double beam IR instruments can be modified for optical correlating techniques in the non-scanning mode with high sensitivity and selectivity for most stable air pollutants.

For complete spectra of mixtures, GC/IR is most promising.<sup>3</sup> Spectroscopy of low concentrations of materials can be improved by long path methods. For selective monitoring, the use of laser beams is very promising as path lengths can be extended tremendously with very little energy loss and collimation is easy because of the beam's coherence. Tunable lasers enhance the power and versatility of this technique. Portable IR spectrophotometers are marketed by Barnes and by Wilks and by other manufacturers.<sup>6</sup>

#### 4.5.4 References

1. An excellent introductory volume is: Cross, A. D., Practical Infra-Red Spectroscopy."
2. Philip L. Hanst in "Spectroscopic Methods on Air Pollution Measurement," which is a chapter in "Advances in Environmental Science and Technology." Vol. II, pp. 91-213, edited by Pitts, J. N. and Metcalf, R. L., Wiley, NY, 1971.
3. Brown, R. A., et al., Anal. Chem. 43, p. 353 (1971) (rapid scan IR, 5 sec. scan, sample size as low as 20  $\mu$ g).
4. Supplied by Barnes Engineering and other firms.
5. Reference 2, pp. 154-155.
6. See Section 4.5.2, Instruments and Manufacturers.

#### 4.6 Ion Selective Electrodes<sup>1,2</sup>

The most attractive features of Ion Selective Electrodes are their specificity, rapid response, and potential for "in-situ" measurement. They are often fairly rugged and their output is readily transmitted, stored, or measured. Although they are highly sensitive, their accuracy is relatively low. They have great potential for remote monitoring of rivers, lakes, and sea water.<sup>3</sup>

##### 4.6.1 Theory of Operation

In an Ion-Selective Electrode, a potential is developed across a membrane that (ideally) is permeable only to a specific ion. The membrane may be glass, solid, a liquid ion exchange or heterogeneous. The membrane contacts the sample on one side and a reference solution on its other side. The reference solution is of fixed activity. Using a reference electrode, the potential across the membrane is measured (potentiometry) using the Nernst Equation:

$$E = E_0 + 2.3RT/ZF \log a$$

$E_0$  is determined by standardizing the electrode in an appropriate solution of known activity,  $a$ . In most cases, the response is close to theory which leads to a precision of about  $\pm 0.2$  mV for direct potentiometric work or 0.8% relative error for univalent ions. In field use, temperature variation and infrequent standardization can lead to errors in the range of 10-15%.<sup>4</sup>

Speed of Response depends on the ion concentration, extent of concentration change, and amount of ionic interferences. For small concentration changes, only seconds are required; but usually 2-15 minutes are required for full response. Dilute solutions near the limit of detection may require hours for accurate results. In most cases, the instrument shows low drift (2-3%) over extended time periods.

Membrane electrodes respond to the activity of the free ion in solution. The activity of the specific ion will be decreased in solutions of high ionic strengths. For sea water and similar complex ionic mixtures, the approximate composition must be known so that the total concentration of the specific ion can be obtained from the sum of the free ion concentration and the complexed ion concentration. The free ion concentration can be calculated if its activity coefficient ( $\kappa$ ) is known.

$$a = \kappa c_{\text{free ion}} \text{ where } a \text{ is the known activity}$$

In some cases, PH changes will affect electrode response by shifting ionic equilibria.

#### 4.6.2 Selectivity and Sensitivity

Since very few membranes are completely selective, great care must be taken to avoid interfering ions in concentrations large enough to be measured. Liquid membranes<sup>5</sup> are more susceptible to interference

by ions of high activity, but corrections for interference can be often applied successfully.

Solid membrane electrodes are affected by interferences reacting chemically with their surface, changing the surface from the desired compound; e. g., silver-bromide to another species, such as silver thiocyanate (both solids). The ion ratio for this change depends on the ratio of solubility products of the insoluble compounds.<sup>6</sup>

Currently available electrodes, their pH range, limits of detection and interfering ions are listed in the attached table,<sup>3</sup> Table 4.6 and 4.7. The successful application of these electrodes for in-situ work is dependent on the lack of significant interferences. For laboratory work, samples may be treated with masking agents or separations can be effected before measurement. The result is higher sensitivity and accuracy. However, temperature effects still remain a serious problem in most in-situ work.

Many modifications, possible in laboratory work, can lead to very high accuracy and greatly increased sensitivity. Concentration cell techniques permit measurements on very small samples; e. g., determination of nanogram quantities of  $F^-$  and  $Ag^+$  in samples as small as 10  $\mu$ l with less than 1% error.<sup>7</sup> Microelectrodes have been developed for use with living species (in vivo) in their environments.<sup>8</sup> The important problem of total ion concentration of specific ions when substantial complexing is present can be treated effectively by known-addition techniques.<sup>9</sup>

Table 4.6

## Properties of Commercially Available Solid-State or Diffusion Electrodes\* 3

Ion	Electrode Concentration Range (M)	C <sub>0</sub> in Seawater (M)	pH Range	Interfering Ions			Minimum C <sub>0</sub> Determinable (M)	Useful In Situ?
				Ion i	Seawater C <sub>i</sub> (M)	C <sub>i</sub> Max. (M)		
Ammonia NH <sub>3</sub>	1 to 10 <sup>-6</sup>	0.4 to 4x10 <sup>-6</sup>	Must adjust to fixed pH or above 11	Volatile amines may interfere	Very low	-----	-----	No
Bromide Br <sup>-</sup>	1 to 5x10 <sup>-6</sup>	8x10 <sup>-6</sup>	0-14	S <sup>2-</sup>	0 (not anoxic)	10 <sup>-7</sup> M	-----	No
				Cl <sup>-</sup>	0.55	400 C <sub>0</sub>	1x10 <sup>-3</sup>	
				CN <sup>-</sup>	-----	trace	-----	
				I <sup>-</sup>	8x10 <sup>-8</sup>	trace	-----	
				OH <sup>-</sup>	10 <sup>-8</sup>	3x10 <sup>4</sup> C <sub>0</sub>	10 <sup>-13</sup>	
Cadmium Cd <sup>++</sup>	1 to 10 <sup>-7</sup>	1x10 <sup>-9</sup>	1-14	Ag <sup>+</sup>	4x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	No
				Hg <sup>++</sup>	2x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	
				Cu <sup>++</sup>	5x10 <sup>-8</sup>	10 <sup>-7</sup> M	-----	
				Fe <sup>+++</sup>	very low	C <sub>0</sub>	-----	
				Pb <sup>++</sup>	2x10 <sup>-10</sup>	C <sub>0</sub>	2x10 <sup>-10</sup>	
Chloride Cl <sup>-</sup>	1 to 5x10 <sup>-5</sup>	5.5x10 <sup>-1</sup>	0-14	S <sup>2-</sup>	0	10 <sup>-7</sup> M	-----	Maybe
				Br <sup>-</sup>	8x10 <sup>-4</sup>	3x10 <sup>-3</sup> to 3x10 <sup>-5</sup> C <sub>0</sub>	2 to 0.2	
				CN <sup>-</sup>	-----	trace	-----	
				I <sup>-</sup>	8x10 <sup>-8</sup>	trace	-----	
				S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	-----	10 <sup>-2</sup> C <sub>0</sub>	-----	
				NH <sub>4</sub> <sup>+</sup>	3.5x10 <sup>-6</sup>	1/8 C <sub>0</sub>	3x10 <sup>-5</sup>	
				OH <sup>-</sup>	10 <sup>-8</sup>	10 <sup>-2</sup> C <sub>0</sub>	1x10 <sup>-10</sup>	
Cupric Cu <sup>++</sup>	1 to 10 <sup>-7</sup>	5x10 <sup>-8</sup>	0-14	S <sup>2-</sup>	0	10 <sup>-7</sup> M	-----	No
				Hg <sup>++</sup>	2x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	
				Ag <sup>+</sup>	4x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	
				Cl <sup>-</sup>	0.55	high	?	
				Fe <sup>+++</sup>	very low	0.1C <sub>0</sub>	-----	
				Br <sup>-</sup>	8x10 <sup>-4</sup>	high	?	
Cyanide CN <sup>-</sup>	10 <sup>-2</sup> to 10 <sup>-6</sup>	Low	0-14	S <sup>2-</sup>	0	10 <sup>-7</sup> M	-----	No
				Cl <sup>-</sup>	0.55	10 <sup>6</sup> C <sub>0</sub>	5x10 <sup>-7</sup>	
				Br <sup>-</sup>	8x10 <sup>-4</sup>	5000 C <sub>0</sub>	2x10 <sup>-7</sup>	
				I <sup>-</sup>	8x10 <sup>-8</sup>	0.1 C <sub>0</sub>	8x10 <sup>-7</sup>	
				metal complexants	-----	-----	-----	
Fluoride F <sup>-</sup>	1 to 10 <sup>-6</sup>	7x10 <sup>-5</sup>	0-8.5	OH <sup>-</sup>	10 <sup>-6</sup>	10 C <sub>0</sub>	10 <sup>-7</sup>	Yes
Iodide I <sup>-</sup>	1 to 2x10 <sup>-7</sup>	8x10 <sup>-8</sup>	0-14	S <sup>2-</sup>	0	10 <sup>-7</sup> M	-----	No
				Cl <sup>-</sup>	0.5	10 <sup>6</sup> C <sub>0</sub>	5x10 <sup>-7</sup>	
				Br <sup>-</sup>	8x10 <sup>-4</sup>	5000 C <sub>0</sub>	2x10 <sup>-7</sup>	
				CN <sup>-</sup>	nil	0.4 C <sub>0</sub>	-----	
Lead Pb <sup>++</sup>	1 to 10 <sup>-7</sup>	2x10 <sup>-10</sup>	2-14	Ag <sup>+</sup>	4x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	No
				Cu <sup>++</sup>	5x10 <sup>-8</sup>	10 <sup>-7</sup> M	-----	
				Hg <sup>++</sup>	2x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	
				Fe <sup>+++</sup>	Low	C <sub>0</sub>	-----	
				Cd <sup>++</sup>	1x10 <sup>-9</sup>	C <sub>0</sub>	1x10 <sup>-9</sup>	
				H <sub>2</sub> <sup>++</sup>	2x10 <sup>-10</sup>	10 <sup>-7</sup> M	-----	
Silver Ag <sup>+</sup>	1 to 10 <sup>-7</sup>	4x10 <sup>-10</sup>	0-14	None	-----	-----	-----	No
Sulfide S <sup>2-</sup>	1 to 10 <sup>-7</sup>	0 to 6x10 <sup>-4</sup>	0-14	None	-----	-----	-----	Yes
Thiocyanate SCN <sup>-</sup>	1 to 5x10 <sup>-6</sup>	Low	0-14	OH <sup>-</sup>	10 <sup>-8</sup>	100 C <sub>0</sub>	1x10 <sup>-10</sup>	No
				Br <sup>-</sup>	8x10 <sup>-4</sup>	3x10 <sup>-3</sup> C <sub>0</sub>	3x10 <sup>-7</sup>	
				Cl <sup>-</sup>	5x10 <sup>-1</sup>	20 C <sub>0</sub>	3x10 <sup>-2</sup>	
				NH <sub>3</sub>	4x10 <sup>-6</sup>	0.13 C <sub>0</sub>	3x10 <sup>-5</sup>	
				S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	Nil	0.01 C <sub>0</sub>	-----	
				CN <sup>-</sup>	Nil	7x10 <sup>-3</sup> C <sub>0</sub>	-----	
				I <sup>-</sup>	8x10 <sup>-8</sup>	10 <sup>-7</sup> M	-----	
				S <sup>2-</sup>	Nil	10 <sup>-7</sup> M	-----	

\*Col. 2 gives the concentration range in which electrode is useful; Col. 3 gives C<sub>0</sub>, the concentration of the given ion in seawater; Col. 4 gives the useful pH range of the electrode; Col. 6 gives C<sub>i</sub>, the concentration of interfering ion i in seawater; Col. 7 gives maximum permissible C<sub>i</sub> relative to C<sub>0</sub>, i.e., the electrode selectivity for ion i; and Col. 8 gives minimum C<sub>0</sub> determinable in seawater due to presence of ion i as an interference. Interfering concentrations given for NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup> in seawater are at the high end of the normally encountered range. All units in moles/liter or gram-atoms/liter.

Table 4.7

Properties of Commercially Available Electrodes with Liquid and Glass Ion Exchange Membranes<sup>3</sup>

Ion	Electrode Concentration Range (M)	C <sub>0</sub> in Seawater (M)	pH Range	Interfering Ions				Useful In Situ?					
				Ion i	k <sub>i</sub>	Seawater C <sub>i</sub> (M)	k <sub>i</sub> b <sub>i</sub> (see text)						
Ammonium <sup>30</sup> NH <sub>4</sub> <sup>+</sup>	10 <sup>-1</sup> to 10 <sup>-6</sup>	0.4 to 4x10 <sup>-6</sup>	not specified	Hg <sup>++</sup>	3x10 <sup>-1</sup>	2x10 <sup>-10</sup>	2x10 <sup>-7</sup>	No					
				K <sup>+</sup>	1.5x10 <sup>-1</sup>	1x10 <sup>-2</sup>	7x10 <sup>-5</sup>						
				Rb <sup>+</sup>	1.2x10 <sup>-1</sup>	2x10 <sup>-6</sup>	1x10 <sup>-7</sup>						
				Ag <sup>+</sup>	5x10 <sup>-2</sup>	4x10 <sup>-10</sup>	2x10 <sup>-11</sup>						
				Na <sup>+</sup>	1.7x10 <sup>-3</sup>	5x10 <sup>-1</sup>	5x10 <sup>-4</sup>						
				Ba <sup>++</sup>	1.10 <sup>-3</sup>	2x10 <sup>-7</sup>	2x10 <sup>-8</sup>						
				Cu <sup>++</sup>	1x10 <sup>-4</sup>	5x10 <sup>-8</sup>	4x10 <sup>-9</sup>						
				Pb <sup>++</sup>	1x10 <sup>-4</sup>	1x10 <sup>-10</sup>	5x10 <sup>-10</sup>						
				Co <sup>++</sup>	7x10 <sup>-5</sup>	1x10 <sup>-2</sup>	4x10 <sup>-6</sup>						
				Ni <sup>++</sup>	7x10 <sup>-5</sup>	5x10 <sup>-8</sup>	3x10 <sup>-9</sup>						
				Mn <sup>++</sup>	7x10 <sup>-5</sup>	3x10 <sup>-8</sup>	4x10 <sup>-9</sup>						
				Zn <sup>++</sup>	7x10 <sup>-5</sup>	2x10 <sup>-7</sup>	2x10 <sup>-8</sup>						
				Calcium Ca <sup>++</sup>	1 to 10 <sup>-5</sup>	10 <sup>-2</sup>	5.5-11		Zn <sup>++</sup>	3.2	2x10 <sup>-7</sup>	2x10 <sup>-7</sup>	Yes
									Fe <sup>++</sup>	0.8	< 2x10 <sup>-7</sup>	< 5x10 <sup>-8</sup>	
Pb <sup>++</sup>	0.63	1x10 <sup>-10</sup>	2x10 <sup>-11</sup>										
Mg <sup>++</sup>	0.014	5x10 <sup>-2</sup>	3x10 <sup>-4</sup>										
Se <sup>++</sup>	0.01	2x10 <sup>-7</sup>	6x10 <sup>-10</sup>										
Be <sup>++</sup>	0.003	0.5	4x10 <sup>-4</sup>										
Chloride Cl <sup>-</sup>	10 <sup>-1</sup> to 10 <sup>-5</sup>	0.5	2-10	I <sup>-</sup>	17	8x10 <sup>-8</sup>	10 <sup>-6</sup>	Yes					
				NO <sub>3</sub> <sup>-</sup>	4.2	4x10 <sup>-5</sup>	1x10 <sup>-4</sup>						
				Br <sup>-</sup>	1.6	8x10 <sup>-4</sup>	9x10 <sup>-4</sup>						
				OH <sup>-</sup>	1.0	10 <sup>-6</sup>	10 <sup>-6</sup>						
				HCO <sub>3</sub> <sup>-</sup>	0.19	2.3x10 <sup>-3</sup>	4x10 <sup>-4</sup>						
				SO <sub>4</sub> <sup>2-</sup>	0.14	2.8x10 <sup>-2</sup>	1x10 <sup>-2</sup>						
Chloride (continued)				F <sup>-</sup>	0.1	7x10 <sup>-5</sup>	5x10 <sup>-6</sup>						
				Divalent Cation (Mg <sup>++</sup> & Ca <sup>++</sup> )	1 to 10 <sup>-8</sup>	Ca <sup>++</sup> : 1x10 <sup>-2</sup> Mg <sup>++</sup> : 5x10 <sup>-2</sup>	~ 5.5-11		Zn <sup>++</sup>	1	2x10 <sup>-7</sup>	6x10 <sup>-8</sup>	Yes
									Sr <sup>++</sup>	1	2x10 <sup>-7</sup>	6x10 <sup>-8</sup>	
									Mg <sup>++</sup>	1			
									Co <sup>++</sup>	1			
									Na <sup>+</sup>	1x10 <sup>-2</sup>	5x10 <sup>-1</sup>	1x10 <sup>-3</sup>	
K <sup>+</sup>	1x10 <sup>-2</sup>	1x10 <sup>-2</sup>	5x10 <sup>-7</sup>										
Fluoroborate BF <sub>4</sub> <sup>-</sup>	0.5 to 10 <sup>-5</sup> (BF <sub>4</sub> <sup>-</sup> ) 3x10 <sup>-6</sup> (F <sup>-</sup> ) <sup>300</sup>		2-12	I <sup>-</sup>	0.13	8x10 <sup>-8</sup>	8x10 <sup>-9</sup>	No					
				NO <sub>3</sub> <sup>-</sup>	2x10 <sup>-2</sup>	4x10 <sup>-5</sup>	6x10 <sup>-7</sup>						
				Br <sup>-</sup>	1x10 <sup>-2</sup>	8.2x10 <sup>-4</sup>	6x10 <sup>-6</sup>						
				Cl <sup>-</sup>	5x10 <sup>-4</sup>	5x10 <sup>-2</sup>	2x10 <sup>-5</sup>						
				F <sup>-</sup>	2x10 <sup>-4</sup>	7x10 <sup>-5</sup>	1x10 <sup>-9</sup>						
				PO <sub>4</sub> <sup>3-</sup>	2x10 <sup>-4</sup>	< 3x10 <sup>-6</sup>	< 1x10 <sup>-6</sup>						
				S <sup>2-</sup>	1x10 <sup>-4</sup>	0	-----						
				CO <sub>3</sub> <sup>2-</sup>	5x10 <sup>-6</sup>	< 2x10 <sup>-3</sup>	< 1x10 <sup>-7</sup>						
				SO <sub>4</sub> <sup>2-</sup>	< 1x10 <sup>-4</sup>	3x10 <sup>-2</sup>	2x10 <sup>-8</sup>						
									ClO <sub>3</sub> <sup>-</sup> , ClO <sub>4</sub> <sup>-</sup> , OAc <sup>-</sup> , CN <sup>-</sup> , Fe(CN) <sub>6</sub> <sup>4-</sup> are low				
				Nitrate NO <sub>3</sub> <sup>-</sup>	10 <sup>-1</sup> to 10 <sup>-5</sup>	0 to 4x10 <sup>-5</sup>	2-12		ClO <sub>3</sub> <sup>-</sup>	1000	low	-----	No
									I <sup>-</sup>	20	8x10 <sup>-8</sup>	1x10 <sup>-4</sup>	
									Br <sup>-</sup>	1x10 <sup>-1</sup>	8.2x10 <sup>-4</sup>	6x10 <sup>-5</sup>	
									NO <sub>2</sub> <sup>-</sup>	4x10 <sup>-2</sup>	< 3x10 <sup>-4</sup>	< 8x10 <sup>-8</sup>	
Nitrate (continued)				Cl <sup>-</sup>	4x10 <sup>-3</sup>	5x10 <sup>-1</sup>	1x10 <sup>-3</sup>						
				CO <sub>3</sub> <sup>2-</sup>	2x10 <sup>-4</sup>	< 2x10 <sup>-3</sup>	< 4x10 <sup>-6</sup>						
				F <sup>-</sup>	6x10 <sup>-5</sup>	7x10 <sup>-5</sup>	3x10 <sup>-9</sup>						
				SO <sub>4</sub> <sup>2-</sup>	3x10 <sup>-5</sup>	3x10 <sup>-2</sup>	3x10 <sup>-4</sup>						
Perchlorate ClO <sub>4</sub> <sup>-</sup>	10 <sup>-1</sup> to 10 <sup>-5</sup>	low	4-11	I <sup>-</sup>	1.2x10 <sup>-2</sup>	8x10 <sup>-8</sup>	7x10 <sup>-10</sup>	No					
				NO <sub>3</sub> <sup>-</sup>	1.5x10 <sup>-3</sup>	4x10 <sup>-5</sup>	4x10 <sup>-8</sup>						
				Br <sup>-</sup>	5.6x10 <sup>-4</sup>	8.2x10 <sup>-4</sup>	3x10 <sup>-7</sup>						
				F <sup>-</sup>	2.5x10 <sup>-4</sup>	7x10 <sup>-5</sup>	1x10 <sup>-8</sup>						
				Cl <sup>-</sup>	2.2x10 <sup>-4</sup>	0.5	8x10 <sup>-4</sup>						
Potassium K <sup>+</sup> <sup>3000</sup>	1 to 5x10 <sup>-6</sup>	10 <sup>-2</sup>	-2-11	Rb <sup>+</sup>	2.2	low	-----	Yes					
				Ca <sup>++</sup>	5x10 <sup>-1</sup>	4x10 <sup>-9</sup>	2x10 <sup>-9</sup>						
				NH <sub>4</sub> <sup>+</sup>	1.4x10 <sup>-2</sup>	< 4x10 <sup>-6</sup>	< 6x10 <sup>-8</sup>						
				Ag <sup>+</sup>	2x10 <sup>-3</sup>	4x10 <sup>-10</sup>	6x10 <sup>-13</sup>						
				Li <sup>+</sup>	3x10 <sup>-4</sup>	2x10 <sup>-5</sup>	4x10 <sup>-9</sup>						
				H <sup>+</sup>	2x10 <sup>-4</sup>	~ 10 <sup>-8</sup>	2x10 <sup>-12</sup>						
				Na <sup>+</sup>	< 2x10 <sup>-4</sup>	5x10 <sup>-1</sup>	< 7x10 <sup>-5</sup>						
				Cu <sup>++</sup>	5x10 <sup>-5</sup>	5x10 <sup>-8</sup>	6x10 <sup>-9</sup>						
				Co <sup>++</sup>	4x10 <sup>-5</sup>	1x10 <sup>-2</sup>	2x10 <sup>-6</sup>						
				Ni <sup>++</sup>	4x10 <sup>-5</sup>	5x10 <sup>-2</sup>	5x10 <sup>-4</sup>						
Sodium Na <sup>+</sup>	1 to 10 <sup>-6</sup>	3.5	3-12	Ag <sup>+</sup>	350	4x10 <sup>-10</sup>	3x10 <sup>-8</sup>	Yes					
				K <sup>+</sup>	100	~ 10 <sup>-8</sup>	1x10 <sup>-4</sup>						
				Li <sup>+</sup>	2x10 <sup>-3</sup>	2x10 <sup>-5</sup>	3x10 <sup>-8</sup>						
				Ca <sup>++</sup>	1.5x10 <sup>-3</sup>	4x10 <sup>-9</sup>	5x10 <sup>-12</sup>						
				K <sup>+</sup>	1x10 <sup>-3</sup>	1x10 <sup>-2</sup>	7x10 <sup>-4</sup>						
				H(C <sub>2</sub> H <sub>3</sub> ) <sub>4</sub> <sup>+</sup>	5x10 <sup>-4</sup>	low	-----						
				Tl <sup>+</sup>	2x10 <sup>-4</sup>	low	-----						
				Mn <sup>++</sup>	3x10 <sup>-5</sup>	< 4x10 <sup>-4</sup>	< 9x10 <sup>-11</sup>						
				Rb <sup>+</sup>	3x10 <sup>-5</sup>	low	-----						

<sup>30</sup>Col. 6 gives k<sub>i</sub> the selectivity ratio for interfering ion i listed in Col. 5. If the k<sub>i</sub>b<sub>i</sub> term in Col. 8 is small relative to C<sub>0</sub> in Col. 3, then interference due to this ion is negligible.



<sup>3000</sup>A solid organic membrane (Cosgrove, Mask, and Krull, 1970).

<sup>30000</sup>A solid organic membrane (Krull, Mask, and Cosgrove, 1970).

One of the most important areas to be developed is the wider application of ion-selective electrodes for "in-situ" analyses. The selectivity of  $\text{Cu}^{++}$  electrodes and others hampered by interferences should be capable of improvement by electrode membrane design or by developments in masking techniques for in-situ work.

#### 4.6.3 Instruments and Manufacturers

Several commercial firms offer ion selective electrodes and accessories. For example, Orion sells a  $\text{Cu}^{++}$  selective electrode for about \$300 that is sensitive to  $10^{-7}$  M (molar)  $\text{Cu}^{++}$ . In addition, Orion offers a complete range of other ion-selective electrodes and accessories. Leeds and Northrup, Corning, Beckman, and London are other excellent sources. Special apparatus can be ordered from these and many other sources.

1. Orion Research  
11 Blackstone Street  
Cambridge, Massachusetts 02139  
Complete line of electrodes including  $\text{F}^-$  and  $\text{Cu}^{++}$  (\$250);  
also, meters and reference electrodes.
2. Leeds and Northrup Company  
Sumneytown Pike  
North Wales, Pennsylvania 19454  
Fairly complete line of ion selective electrodes.
3. Corning Glass Works  
Houghton Park  
Corning, New York 14830

4. The London Company  
811 Sharon Drive  
Cleveland, Ohio 44145

Selectrodes - claim excellent selectivity and response for  $\text{Cl}^-$ ,  $\text{Br}^-$ , and  $\text{Cu}^{++}$ ; also, new types using electro-active materials on graphite rod surfaces.

#### 4.6.4 References

1. Excellent source: Durst, R. A., "Ion Selective Electrodes," NBS special publication 314, (1969); contains contributions on all aspects of the field.
2. Buck, R. P. in Physical Methods of Chemistry, Part IIA, Electrochemical Methods (edited by Weissburger, A.), pp. 61-162, Wiley, New York, 1971. Excellent survey of principles and applications.
3. Warner, T. B., MTS Journal 6, pp. 24-32, (1972).
4. Ross, (1969), in reference 3.
5. Reference 2, page 149, Table 2.19.
6. Reference 2, pp. 141-142.
7. Reference 1, pp. 371-379.
8. Walker, (1971), in reference 3.
9. Bauman, E. W., Anal. Chem. Acta 42, pp. 127-132, (1968).

#### 4.7 Mass Spectrometry

In the last few years, there has been remarkable growth in the application of mass spectrometry to a very wide range of problems in analysis and structure determination.<sup>1</sup> Mass spectrometry is useful in the analysis of gas, liquid, and solid inorganic and organic pollutants.<sup>2,3</sup> Because the instrument needs only a very small sample and is highly sensitive, it is well suited for analysis of trace materials (and for coupling with Gas Chromatography).

Recently, the reliability, sensitivity, and resolving power of inexpensive mass spectrometers have been increased by significant improvements in design.<sup>1,2,10</sup> These low and medium resolution instruments (especially quadrupole types) are much more reliable and troublefree than in the past. High resolution instruments have also increased in resolving power and reliability but are still very expensive and require expert attention for proper operation.

##### 4.7.1 Theory of Operation

The main purpose of a mass spectrometer is the measurement of the mass/charge ratio of ions in order to identify them. There are four major parameters in mass spectrometry: mass, charge, velocity, and intensity (mass and charge are determined as a ratio  $m/e$ ). The resolution of an ion beam of mass  $m$  from a beam of very similar mass  $m + \Delta m$ , and the maximization of the resolved ion intensities

are the principal objectives of a mass spectrometer. These can be compared to the action of prisms (dispersion) and lenses (focusing) in optical systems and are carried out by magnetic and electric fields.

Momentum, energy, and velocity are the three most important properties of charged particles. Only two are needed to determine  $m/e$  ratios. All mass analyzers utilize one or more of three basic principles: (a) magnetic analysis, (b) electrostatic analysis, and (c) time of flight analysis. The many types of mass spectrometers including single and double focusing magnetic analyzers, cycloidal, cyclotron resonance, time of flight, quadrupole and  $f$  mass filter instruments all operate on the above principles.

#### 4.7.1.1 Magnetic Analysis

In the simple magnetic analyzer illustrated in Fig. 4.2, an electrostatic accelerator is used to obtain an ion beam homogeneous in energy, and a homogeneous magnetic field effects mass dispersion. Under these conditions the radius of curvature for an ion in cm will be given by:

$$r_m = 144 (1/B) \sqrt{MV/e}$$

where

$B$  = magnetic flux density in Gauss, G.

For example, an  $^{14}\text{N}^+$  ion accelerated to 2000 eV will be bent by a 100 G magnetic field into a curved path of approximately a 24 cm radius. An  $^{15}\text{N}^+$  ion will have a radius of approximately 25 cm under the same conditions. In the Fig. 4.2, the ion collector is shown in a fixed position which corresponds to a fixed value of  $r_m$ . Successive ions of increasing  $M/e$  are brought onto the collector by scanning methods involving varying  $V$  with  $B$  fixed or  $B$  with  $V$  fixed (voltage and magnetic scanning).

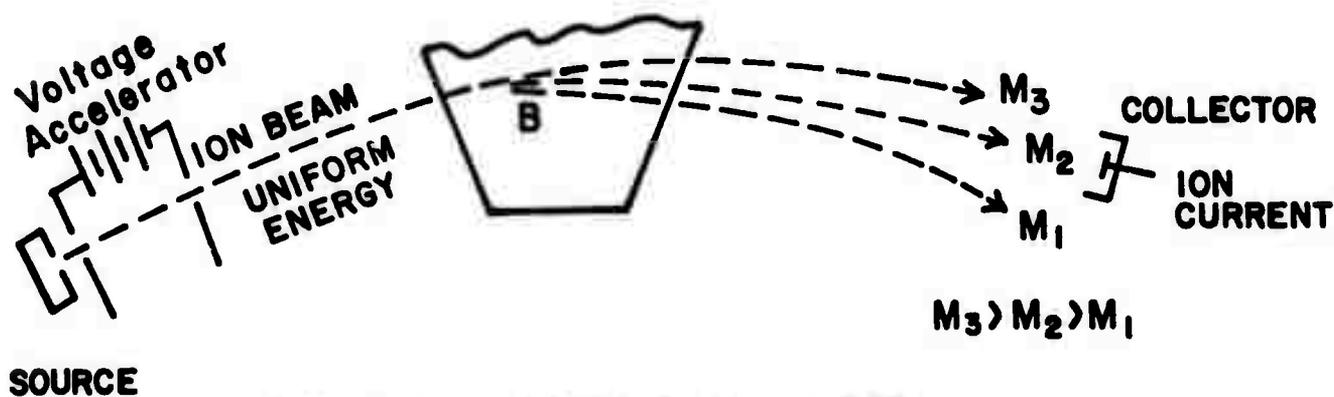


FIG. 4.2 MAGNETIC ANALYZER

A single focusing instrument of this type has a maximum resolving power of about 3000, which is adequate for most pollutant analyses. Higher resolution with magnetic instruments requires double focusing with attendant increases in price, complexity, difficulty of operation and down time.

#### 4.7.1.2 Electrostatic Analysis

Electrostatic analysis involves the use of radial electrostatic fields as energy filters for ion beams. If positive ions of various masses and energies are injected midway between the plates of two coaxial sector shaped electrodes, some of the ions will describe an exactly circular trajectory along the equipotential curve, PQ; these ions must have an energy such that the centrifugal force is exactly balanced by the acting electrostatic force:

$$mv^2/r_e = eE$$

since

$$\text{K.E.} = mv^2/2 = eE \quad \text{and} \quad v^2 = 2eV/m$$

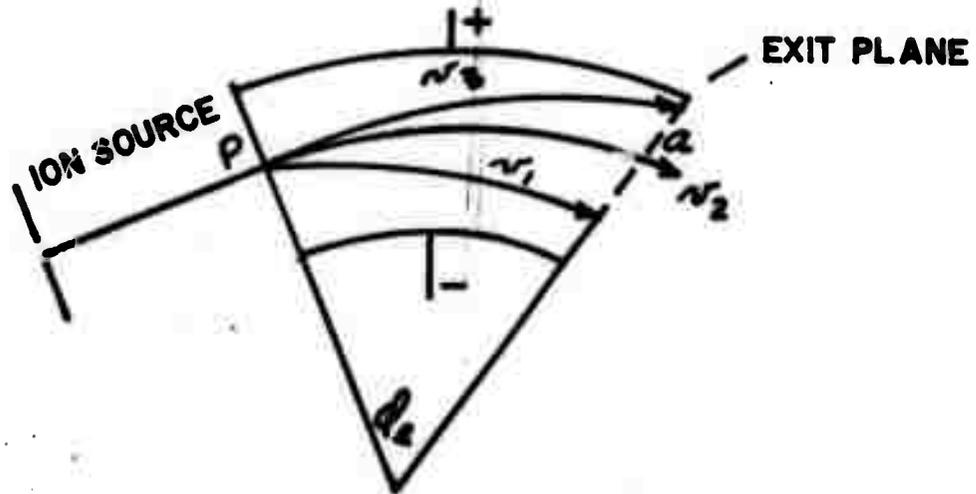
then

$$m(2eV/m) = r_e eE$$

and

$$r_e = 2V/E.$$

Therefore, the electrostatic analyzer does not analyze mass but rather analyzes energy in terms of V (potential difference). Only ions with a predetermined energy can follow a circular path of radius  $r_e$ , and these ions can be passed through a small aperture in the exit plane yielding an ion beam nearly homogeneous in energy. Ions with other energies will follow more complex trajectories resulting in an energy spectrum at the exit plane. The prism action of the electrostatic field is illustrated below in Fig. 4.3.



NOTE THAT THE BEAM FROM THE SOURCE IS NOT MADE HOMOGENEOUS

FIG. 4.3 ELECTROSTATIC FIELD ANALYZER

#### 4.7.1.3 Time of Flight Analysis

Time of flight analysis achieves dispersion by the velocity differences between ions of different masses in a homogeneous energy beam. A short pulse will disperse, as it moves through a "drift" tube, into groups of ions having the same mass. No magnetic fields are needed in a linear path instrument.

The velocity acquired by an ion passed through an electrostatic analyzer (to get a homogeneous energy beam) is given by:

$$v = \sqrt{2eV/m}$$

and the time of flight:

$$t_f = d/v = d \sqrt{1/2v} \sqrt{m/e}$$

where

where  $d$  = linear path distance.

With  $d$  and  $v$  constant:

$$t_f \propto \sqrt{m/e}$$

For example the time of flight for  $^{15}\text{N}^+$  in a 1 meter drift tube is  $6.1 \mu\text{sec}$ .  $^{14}\text{N}^+$  will then have a time of flight =  $6.1 \sqrt{14/15} = 5.8 \mu\text{sec}$ .

At higher masses, good resolution requires tremendously sophisticated electronics as the mass ratios approach 1. Instruments using magnetic fields in conjunction with time of flight methods show greatly improved resolution (ion cyclotron methods). Time of flight methods are simple and permit very rapid scanning. However, linear time of flight is limited to resolution less than 700. Their best application has been in Gas Chromatograph-Mass Spectrometer (GC-MS) where they are being displaced by quadrupole<sup>10</sup> and low resolution magnetic analyzers.

#### 4.7.2 Operation of Simple Mass Spectrometer

Every mass spectrometer has 4 functional elements:

1. The source, where the ion beam representative of the sample is generated;
2. The analyzer, in which the separation is effected either in space or in time;
3. The detector, where the resolved ions are detected and their number is counted; and

4. The vacuum system, where all the processes occur.

The sample inlets can be considered as part of the vacuum system.

#### 4.7.3 Sources

(1) Electron impact is the most frequently used source type. The sample is introduced in gaseous form into an evacuated chamber where it is bombarded by a stream of electrons perpendicular to the direction of gas flow. The energy and intensity of the beam is closely regulated. Energies of 70 - 80 V are generally used. Ions are separated from electrons and removed by a repeller voltage and a drawing out field. Since samples must be gaseous, vaporization for very low vapor pressure materials ( $<10^{-1}$  torr @ 250°C) must be provided for in the source. Vaporization can be achieved by heating in a crucible, arc-imaging, laser beam heating, etc.

(2) Thermal sources involve evaporation of the sample in solution or as a slurry from a filament. It is generally imaged by an adjacent filament at higher temperature.

(3) Ion bombardment by energetic positive ions (20-1800 eV) of a solid sample leads to removal of charged particles from the surface of the sample (sputtering). Argon ions are often used as bombardment particles (very useful for surface studies).

(4) Vacuum discharge sources involve building up a potential between electrodes until discharge occurs. Ions are produced by the resulting spark.

The electron impact and thermal emission sources produce an ion beam with a low energy spread, allowing higher resolution with single focusing instruments.

The basic types of analyzers have been described previously. Resolution ( $R = m/\Delta m$ ) varies with the analyzer type. Double focusing instruments can achieve  $R > 120,000$ .

#### 4.7.4 Ion Detectors

Detection can be achieved by electrical or photographic means. Sensitivity and speed of response are the vital parameters; one can only be increased at the expense of the other. The lower limit of ion current detection is near  $2 \times 10^{-19}$  amperes. (One ion/sec.)

Both electrometers and multipliers are used in detection. Vibrating reed (VR) electrometers can detect  $10^{-6}$  amperes or a response time of  $\approx 1$  sec. Secondary electron multipliers can be used to achieve high detection sensitivity or rapid recording measurement to  $10^{-18}$  amperes has been accomplished. Photographic techniques are still useful detectors, especially with spark sources as they are integral detectors.

#### 4.7.5 Applications

Mass spectrometry is still used for trace analysis of gases,<sup>4</sup> where it functions better when linked with a Gas Chromatograph. Parts per billion (ppb) analyses of good accuracy can be achieved with pre-concentration.<sup>1</sup> Trace metals and particulates in the atmosphere, water, sediments, and solids can be readily handled.<sup>3</sup> Complex mixtures can be analyzed directly by the potent GC/MS/computer combination.<sup>5</sup> or by pre-separation by GC, HPLC or TLC followed by mass spectrometry. The fragmentation patterns obtained with organic compounds, coupled with the molecular weight given by the parent ion can be used in elucidating the structure of new compounds as "fingerprints" in identification.<sup>7</sup> Quantitative results of high accuracy are possible as well. Pesticide residues, PCBs and other important pollutants are best treated by the GC/MS combination.<sup>8</sup> The problems of coupling GC and MS (reduction of effluent pressure to  $10^{-5}$  torr; i.e., removal of carrier gas) have been solved by several methods including those of Watson and Biemann.<sup>9</sup>

#### 4.7.6 Instrument and Manufacturers

At present, there are many mass spectrometer manufacturers. The price of the instrument depends mainly on the performance attained and, generally, upon the resolution.

Residual gas analyzers are the least expensive ranging from \$3,000-\$5,000 with a resolution up to 80. Quadrupole types with resolution to 500 are selling for \$8,000-\$13,000. These do not have full vacuum and inlet systems. The full mass spectrometer versions of these sell as high as \$25,000. An exception is the low price Varian EM 600, which is a full magnetic-mass spectrometer (each \$6,000), mass to 350 Atomic Mass Units (AMU).

General purpose medium resolution instruments ( $\geq 3000$ ) and time of flight instruments ( $R \leq 700$ ) are in the \$30,000-\$50,000 range. High resolution, double focusing instruments run to \$100,000 or more. Many optional accessories are available with these instruments and special modifications can be ordered.

An excellent guide to selecting instruments is given by Roboz,<sup>1</sup> see Table 4.8. Most analytical work with inorganic or organic ions can be handled by low and medium resolution instruments. An important consideration for GC/MS is rapidity of scanning and response. However, time of flight and quadrupole instruments do better and these are obtainable from Bendix and Finnigan, respectively.

**Table 4.8**

**Instrument Manufacturers and Representatives <sup>1</sup>**

Company*	Address	Specialty
Aero Vac Corp.	Troy, N.Y.	Single-focusing magnetic; magnetic residual
AEI: Associated Electrical Industries, Ltd. Marketed in USA by Picker X-Ray Corp.	Manchester, England, 1275 Mamaroneck Ave., White Plains, N.Y.	Full line single/double focusing magnetic
AVCO Corp., Electronics Division	10700 E. Independence St., Tulsa, Oklahoma	Custom-made 90° single-focusing magnetic with variety of sources TOF instruments
Bendix: The Bendix Corp., Cincinnati Division	3130 Wasson Road, Cincinnati, Ohio	
CEC: Consolidated Electro-dynamics Corp. A subsidiary of Bell & Howell Corp.	1500 S. Shamrock Ave., Monrovia, Calif.	Full line single/double focusing magnetic; magnetic residual
EAI: Electronic Associates, Inc. Finniigan Instruments Corp.	4151 Middlefield Rd., Palo Alto, Calif. 2625 Hanover St., Stanford Industrial Park, Palo Alto, California	Quadrupole Quadrupole
GCA Corp., Technology Division GE: General Electric Co. Vacuum Products Division	Bedford, Mass. Schenectady, N.Y.	Double-focusing ion microprobe Monopole residual Magnetic residual
Granville-Phillips Co.	5675 East Arapahoe Ave., Boulder, Colo.	Quadrupole residual
Hitachi: Hitachi Ltd. Marketed in USA by Perkin-Elmer Corp.	Tokyo, Japan Main Ave., Norwalk, Conn.	Full line single/double focusing magnetic
JEOL: Japan Electron Optics Laboratory Co.	477 Riverside Ave., Medford, Mass.	Full line single/double focusing magnetic
LKB Instruments, Inc.	1221 Parklawn Drive, Rockville, Maryland	60° single-focusing magnetic for gas chromatography work
NUCLIDE: Nuclide Analysis Associates	642 E. College Ave., State College, Pa.	Full line single/double focusing magnetic; custom-made instruments
The Perkin-Elmer Corp.	Main Ave., Norwalk, Conn.	Nier-Johnson intermediate-resolution double-focusing
Process & Instruments Co.	15 Stone Ave., Brooklyn, N.Y.	Custom-made 60° deflection magnetic
Sloan Instruments Corp.	P.O. Box 4608, Santa Barbara, Calif.	Omegatrons
Thomson-Houston Corp.	173 Bd Haussmann, Paris, France	Full line single-focusing magnetic
Utek Corp., subsidiary of The Perkin-Elmer Corp.	Box 10920, Palo Alto, Calif.	Quadrupole residual
Vacuum Electronics Corp.	Terminal Drive, Plainview, N.Y.	Magnetic deflection residual
Varian Associates	611 Hansen Way, Palo Alto, Calif.	Cycloidal, intermediate-resolution; synchrotron; quadrupole residual
Varian/MAT, formerly Fried. Krupp Mess und Analysen Technik	Wolterhauser Str. 442, Bremen, Germany	Full line single/double focusing magnetic; quadrupole residual

\* Abbreviations preceding full names are used in text to identify manufacturers

#### 4.7.7 References

1. An excellent book on recent developments: Roboz, J., "Introduction to Mass Spectrometry," Interscience, New York, 1968.
2. White, F. A., "Mass Spectrometry in Science and Technology," Wiley, New York, 1968.
3. Roboz, J. in "Trace Analysis: Physical Methods," edited by Morrison, G. H.
4. Rhapman, R. L., "Environmental Pollution Instrumentation," ISA, Pittsburgh, 1969.
5. Binks, R., Chem. Britain, 7, p. 8, (1971), "Real Time Processing of Low Resolution Mass Spectra."
6. See Sections on GC and HPLC and Bobbit, J., "Introduction to Chromotography."
7. For examples, see Budzukiewicz, H., Djerassi, C., and Williams, D. H., "Interpretation of Mass Spectra of Organic Compounds," Holden-Day, San Francisco, 1964.
8. Bonelli, E. J., American Laboratory, 3, pp. 27-37, (1971), (Finnigan model 1015 used).
9. Watson, J. T. and Biemann, K., Anal. Chem., 37, p. 849, (1965).
10. NOTE: An excellent introduction to the important new developments in Radio Frequency (RF) quadrupole mass spectrometry. Lawson, G. and Todd, J. F. J., Chem. Britain, 8, p. 373, (1972). While resolution is approximately 500, they are highly sensitive, rugged, and have very fast scans, and are much cheaper than time of flight instruments. (May get down to approximately \$5,000. May be best for monitoring alone and with GC for all pollution work.)

#### 4.8 Polarography

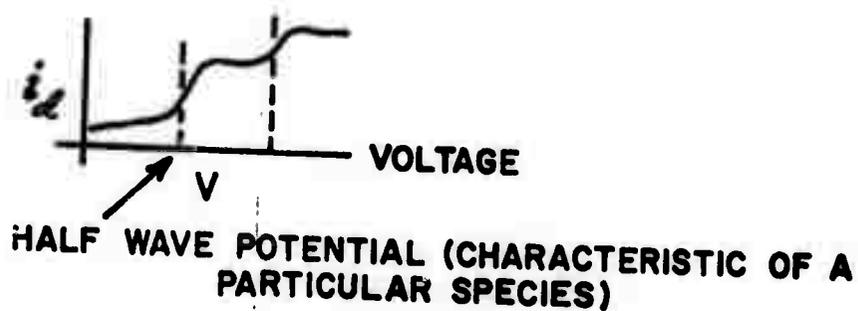
Polarography is the most generally useful electrochemical method for the determination of inorganic and organic pollutants.<sup>1</sup> It is a highly sensitive technique of wide applicability. Polarography is a combination technique: current vs. potential (voltammetry). Other electrochemical techniques are chronopotentiometry (potential vs. time) and coulometry (current vs. time). Coulometry has found considerable application in analysis and microcoulometry is a useful technique for Gas Chromatograph detection, particularly for pesticide determinations.<sup>2</sup>

All electrochemical methods involve an oxidation or reduction, at an electrode, of the species of interest. The high precision with which current and voltage can be controlled and measured permits extremely precise and sensitive techniques. Voltammetric methods, including the various forms of polarography work best when the constituent being determined is present in low concentration.

##### 4.8.1 Conventional Polarography

Voltammetry with the dropping mercury electrode (DME) is known as polarography. Conventional polarography employs a DME emitting 10-30 drops/minute, with masses of 6-20 mg. The current-voltage curves obtained with these electrodes show portions of low

slope, about  $0.3 \mu\text{A}/\text{V}$ , upon which steps of magnitude depending upon the concentration of electrolyzable material are superimposed. The steps are a measure of the diffusion current which is usually about  $6 \mu\text{A}/\text{meg}/1$  (meg of reactive species present). The residual current usually amounts to  $0.1-0.2 \mu\text{A}$ . (Refer to Fig. 4.4 for a typical polarographic curve.)



**FIG. 4.4 TYPICAL POLAROGRAPHIC CURVE**

While a considerable theoretical basis describing the nature of the limiting current and the diffusion current has been developed, results have been unsatisfactory for work based on the various diffusion current equations.<sup>3</sup> For this reason, almost all analytical work depends on empirical calibration with standards.

Solutions as dilute as  $10^{-5}$  M (molar) can be analyzed using only a few tenths of a milliliter. Other polarographic methods are considerably more sensitive. The upper range is approximately  $10^{-2}$  M.

Many refinements in conventional polarography have led to improved sensitivity. Improvements in the design of the DME, including shock mounting and tapered base capillance, have extended measurements to the  $10^{-7}$  M range.<sup>4</sup> If the trace amounts are to be determined in the presence of large quantities of more easily electrolyzable materials, the interfering materials must be removed by pre-separations or by complexing. Separation techniques that are often useful in concentrating a trace component so that it surpasses the limits of detection include ion-exchange, solvent extraction, and electrolysis at controlled potentials.

Other types of polarography include:

#### 4.8.2 Derivative Polarography

Derivative polarography involves differentiation of the current-voltage curve as it is being recorded, yielding a series of sharp peaks. Its main advantage is very high resolution of peaks with similar half-wave potentials (characteristic potential for a species) as no significant improvement in sensitivity results.

#### 4.8.3 Cathode Ray Polarography

Cathode ray polarography is a dc method using a high rate of voltage scan and an oscilloscope for current measuring. This method is very rapid and somewhat more sensitive than conventional polarography.

It has been used for a wide range of determination of trace metals and organic pollutants in many different matrices. A pertinent example is the determination of lead in blood to a limit of  $0.05 \mu\text{g/ml}$ .<sup>5</sup> Several commercial instruments are available while others can readily be assembled from components.

#### 4.8.4 Alternating Current Polarography

Alternating current polarography involves superimposing a small alternating potential on the slow scan of conventional polarography. Derivative polarograms are obtained with peaks corresponding to the half-wave potentials. This is a very sensitive, high resolution technique. The most important modifications of AC polarography are square wave and pulse polarography. In the first modification, a conventional DME is used and a square wave is applied at the end of the drop-life cycle. Sensitivity is high enough to determine minor constituents present at approximately 0.001% in 20 mg samples. High resolution is also attained. Pulse polarography involves a 40 ms pulse applied two times after the start of growth of a drop. Measurement takes place during the last 20 ms of the pulse. Sensitivity to concentrations as low as  $10^{-8}$  M has been reported.<sup>6</sup>

#### 4.8.5 Applications

Inorganic and organic pollutants in liquids and solid matrices are readily determined. Organic polarography has been treated extensively by Zuman.<sup>7</sup> The following table, Table 4.9, covers a wide range of applications.

#### 4.8.6 Manufacturers

Commercial instruments are, in general, moderately priced with many options available. Some of the manufacturers include Leeds and Northrup, Beckman Instruments, and Sargent-Welch.

1. Beckman Instruments, Inc.  
2500 Harbor Blvd.  
Fullerton, California 92634
2. Leeds and Northrup  
Sumneytown Pike  
North Wales, Pennsylvania 19454
3. Sargent-Welch Scientific Company  
7300 North Linder Avenue  
Skokie, Illinois 60076

Table 4.9: Selected Polarographic Methods of Trace Analysis

Matrix	Sample size	Technique	Determined	Range or sensitivity	Matrix	Sample size	Technique	Determined	Range or sensitivity	Matrix	Sample size	Technique	Determined	Range or sensitivity
<b>Agricultural and food analysis</b>														
Wine	50-100 ml	Hg-plated Pt electrode	Tl	1.5 µg	Acids, bases NH <sub>4</sub> ReO <sub>4</sub> Br <sub>2</sub> , HBr, HCl Pb salts and thiourea	0.2 g	ASP SWP CRP	Pb, Cu, Zn W F <sup>-</sup> Ag	10 <sup>-10</sup> % 0-17 µg	Mn ores Minerals	1-5 g		Zn Cu, Ni, Co, Zn, Cd	2 X 10 <sup>-10</sup> % <1 µg
Cocoa	2-3 g	SWP	Pb	<1 ppm	NaCl-KCl Th compounds U salts UO <sub>2</sub> SO <sub>4</sub>	1 g	DP	Ba, Sr Cd	0.0001- 0.0001%	Minerals and concentrates	1-2 g		Mo Ic As, Sb	10 <sup>-10</sup> % 10 <sup>-1</sup> to 0.5% µg amb.
Food-stuff	5 g	CRP	Cu, Pb, Sn, Zn	<10 <sup>-5</sup> M										
Food-stuff	5 g	CRP	DDT	5-500 µg										
Potatoes	100 g	CRP	Tetrachloro-nitrobenzene	0.1-5 ppm										
Vegetables	100 g	CRP	Pentachloro-nitrobenzene	0.1-5 ppm										
Forage	100 g	CRP	Pentachloro-nitrobenzene	0.1-5 ppm										
Crops	100 g	CRP	Azinphosmethyl	0.1 µg/ml										
Fertilizer	5 g		Cu, Zn	0.001%										
Soil	1 g		Cu, Ni, Zn, Co	0.001%										
Soils and vegetation	1 g		Pb	1-10 µg/ml										
<b>Pure materials</b>														
	Al					5 g	ASP	Cd, Cu, Ni, Zn, Fe, Pb	0.0001%					
	Al					1 g	ASP	Ga, Zn, Cd	1 X 10 <sup>-10</sup> %					
	GaAs					0.5 g	SWP	Bi, Cu, In, Cd	0.1-1 ppm					
	As					0.5 g	SWP	Bi, Cd, Cu, Fe, Ni, Pb, Zn	0.01-0.1 ppm					
	In					0.1-0.6 g	ASP	Cu, Pb, Cd, Zn	10 <sup>-10</sup> %					
	Sn					1 g	ASP	Zn, Pb, Cu	10 <sup>-1</sup> to 10 <sup>-10</sup> %					
	U					0.5 g	SWP	Cu, Pb, Cd, Zn	0.025-0.05 ppm					
	Zn						RME	Pb	0.001%					
	Zn						ASP	Cu, Pb, Cd, Sb, In, Bi	10 <sup>-10</sup> %					
<b>Metals</b>														
	Crude Cu, Ag, Se					1-10 g	SWP	Te	0.0001%					
	Cast iron						CRP	Various						
	Cast iron						CRP	Al	0.0001%					
	Cast iron						CRP	Pb, Bi	0.001-0.01%					
	Steel (18-8)					1-4 g	CRP	Co	0.0001%					
	Steel						CRP	Sa	0.5 µg/ml					
	Steel						CRP	Cu, Pb	0.001-0.02%					
	Electrolytic Ag					5 g	SWP	Bi, Pb	0.0001%					
	Zinc-base alloys					10 g	CRP	In	0.001%					
	Zincalloy-2, Hf, Zr						SWP	U	1 ppm 0.5-5 ppm					
<b>Biological materials</b>														
Urine	10 ml		Se	0.5-14 µg/ml										
Urine	3 ml		Pb	1 µg										
Blood	3-10 ml	CRP	Pb	0.05 µg/ml										
Blood	5 ml		U	0.05-4 µg/ml										
Blood	0.2 ml	CRP	Zn	10 µg										
Blood, plasma	5-10 ml		Morphine	10 µg										
Animal tissue			Dimethyl nitrosamine	1 µg										
Turkey tissue, etc.	5 g		Dimethidazole	0.1 ppm										
Sera	0.5-1 ml		I <sup>-</sup>	0.03 µg										
<b>Hygiene-Sanitation</b>														
Air	100 ml		Mn	2-5 µg										
Trade wastes	5 ml	CRP	Cu, Pb, Ni, Zn, Cd	0.01-1.0 µg/l										
Water	1 ml	Wide-bore DME	CN <sup>-</sup>	0.05 µg/ml										
Water	1 ml	CRP	O <sub>2</sub>	0-15 ppm										
Sea water	4 l	Pulse	Cu, Co, Zn, Mn, Cl	0.05 µg/ml										
Sea water	4 l	Pulse	U	3 µg/l										

\* ACP, alternating current polarography; SWP, square wave polarography; CRP, cathode ray polarography; ASP, anodic stripping polarography; DP, differential polarography; SMC, stirred mercury cathode; H.M.E, rotating mercury electrode; GE, graphite electrode.

4. 8. 7    References

1.    Taylor, J. K., et al., "Trace Analysis: Physical Methods," Chapter 10, Interscience, New York, 1966.
2.    Coulson, D. M., J. Agr. Food Chem., 8, p. 399, (1960).
3.    Reference 1, pp. 380-382.
4.    Cooke, W. D., Kelley, M. T., and Fisher, D. J., Anal. Chem., 33, p. 1209, (1961).
5.    Hairdi, W., Trav. Chem. Aliment. Hyg., 50, p. 243, (1959).
6.    Reference 1, p. 388.
7.    Zuman, P., "Organic Polarography," Pergamon Press, London, 1968.

#### 4.9 Recommendations: New Instruments and Methods

##### 4.9.1 Air Pollution - Solids

A major need is for reliable solid state sensors for detection and measurement of particulates. The technology is available and is starting to be employed. An example of a newly developed solid-state method is the application of energy dispersive X-ray fluorescence spectroscopy to direct analysis of particulates collected on filter paper by Hi-Vol samplers.<sup>1</sup> Extension of this technique to most of the metal particulates should be possible. The method is rapid and sensitive.

Particulates collected by the same sampling method could be analyzed by spark source mass spectrometry.<sup>2</sup> This could be accomplished directly or by first dissolving the collected metal and then transferring the metal ions to a high purity electrode. The technique is very sensitive.

Organic particulates collected on the same filter paper could be determined directly by applying pyrolysis gas liquid chromatography.<sup>3</sup> The lower molecular weight materials would be measured intact while higher molecular weight materials would pyrolyze, decomposing in a reproducible manner giving a pyrolysis "fingerprint." Contributions from the pyrolysis of the paper can be corrected for.

Linkage with a mass spectrometer/computer is a logical extension that would multiply the power of the method. Less accurate but

still acceptable analyses for organic air particulates could be achieved by solvent extraction of the paper and subsequent GC/MS or TLC/scan. TLC/scan methods can involve IR reflectance, UV absorption, or spectrofluorometric techniques. The last technique has seen rapid improvement. However, HPLC methods may be preferable to the above in some instances.

#### 4.9.2 Air Pollution - Hydrocarbons and Volatile Organics

Methods for determining very low levels of hydrocarbons (including olefins) are desirable. By preconcentrating on chromatographic column materials, such as porapak Q<sup>4</sup>, at very low temperatures (liquid N<sub>2</sub>) and subsequently isothermally distilling into a GC gas sampling inlet or by other methods, such as carrier gas sweeping at elevated temperature, input into a gas chromatograph or GC/MS or GC/IR combination can be achieved. This method could be adapted to automated sampling and analysis.

Specific column packings such as the porapaks and silver nitrate/benzyl cyanide can be used to trap particular hydrocarbon constituents preferentially. Many modifications are possible.

A similar but indirect method has been described for MS analysis of bis-chloromethyl ether in air samples.<sup>5</sup> An advantage of the above methods; i.e., MS, GC, GC/IR, GC/MS, is that collected data can be stored or sent from remote locations by interfacing with computer systems.

Low concentrations of  $\text{NO}_1$ ,  $\text{NO}_2$ ,  $\text{CO}$  and  $\text{SO}_3$  have been analyzed by reaction GC.<sup>6</sup> This method, which requires column reactors to bring about reductions, oxidations, etc., achieves high sensitivity and can be extended readily to many classes of inorganic and organic pollutants.

In general, the applications of GC/MS/computer systems should be explored exhaustively, particularly since many inorganics can be handled by GC by conversion to volatile stable complexes. The development of completely automatic GC/MS/computer systems, including automatic sampling, should be feasible, particularly with simple, rugged instruments such as the rf/quadrupole types.

Automatic sampling techniques based on a sequence of trapping, dissolving, and inputting samples reproducibly, must be perfected. They could be used with the entire range of high sensitivity methods including mass spectrometry (including spark source), emission methods, AA, polarography, ion selective electrodes and potentiometry (in general, GC/MS, GC/IR and spectrophotometric methods). Multiple collectors could be used sequentially to increase data output. Completely portable GCs have been developed (see GC section, Section 4.3).

#### 4.9.3 Water

The application of pyrolysis GC to aqueous pollutants, such as surfactants and other non-volatile organics, is a method with great

potential. Automatic sampling and extraction-concentration techniques should be improved.

Continuous monitoring of water pollutants of many types is possible with the newly developed multiple internal reflection probe which dips into the sample to be analyzed. Some type of masking or correlation technique may be possible to enhance the method. Ion selective electrodes are very useful for monitoring waters but are susceptible to interferences. It may be possible to develop a container into which the sample flows, is masked by automatic addition of an appropriate reagent to remove interferences, and measurement is made. Upon achieving a stable reading the container opens, is flushed by the aqueous environment, and is ready to read again at a preset interval.

Since many polarographic methods can simultaneously determine several inorganic pollutants with high sensitivity and can handle a considerable range of organics, much effort should be focused on developing them for applications in pollution work. (Stripping methods appear to be particularly promising.)

TLC/fluorometry methods are capable of analyzing very low concentrations of pesticides and other pollutants (see Section 4.4.4, fluorescence). This is a high potential technique that is inexpensive yet powerful. Fluorescence methods involving complexes of the inorganics are very sensitive in some instances.

Magnetic resonance methods, including Nuclear Magnetic Resonance and Electron Spin Resonance, are potentially useful for some inorganics. For example,  $\text{Cu}^{++}$  can be determined as the ethylene diamine complex by electron spin resonance methods.

The continuous improvement in detectors for GC and HPLC suggests that these methods will be among the most generally useful for handling all types of organic pollutants. Specific detectors, such as electron capture and phosphorus and microcoulometric detectors, are extremely sensitive for specific types of pollutants, while the continuing development of phase transformation detectors greatly enhances the utility of HPLC methods for organics.

Determinations of pollutants in soil must, in general, involve an extraction step unless adsorbed volatiles are present. Pyrolysis and selective adsorption of interfering materials could precede GC or MS or GC/MS analysis; thereby dispensing with the extraction step. Automated sampling of soils is possible, but complicated. (Some aspects were realized on the Apollo missions.) After extraction, analysis is similar to the previously discussed instances.

#### 4.9.4 References

1. Rhodes, J. R., et al., Environ. Sci. Technol., 6, p. 922, (1972).
2. Methods described in "Trace Analysis: Physical Methods," in chapter by Roboz, J. R., pp. 481-501.
3. Wolf, C. J., Levy, R. J., Walker, J. Q., Ind. Res. 13 (1), p. 40, (1971). (Review of Pyrolysis GLC method.)
4. The Porapaks are a polymer packing available in a range of polarities. They are usually used without a liquid phase. Manufactured by Waters Associates.
5. Cram, S. P. and Juvet, Jr., R. S., Anal. Chem. 44, p. 222R, (1972).

## 5.0 Critical Materials

There is a need to identify the critical materials that directly influence the activities of DoD and to evaluate the environmental pollution problem associated with each of these materials to be assured that these materials will always be available to DoD. At the present time, any supplier or manufacturer could have a cease and desist order placed upon their plant as a consequence of a legal action brought about by an environmental pollution problem. This injunction could have a serious impact on DoD's efforts.

Thus, OAS's effort has been directed toward identifying:

1. The critical materials and sole source manufacturers.
2. The local, state, and federal regulations and standards that are applicable to the materials from the mining stage to the finished product.
3. The sensors and instrumentation that are required to monitor the pollution emission levels.
4. The areas where additional technology and instrumentation are needed.

With this information available, DoD will then be able to avoid future environmental difficulties by providing technological assistance and expertise to any supplier or producer whose techniques might require updating to meet the present or future standards.

## 5.1 Stockpiling of Critical Materials

### 5.1.1 Introduction

The Director of the Office of Emergency Preparedness was directed, by Presidential Executive Order 11051, to determine the critical and strategic materials and to establish the quality and quantities of each material for stockpiling to meet the nation's security requirements. Basically, the dual goals of the stockpile are:

1. to protect the national security
2. to minimize the cost of stockpiling.

As of 31 December 1971, the total dollar amount of materials held in the government stockpile was 6.7 billion.

## 5.2 Stockpile Objectives

"The stockpile objectives of the United States are based on the planning assumption of a three-year war estimated to begin not less than one or more than two years in the future."<sup>1</sup> The Office of Emergency Preparedness then estimates the gross national product for several years prior to the armed conflict and for each of the three war years to estimate the consumption level of the materials.

In addition, the trend in material consumption is monitored to be assured that all strategic and critical materials are available to the nation in times of emergency. As of December 1971, seventy-two (72)

materials were stockpiled. The stockpile statistics are given in the following tables, Table 5.1 a, b, and c.<sup>2</sup> The more important mineral materials have been chosen for our investigation of the environmental factors involved in the mining, purification, handling, and finishing of the metals.

## 5.2 Materials and Their Impact on the Environment

In the past, very little attention has been paid to our material resources. The United States appeared to have been blessed with seemingly endless supplies and thus, the materials were taken for granted and the energy and material resources were assumed to be infinite.

However, with the economic and industrial increase in our nation of the past few decades, the national supplies are diminishing and more and more materials must be obtained from foreign countries to fulfill our need. The United States does not produce enough of numerous materials to supply industry with the required quantity.

Table 5.2<sup>3</sup> provides information about mineral materials as they are actually sold, exported and imported in the minerals industry. Table 5.3<sup>5</sup> presents the projected U.S. primary demand for 91 mineral materials in the year 2000.

At the present rate of national consumption, the possibility of having zero-supply of a material within our own nation's boundaries is

Table 5.1a Basic Stockpile Materials<sup>2</sup>

SUMMARY OF GOVERNMENT INVENTORIES, OBJECTIVES,  
EXCESSES AND BALANCE OF DISPOSAL AUTHORIZATIONS

Basic Stockpile Materials  
December 31, 1971

(Market Value - \$ Millions)

Commodity	Unit	Objective	Total Inventory <sup>1</sup>	Market Value <sup>2</sup>	Uncommitted Excess	Market Value <sup>3</sup>	Balance of Disposal Authorization
1. Aluminum	ST	450,000	1,279,017	\$741.8	829,017	\$480.8	829,017 <sup>2</sup>
2. Aluminum Oxide, Fused	ST	300,000	427,475	70.4	127,475	17.9	127,475
3. Antimony	ST	40,700	46,747	52.7	6,047	6.3	6,047
4. Asbestos, Amosite	ST	18,400	58,659	14.5	40,259	9.9	40,259
5. Asbestos, Chrysotile	ST	13,700	11,835	6.1	892	0.1	879
6. Bauxite, Metal, Jamaica	LDT	5,000,000	8,858,881	120.3	3,858,881 <sup>4</sup>	52.4	714,000
7. Bauxite, Metal, Surinam	LDT	5,300,000	5,300,000	54.3	0	0	0
8. Bauxite, Refractory	LCT	173,000	173,000	8.8	0	0	0
9. Beryl	ST	28,000	40,247	78.4	12,247 <sup>4</sup>	26.9	2,451
10. Bismuth	LB	2,100,000	2,335,457	8.2	235,457	0.8	235,457
11. Cadmium	LB	6,000,000	10,147,904	15.2	4,147,904	6.2	4,147,904
12. Castor Oil	LB	50,000,000	50,206,400	11.2	206,400	0.04	182,158
13. Chromite, Chemical	SDT	250,000	570,449	12.7	320,449	7.2	320,449
14. Chromite, Metallurgical	SDT	3,086,800	5,331,462	580.5	2,244,662 <sup>4</sup>	142.1	930,589
15. Chromite, Refractory	SDT	368,000	1,176,961	31.6	808,961	21.7	777,001
16. Chromium Metal	ST	3,775	8,012	19.5	4,237	9.7	4,237
17. Cobalt	LB	38,200,000	77,345,269	167.9	39,145,269	83.9	39,145,269
18. Columbium	LB	1,176,000	9,413,090	14.1	5,841,531 <sup>7</sup>	7.4	5,753,691
19. Copper	ST	775,000	258,688	264.8	0	0	0
20. Cordage Fibers, Abaca	LB	25,000,000	53,616,820	12.9	28,616,820	6.9	27,320,258
21. Cordage Fibers, Sisal	LB	100,000,000	165,768,663	14.9	65,768,663	5.9	65,768,663
22. Diamond Dies, Small	PC	25,000	25,473	1.0	473	0.02	0
23. Diamond, Industrial Bort	KF	23,700,000	42,611,479	101.4	18,911,479	42.6	18,911,479
24. Diamond, Industrial Stones	KT	20,000,000	25,141,634	311.6	5,141,634	78.0	5,141,634
25. Feathers and Down	LB	3,000,000	3,000,000	10.9	0	0	0
26. Fluorspar, Acid Grade	SDT	540,000	890,000	69.9	0 <sup>8</sup>	0	0
27. Fluorspar, Metallurgical	SDT	850,000	411,788	28.2	0	0	0
28. Graphite, Natural, Ceylon	ST	5,500	5,499	1.0	0	0	0
29. Graphite, Natural, Malagasy	ST	18,000	28,386	3.4	10,446	1.3	10,446
30. Graphite, Other	ST	2,800	2,800	0.6	0	0	0
31. Iodine	LB	8,000,000	8,011,814	16.5	11,814	0.02	0
32. Jewel Bearings	PC	57,500,000	60,110,058	19.5	14,726,698 <sup>9</sup>	0.4	0
33. Lead	ST	530,000	1,127,440	315.7	597,440 <sup>8</sup>	167.3	98,973
34. Manganese, Battery, Natural	SDT	135,000	308,350	27.3	173,350	14.5	173,350
35. Manganese, Battery, Synthetic Dioxide	SDT	1,900	18,520	8.6	16,620	7.6	16,620

Table 5.1b Basic Stockpile Materials<sup>2</sup>

**SUMMARY OF GOVERNMENT INVENTORIES, OBJECTIVES,  
EXCESSES AND BALANCE OF DISPOSAL AUTHORIZATIONS (Continued)**

**Basic Stockpile Materials  
December 31, 1971**

(Market Value - \$ Millions)

Commodity	Unit	Objective	Total Inventory <sup>1</sup>	Market Value <sup>2</sup>	Uncommitted Excess	Market Value <sup>3</sup>	Balance of Disposal Authorization
36. Manganese Ore, Chemical A . . . . .	SDT	35,000	146,914	\$ 10.3	111,914	\$ 7.8	111,914
37. Manganese Ore, Chemical B . . . . .	SDT	35,000	100,838	7.2	65,838	4.6	65,838
38. Manganese, Metallurgical . . . . .	SDT	4,000,000	11,189,973	413.2	7,243,597	225.0	6,659,570
39. Mercury . . . . .	FL	126,500	200,105	45.0	73,605 <sup>4</sup>	16.6	0
40. Mica, Muscovite Block St./better . . . . .	LB	6,000,000	14,175,156	57.0	7,415,656 <sup>10</sup>	21.2	7,415,656
41. Mica, Muscovite Film, 1 & 2 quality . . . . .	LB	2,000,000	1,468,980	16.5	640	0	640
42. Mica, Muscovite Splittings . . . . .	LB	19,000,000	42,310,273	45.3	23,310,273	22.5	23,310,273
43. Mica, Phlogopite Block . . . . .	LB	150,000	153,476	0.04	136,758	0.03	136,758
44. Mica, Phlogopite Splittings . . . . .	LB	950,000	4,641,805	5.6	3,691,805	4.4	3,691,805
45. Molybdenum . . . . .	LB	0	42,603,508	76.9	42,603,508 <sup>4</sup>	76.9	6,090,723
46. Nickel . . . . .	ST	0	38,857	103.0	38,857 <sup>4</sup>	103.0	0
47. Opium . . . . .	AvLB	143,000	141,602	14.0	88	0.005	0
48. Platinum Group, Iridium . . . . .	TrOz	17,000	17,176	2.6	184	0.03	184
49. Platinum Group, Palladium . . . . .	TrOz	1,300,000	1,254,994	46.4	0	0	0
50. Platinum Group, Platinum . . . . .	TrOz	555,000	452,645	54.3	0	0	0
51. Pyrethrum . . . . .	LB	63,375	0	0	0	0	0
52. Quartz Crystals . . . . .	LB	320,000	4,852,953	53.1	4,532,953	49.4	4,532,953
53. Quinidine . . . . .	OZ	2,000,000	1,800,377	4.3	0	0	0
54. Quinine . . . . .	OZ	4,130,000	3,548,161	6.2	0	0	0
55. Rubber . . . . .	LT	200,000	305,924	123.3	105,924	42.7	105,924
56. Rutile . . . . .	SDT	100,000	56,525	10.5	0	0	0
57. Sapphire & Ruby . . . . .	KT	18,000,000	16,305,502	0.2	0	0	0
58. Shellac . . . . .	LB	1,000,000	5,393,131	2.5	4,393,131	2.0	4,393,131
59. Silicon Carbide, Crude . . . . .	ST	30,000	196,453	42.6	166,453 <sup>4</sup>	36.1	0
60. Silver . . . . . (fine)TrOz	TrOz	139,500,000	139,500,000	191.0	0	0	0
61. Sperm Oil . . . . .	LB	23,400,000	23,402,645	6.8	2,645	0	0
62. Talc, Steatite Block & Lump . . . . .	ST	200	1,204	0.4	1,004	0.3	1,004
63. Tantalum . . . . .	LB	3,400,000	4,180,504	39.2	967,522 <sup>11</sup>	8.6	0
64. Thorium Oxide . . . . .	ST	40	40 <sup>12</sup>	0.3	0	0	0
65. Tin . . . . .	LT	232,000	250,866	966.5	18,866	72.7	18,866
66. Titanium Sponge . . . . .	ST	33,500	35,015	85.6	8,514	18.0	8,514
67. Tungsten . . . . .	LB	60,000,000	129,141,844	455.5	69,142,661	241.5	68,886,097
68. Vanadium . . . . .	ST	540	3,307	21.2	2,767	18.3	2,767

Table 5.1c Basic Stockpile Materials<sup>2</sup>

SUMMARY OF GOVERNMENT INVENTORIES, OBJECTIVES,  
EXCESSES AND BALANCE OF DISPOSAL AUTHORIZATIONS (Continued)

Basic Stockpile Materials  
December 31, 1971

(Market Value - \$ Millions)

Commodity	Unit	Objective	Total Inventory <sup>1</sup>	Market Value <sup>2</sup>	Uncommitted Excess	Market Value <sup>3</sup>	Balance of Disposal Authorization
69. Vegetable Tannin, Chestnut . . . . .	LT	9,500	26,147	\$ 7.2	16,647	\$ 4.6	16,567
70. Vegetable Tannin, Quebracho . . . . .	LT	50,600	185,818	52.4	135,218	38.2	135,218
71. Vegetable Tannin, Wattle . . . . .	LT	9,500	32,529	8.4	23,029	5.9	23,029
72. Zinc . . . . .	ST	560,000	1,117,913	380.1	557,913 <sup>4</sup>	189.7	42,677

FOOTNOTES

- <sup>1</sup>Total inventory consists of stockpile and nonstockpile grades and reflects uncommitted balance.
- <sup>2</sup>Market values are estimated from prices at which similar materials are being traded; or in the absence of trading data, at an estimate of the price which would prevail in the market. Prices used are unadjusted for normal premiums and discounts relating to contained qualities or normal freight allowances. *The market values do not necessarily reflect the amount that would be realized at time of sale.*
- <sup>3</sup>Committed for sale but undelivered under long-term contracts.
- <sup>4</sup>Balance of excess; disposal planning deferred due to market conditions.
- <sup>5</sup>Excess quantity includes 3,617 ST in beryllium copper master alloy and 3,160 ST in beryllium metal.
- <sup>6</sup>Balance of excess deferred by the Congress.
- <sup>7</sup>Excludes that quantity represented by tantalum contained in columbium minerals.
- <sup>8</sup>Excludes 350,000 SDT credited to metallurgical fluorspar.
- <sup>9</sup>Factory inspecting feasibility of reworking bearings to meet stockpile specifications.
- <sup>10</sup>Excludes 759,500 LBS credited to mica, muscovite film.
- <sup>11</sup>Material required in upgrading.
- <sup>12</sup>Thorium nitrate credited as 40 ST thorium oxide, \$0.3 million market value.

ABBREVIATIONS

- |                         |                     |
|-------------------------|---------------------|
| FL - Flask              | OZ - Ounce          |
| KT - Carat              | PC - Piece          |
| LB - Pound              | SDT - Short Dry Ton |
| LCT - Long Calcined Ton | ST - Short Ton      |
| LDT - Long Dry Ton      | TrOz - Troy Ounce   |
| LT - Long Ton           |                     |

## Major Mineral Materials

Commodity	Units	U.S. Production	U.S. Consumption
Aluminum	1,000 s.t.	4,225(a)	4,600
Antimony	1,000 s.t.	33,500(a)	34,000
Asbestos	1,000 s.t.	132	757
Barite	1,000 s.t.	814	N.A.
Bauxite	1,000 l.d.t.	2,000	15,700
Beryllium	s.t.(a)	—	9,000
Bismuth	1,000 lb.	N.A.	1,650
Boron	1,000 s.t.	1,061(a)	N.A.
Cadmium	1,000 lb.	7,300(a)	9,000(b)
Chromium	s.t. ore & conc.	None	1,150,000
Coal(a)	1,000 s.t.	550,000(a)	512,000(a)
Coal(b)	Million s.t.	—	—
Cobalt	contained Co s.t.	N.A.	5,500
Columbium and Tantalum	1,000 lb.	None	5,645(a)
Copper	1,000 s.t.	1,538(a)	2,040(b)
Feldspar	1,000 l.t.	636	634
Fluorspar	1,000 s.t.	269(a)	1,320(b)
Gold	Million troy oz.	1.51(a)	6.50
Gypsum	1,000 s.t.	9,647(a)	15,600
Ilmenite	1,000 s.t.	725	1,050
Iron Ore	1,000 l.t. (a)	82,000(a)	124,000(a)
Iron Ore	Million s.t.(b)	121,000	99,500(b)
Steel	1,000 s.t.	—	—
Lead	1,000 s.t.	552(a)	1,350
Magnesium	s.t.	130,000(a)	100,000(b)
Manganese	1,000 s.t.	—	2,000
Mercury	76-lb flasks	18,000(a)	54,000
Molybdenum	1,000 lb contained molybdenum	107,500(a)	47,500
Natural gas	Billion cu. ft.(a)	22,800	23,200
Natural gas (liquid)	1,000 42-gal. bbl.	618,000	614,000
Nickel	s.t. Nickel content	17,000(a)	130,000(b)
Petroleum, crude	Million 42-gal. bbl.	3,488	4,166(a)
Phosphate rock	1,000 s.t.	38,000	27,500
Potash	1,000 s.t.(a)	2,700	4,750
Rutile	s.t. rutile conc.	—	170,000
Salt	1,000 s.t.	44,064	47,134
Sand and gravel	1,000 s.t.	987,342	986,727
Selenium	1,000 lb.	750	1,150
Silver	Million troy oz.	40.9 (a)	122.7(b)
Stone	1,000 s.t.	822,041	822,000(a)
Sulfur	1,000 l.t.	9,450(a)	9,125(a)
Tellurium	1,000 lb.	150	500
Tin	l.t.	N.A.	71,000(b)
Titanium	s.t. Sponge metal	N.A.	12,500
Tungsten	1,000 lb. contained tungsten	7,500(a)	8,000
Uranium	s.t. U <sub>3</sub> O <sub>8</sub>	12,800	12,000(b)
Vanadium	1,000 lb. contained vanadium	N.A.	9,000
Zinc	1,000 s.t. zinc content	500(a)	1,259

—U.S. Statistics for 1971<sup>1</sup>

Imports	Estimated Reserves	Type of Reserves	Notes
745	100,000	(a) Primary and secondary	(a) Primary and secondary
15,800	10,000	(a) Primary	(a) Primary
675	88,000	50% contained Al <sub>2</sub> O <sub>3</sub>	(a) Beryl or bertrandite, 11% BeO
13,700	45,000		(a) Boron minerals and compounds (a) Includes secondary (b) Metal and flu dust
4,200	727,000(a)		(a) Bituminous and lignite
858	Ample		(a) All grades (b) Metallurgical and acid grade
97(a)	330,000	25-45% B <sub>2</sub> O <sub>3</sub>	(a) Mine (b) Excludes coins
1,295(b)	N.A.		(a) Crude (b) Includes anhydrite
1,450,000	8,000,000	35-40% Cr <sub>2</sub> O <sub>3</sub>	(a) Includes slag
58(a)	599,711(b)	Bituminous	(a) Iron and steel products (b) Shipments, all forms
233,723(b)	223,723(b)	Lignite	(a) Mine (b) Ore and conc. Pigs and bars (a) Primary and secondary (b) Primary
6,230	28,000	0.06% Co	(a) Measured and indicated
7,628(b)	12,876,000	Cb <sub>2</sub> O <sub>3</sub> in ore	(a) Mine (b) Conc.
376(c)	81,000	Ta <sub>2</sub> O <sub>5</sub> in ore	(a) Mine (b) Retined (c) Blister and refined
2	500,000		(a) All grades (b) Metallurgical and acid grade
1,038(b)	20,000	35% CaF <sub>2</sub>	(a) Mine (b) Excludes coins
7.50(b)	82		(a) Crude (b) Includes anhydrite
6,000(b)	350,000		(a) Includes slag
150(a)	100,000	0.2-20% TiO <sub>2</sub>	(a) Iron and steel products (b) Shipments, all forms
41,000(a)	10,494(b)	Ore	(a) Mine (b) Ore and conc. Pigs and bars (a) Primary and secondary (b) Primary
17,500(a)	—		(a) Measured and indicated
60(b)	36,000		(a) Mine (b) Conc.
195(c)	—		(a) Mine (b) Conc.
2,000	Small		(a) 14.73 psi @ 60°F.
27,000	380,000		(a) Mine (b) Excludes most secondary (a) Demand
800(b)	6,300,000		(a) Metal and compounds (a) Mine (b) Excludes coinage
925	290,746		(a) About same as production (a) All forms (b) Frasch. acid in pyrites
25,500	1,000,000	0.4-1.5% Ni ore	(a) Metal and tin in ores (b) Primary and secondary
145,000	39,000		(a) Mine (b) In conc.
109	7,850,000		(a) Conc. (b) Industrial (a) Ore and conc.
2,600	480,000		(a) Measured and indicated ore
200,000	500,000		(a) Mine (b) In conc.
3,850	Large		(a) Measured ore
885	Ample		500,000
400(a)	Adequate		Inferred ore
53.0(b)	1,300	In currently operating mines	230,000
—	Adequate		(a) Ore and conc.
1,480(b)	75,000		(a) Mine (b) In ore and conc. (c) Slab Zinc
60	Adequate		
52,000(a)	Negligible		
4,000			
510(b)	175,000	0.3-1.0% W <sub>2</sub> O <sub>3</sub>	
360(a)	300,000	Measured ore	
3(a)	500,000	Inferred ore	
345(b)	30,000	Measured and indicated ore	
278(c)			

<sup>1</sup> Source: COMMODITY DATA SUMMARIES, U.S. Bureau of Mines. All 1971 data are estimates. Abbreviations: l.t., long tons of 2,240 lb.; s.t., short tons of 2,000 lb.; l.d.t., long dry tons; t conc., concentrates; N.A., Not Available; 1 ounce troy = 1.09714 ounce avoirdupois.

Table 5.3

91 Mineral Materials Extracted from the Earth\*

Commodity	Units	How much the United States produced in 1969		How much the United States used in 1969		How much the United States may require by the year 2000	
		U.S. Primary Production	U.S. Primary Demand	U.S. Primary Demand	Projected U.S. Primary Demand		
Aluminum	Thousand S.T.	500	5,100	26,400	2,430		
Antimony	S.T.	2,218	20,689	48,000	174		
Arsenic	S.T.	(1)	(1)	38,000	37		
Barium	Thousand S.T.	603	899	1,380	1,100		
Beryllium	S.T.	(1)	(1)	491	2,000		
Bismuth	Thousand lb	(1)	2,539	708	2,500		
Boro:	Thousand S.T.	171	86	20	53		
Bromine	Million lb	335	327	(1)	95		
Cadmium	Thousand lb	4,680	14,324	9,881	35,000		
Calcium	Thousand S.T.	89,190	89,190	(1)	630		
Cesium	lb	0	(1)	133	448		
Chlorine	Thousand S.T.	9,422	9,419	(1)	134		
Chromium	Thousand S.T.	0	475	471	6,584		
Cobalt	Thousand lb	1,000	18,900	3,609	1,350		
Columbium	Thousand lb	0	4,660	937	12,000		
Copper	Thousand S.T.	1,545	1,696	646	3,200		
Fluorine	Thousand S.T.	82	603	1,873	2,520		
Gallium	Kg	(1)	(1)	1,029	3,820		
Germanium	Thousand lb	30	17	309	2,300		
Gold	Thousand T. oz	1,733	6,567	10,473	725		
Hafnium	S.T.	0	(1)	8,809	2,300		
Indium	S.T.	(1)	(1)	561	1,000		
Iodine	Thousand lb	(1)	4,902	20,700	49,000		
Iron	Million S.T.	59	90	572	2,200		
Lead	Thousand S.T.	509	873	3,952	14,500		
Lithium	S.T.	(1)	(1)	0	1,500		
Magnesium-Metal	Thousand S.T.	100	102	10,069	62,000		
Magnesium-Nonmetal	Thousand S.T.	1,110	1,140	148	772		
Manganese	Thousand S.T.	93	1,317	760	2,500		
Mercury	Thousand S.T.	29	59	2,163	10,500		
Molybdenum	Thousand lb	99,807	57,287	12,840	64,500		
Nickel	Thousand lb	31,200	299,200	188,000			
Nitrogen-Compounds	Thousand S.T.	10,611	9,940	770,000			
Nitrogen-Gas & Liquid	Thousand S.T.	4,879	4,879	39,700			
Palladium	Thousand S.T.	10	531	20,900			
Phosphorus	Thousand S.T.	5,099	3,400	1,060			
Platinum	Thousand T. oz	11	38	12,000			
Potassium	Thousand S.T.	2,327	3,901	1,000			
Rare Earths	S.T.	(1)	11,000	22,000			
Rhenium	lb	2,500	1,250	12,700			
Rhodium	T. oz	0	38	85			
Rubidium	lb	0	(1)	2,200			
Scandium	Kg	(1)	5	25			
Selenium	lb	1,199	1,226	1,620			
Silicon	Thousand S.T.	471	477	1,000			
Silver	Thousand T. oz	41,900	98,500	210,000			
Sodium	Thousand S.T.	18,994	19,919	57,200			
Strontium	S.T.	0	(1)	34,200			
Sulfur	Thousand L.T.	9,540	9,175	30,000			
Tantalum	Thousand lb	0	1,287	4,010			
Tellurium	Thousand lb	234	312	366			
Thallium	lb	(1)	(1)	9,000			
Thorium	lb	(1)	(1)	1,500			
Tin	S.T.	(1)	58,015	90,000			
Titanium-Metal	L.T.	0	27	163			
Titanium-Nonmetal	Thousand S.T.	302	508	1,810			
Tungsten	Thousand lb	7,439	15,356	74,000			
Vanadium	S.T.	5,900	8,000	31,000			
Yttrium	S.T.	(1)	(1)	420			
Zinc	Thousand S.T.	553	1,504	3,000			
Zirconium-Metal	S.T.	0	(1)	20,000			
Zirconium-Nonmetal	Thousand S.T.	(1)	(1)	167			

\* Source: MINING CONGRESS JOURNAL, September 1971. Table prepared by the U.S. Bureau of Mines. (1) Certain data are not available because the manner in which the information became available to the U.S. Bureau of Mines does not permit general disclosure. Abbreviations: S.T., short tons of 2,000 lb.; L.T., long tons of 2,240 lb.; T. oz., Troy oz.; Revised April 1972.

definitely real. In addition, every time that a material is removed from the earth or the ocean and made into a saleable product, the nation, which might not experience an environmental problem during the initial stages in the development of the product, eventually winds up with the waste removal and disposal problem when the product is no longer useful and is discarded. Until recently, our production and consumption system operated solely on a one-time use basis. This policy generates large quantities of solid waste. While some of the discarded material eventually returns to nature, a very large quantity remains to mar the landscape and degrade the total environment.

Lately, it has become a national goal to set a balance between material needs and environmental quality. To do so, the aforementioned business and production policy must change to a closed cycle of use, salvage, reclaim/reprocess, and reuse. This will not only help the environment but alleviate some of the drain on our raw materials supply.

This closed loop materials policy can help our nations's environmental effort and our nation's natural resources depletion problem. To this end, the National Commission on Materials Policy was established by Congress under Title II of the Resource Recovery Act of 1970. Some of the Commission's tasks are to make a determination of:

- "1. National and international materials requirements, priorities, and objectives, both current and future, including economic projections.

2. The relationship of materials policy to:
  - a. national and international population size, and
  - b. the enhancement of environmental quality.
  
3. Recommended means for the extraction, development, and use of materials which are susceptible to recycling, reuse or self destruction, in order to enhance environmental quality and conserve materials.
  
4. Means of exploiting existing scientific knowledge in the supply, use, recovery, and disposal of materials and encouraging further research and education in this field.
  
5. Means to enhance coordination and cooperation among Federal departments and agencies in materials usage so that such usage might best serve the national materials policy.
  
6. The feasibility and desirability of establishing computer inventories of national and international materials requirements, supplies, and alternatives.
  
7. Which Federal agency or agencies shall be assigned continuing responsibility for the implementation of the national materials policy." 4

### 5.3 Critical Materials and Environmental Factors

Several of the materials which are critical to DoD have been evaluated and their impact upon the environment in every stage from the ore in the earth to the finished product has been assessed. A brief environmental impact description is presented for a few of the critical materials.

#### 5.3.1 Aluminum

To reduce the aluminum metal from its oxide requires an extensive amount of energy. Naturally, this produces all the general pollution problems that are associated with electrical power generation.

"Additional problems can be created by fluorine-containing dust and gases emitted from alumina reduction cells. The disposal of waste red muds from present-day Bayer plants treating bauxite poses a problem that will become more critical with time. However, land use conflicts also would accompany any large-scale employment of domestic clays as a primary source of aluminum." <sup>6</sup>

#### 5.3.2 Antimony

Environmental considerations for domestic production of antimony relate to mining and processing lead or lead-silver ores, inasmuch as antimony is a minor byproduct.

In the largest domestic antimony smelter, the fumes and flue dusts from all reverberatory furnaces are collected in bag houses.

#### 5.3.3 Asbestos

Inhalation of different chemical and physical types of asbestos results in the development of asbestosis of the lungs. Since the hazard has been known,

precautionary measures have been taken to filter the air and properly ventilate the mines and processing plants.

There do not appear to be any land use problems associated with asbestos. Most of the asbestos deposits are on privately owned or leased lands which are far away from the major populated areas.

Dust control is very important in the asbestos industry. For example, water sprays allay the dust as the tailings are discharged. In the processing plants, asbestos is usually milled as a dry operation and all the screens are hooded and operate under a slightly negative pressure for dust control.

#### 5.3.4 Beryllium

After World War II it was discovered that beryllium dust and fumes even in small quantities can cause in susceptible persons a serious chronic lung disorder called berylliosis.

To prevent new occurrences, working places are kept clean, workers are required to wash their hands regularly, clothing is laundered regularly, fumes and mist are caught at source and deposited in dust collectors. Numerous other precautions including medical programs have been adopted to make working conditions safe. Avoidance of the health hazards adds significantly to costs. No one is known to have been poisoned from ingestion of beryllium compounds or to have contracted dermatitis or pneumonitis from handling or mechanically working low beryllium alloys such as beryllium-copper alloys.

The two major producers of beryllium have arranged with the National Center for Urban and Industrial Health of the U. S. Public Health Service to make a comprehensive study of the entire health question.

#### 5.3.5 Bismuth

By itself, bismuth has no impact on the environment except when and where it is mined in association with other metals, e. g., copper, tin or silver.

#### 5.3.6 Cadmium

The fumes of cadmium and its compounds are extremely toxic, so that extreme care must be taken during processing to prevent inhalation of the fumes. The recommended maximum allowable concentration for cadmium in air has been set at 0.1 milligrams per cubic meter of air by the American Standards Association. Death due to ingesting cadmium is rare, and usually not enough cadmium is absorbed to cause serious damage.

#### 5.3.7 Chromium

The processing of chromium ore to a ferro-chrome product generates objectionable emissions, which now are largely collected and the process meets air pollution standards. However, the collected dust is a solid waste disposal problem as is the slag generated during smelting. Refractory and chemical uses of chromium ore cause solid waste disposal problems in the form of burned out refractories and iron sludge.

#### 5.3.8 Cobalt

No known problems exist, to date, in the United States.

#### 5.3.9 Columbium

Mining, which is open pit mining, is the only environmental problem that exists with this material.

### 5.3.10 Copper

"Emission of sulfur compounds to the atmosphere during smelting is the most pressing immediate problem facing the domestic copper industry. New technology and large capital investments will be required to either modify existing pyrometallurgical practices or adopt new chemical-process techniques as a solution to the problem if the United States is to maintain a viable copper industry.

The domestic extraction industry also faces potentially critical land-use conflicts. Unless opposing views on surface restoration standards, waste disposal, and pollution issues are reconciled without excessive increases in operating costs, the competitive position of the U. S. supplies will deteriorate sharply.

The Wilderness program and public works designed to conserve essential land and water resources will increase confrontations with the industry and will present increasingly difficult problems for reconciliation.

Because approximately one ton of makeup water is required per ton of ore processed in the concentrator, and with population increases and industry expansions, conflicts for sufficient water to process increasing quantities of ore can be anticipated in the Western States where much of the production is obtained. Decreased water requirements could result from research on the beneficiation step." <sup>7</sup>

### 5.3.11 Iron

Air, water, and waste disposal problems beset the entire process of iron and steelmaking from ore to shipped steel products. Air pollution problems are associated with blast furnace, coke plant and steel melting operations, and captive power plants. Water problems arise from the discharge of large volumes of cooling water and from the disposal of waste products, such as spent liquors and used oil. Solid waste problems include disposal of mine overburden, concentrate tailings, sludges, and slags.

### 5.3.12 Lead

"Lead mines are essentially located in remote areas populated mainly by people dependent upon the mines, or in the Missouri area by farming communities. The mines are underground with a small surface area required for mine plant and disposal of waste materials. In fact, utilization of waste for highway and other uses has extensively reduced land use required for waste disposal. Conflicting land use is thus small or negligible, and landscape beautification is of minimal consequence. Mine wastes where not commercially utilized are to a large extent returned to the underground workings as backfill or are dewatered and impounded, thus minimizing stream and atmospheric pollution.

Lead smelters are equipped with efficient dust and fume collection systems to maintain the 98-percent recovery factor and are equipped with protective devices to prevent lead poisoning. The smelters are also equipped with or in the process of installing smoke purification devices for collection and manufacture of sulfur fume into sulfuric acid.

Lead poisoning may occur by ingestion of lead or by exposure to lead vapors. The danger is well recognized in smelters, foundries, and other lead plants; with proper worker precautions, ample dust and fume collections, and ventilation properly installed, lead poisoning has not been a health hazard. Periodic medical checks are usually insisted upon at lead plants to permit early detection and treatment. The possible harmful effect of lead compounds in exhaust emissions from gasoline-powered engines and the degree of contribution to air pollution in industrial areas are being extensively investigated by public health agencies and the lead industry.

One of the current objections to the use of lead in gasolines is that it contributes to the poisoning of catalysts in some devices now being developed to reduce air pollution from internal combustion engines." <sup>8</sup>

### 5.3.13 Manganese

Very little mining is done in the U.S. for manganese; the associated environmental problems are minor. The U.S. does process the imported ore to ferroalloy; however, the environmental considerations associated with this metallurgical process are also minor.

### 5.3.14 Mercury

"The major loss of mercury during extraction occurs in the stack gases, with minor losses in the calcine, soot, and spillage. Furnace plants are equipped with dust-collection units so air pollution from particulates is not a major problem. The small quantity of dust is either discarded or processed to recover the contained mercury.

Poisoning of workers caused by exposure to mercury may occur in mining and retorting metallic mercury and in any industry in which mercury is used. Therefore, precautions such as proper ventilation, use of respirators or masks, personal cleanliness, use of mercury vapor detectors are required.

Much of the mercury consumed is for dissipative uses which may ultimately lead to environmental pollution. Spent catalysts, in the form of inorganic mercury compounds from plastic manufacturing, can contaminate natural waters. Mercury losses from mercury cells in the caustic soda and chlorine industries contribute to air and water pollution. Other uses of mercury giving rise to environmental concern are in agriculture, amalgamation, paints and pulp and paper.

In March 1971, mercury was designated a hazardous air pollutant by the Environmental Protective Agency. According to the Clean Air Act of 1970, emission standards will now be promulgated for mercury." <sup>9</sup>

### 5.3.15 Molybdenum

"The mining of molybdenum primary ores entails the disturbance of some land areas which in the future may require reclamation. The problem is minimal, however, because of the very few acres involved per unit of production. Molybdenum recovered in conjunction with copper production entails the disturbance of significantly larger land areas.

The conversion of molybdenum to molybdic oxide involves roasting which releases sulfur that is exhausted as sulfur oxides into the atmosphere. Pollution from roasting is more widespread because molybdenite is shipped to a number of subsidiary companies and other consumers in many parts of the country for processing. The growing national concern for air pollution will probably alter molybdenite processing practices in the future.

There are undoubtedly other pollution considerations that must be resolved in the recovery of molybdenum. The problems at present are relatively local, however, and undefined."<sup>10</sup>

### 5.3.16 Nickel

The emission of sulphur dioxide during the process of smelting the nickel sulphide ores appears to be the major environmental problem associated with the mining and refinement of nickel ore. However, this problem appears to be under control. Open pit mining for the material has, so far, taken place in tropical areas where the land recovers quickly, or in remote areas.

### 5.3.17 Radium and Uranium

"Uranium will be used primarily for generation of electricity. The fissioning of the uranium will generate relatively small volumes of highly radioactive materials. Only a minute portion of this radioactivity will reach the environment. The bulk of the radioactive wastes will be separated during recovery of the nuclear fuel for eventual storage in solid form

in a Federal repository that will effectively isolate it from man's environment.

Waste heat from nuclear plants is higher than from some modern fossil plants because of lower thermal efficiency. Careful plantsiting and use of cooling devices can minimize the environmental effects of the waste heat. In addition, advanced reactor designs will be of higher thermal efficiency, reducing the heat to be dissipated.

Recycling -- Since only a small portion of the uranium in a reactor core is consumed during a reactor cycle, reprocessing of wastes and irradiated cores is planned as a normal operational procedure. In addition, plutonium, generated in the reactor will be recovered at the same time. While special techniques are required, the technology is well developed. "11

#### 5.3.18 Silver

"For more than 50 years, tailings from Idaho silver operations were discharged into streams that ultimately lead to the Coeur d'Alene River and then to Coeur d'Alene Lake. Current programs for tailings disposal will impound the mill tails so that only clear water will overflow into the river. The Bunker Hill lead-silver smelter has installed facilities to recover SO<sub>2</sub> gas, alleviating the air pollution problem.

There is an increasing mutual awareness of both mine management and the public for a better environment and recent actions such as those taken at Coeur d'Alene have begun to remedy the situation. However, much needs to be done in solving the overall environmental problems of the primary industries which produce silver as their coproduct or byproduct. More detailed coverage of environmental consideration for these resources may be found in the Copper, Lead, and Zinc chapters." 12

### 5.3.19 Tantalum

"The two small tantalum-bearing pegmatite domestic mining operations disturb very little land. No land use conflict is expected if the Idaho placer deposits are developed because of their remote location. Dredging these deposits would muddy, but not pollute the downstream waters and this could be minimized by the use of settling ponds and flocculating agents. Even so, complaints could be expected from sport fishermen. In one known case, however, a dredging operation in Idaho actually improved the fishing. It proved to be easier to catch trout and other sport fish in the slightly milky water caused by the dredging than in the previously crystal clear stream. Heavy rains and spring runoff of melting snow cause the streams to carry more sediments than properly controlled dredging operations that comply with the Federal Water Quality Act of 1965.

Stack exhaust fumes, gases, and dust from tantalum extraction plants are easily controlled. Tantalum is an inert metal. There are no known health hazards connected with its production or fabrication." 13

### 5.3.20 Tin

"Because 99 percent or more of the primary tin consumed by the United States reaches this country ready to use, mining and smelting pollution problems are practically nonexistent. In any secondary detinning operation, tin-containing muds are generated as waste material. Waste water from the rinsing of detinned steel may contain small amounts of caustic, sodium nitrate and tin. Drosses and dusts accumulate in industrial centers, especially on the east coast, but these eventually become sources of secondary tin and do not constitute an environmental problem during the periods of accumulation. Organotin compounds, known for over 100 years, have taken on new importance as agricultural biocidal chemicals as a result of concern over mercury. Certain organotins decompose during natural weathering to nontoxic compounds.

In Southeast Asia, particularly Malaysia, restrictions are imposed against abandoning dredged ground until it has been returned to a productive capability. No restriction of supplies of tin appear likely because of these laws, but the cost of such rehabilitation might be passed along to the consumer. " 14

### 5.3.21 Titanium

"Operating factors in the titanium production cycle that relate to the environment include disposal of solid and liquid wastes. Significant quantities of mud and slimes, resulting from dredging and concentrating titanium minerals from some sand deposits, constitute a serious and growing problem of disposal for some operations. The mud and slimes, which contain approximately 50 percent kaolin and considerable organic matter, are acidified and permitted to settle in large mud lakes on land which must be purchased by the mining company. The small quantity of clear water resulting from the settling must be neutralized with lime before it is fed back into nearby streams.

The principal solid waste generated at plants using the sulfate process to make titanium pigments are copperas ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ) and the monohydrate ( $\text{FeSO}_4 \cdot \text{H}_2\text{O}$ ). About 1.1 million tons of byproduct copperas and 0.4 million tons of the monohydrate are generated annually at domestic plants. About one-fifth of the copperas is utilized in making iron oxide pigments, ferrites, and fertilizers, and in water treatment plants. The remainder, containing a small quantity of entrained sulfuric acid, is neutralized and dumped on land, in streams, in the ocean, or stockpiled. Apparently all of the monohydrate, containing entrained acid, is dumped in the same manner. " 15

#### 5.3.22 Tungsten

The environmental factors of concern with the refinement of the material tungsten is the disposal of the tailings from mining and the purification of the water used in the solvent extraction plants. However, these environmental considerations are local in nature.

#### 5.3.23 Vanadium

Vanadium, which is mined by both open pit or underground methods, presents some problems in land use and disposal of solid waste. It is a co-product with uranium production and is subject to the same environmental problems that originate from the uranium.

Production of various vanadium products from the ore or their use in metal or chemical production, cause no serious environmental problems.

#### 5.3.24 Zinc

Zinc is usually mined as an underground operation. As such, there are no objectionable environmental factors such as open pit mining or waste stripping. However, the underground waste and mill tailings present a land-use conflict problem in some areas.

In addition, when zinc sulfide concentrates are converted to zinc oxide via smelting or electrolytic refining processes, a pollution problem exists in the release of sulfur dioxide and other fumes.

#### 5.4 Conclusion

This initial contract study has identified the need of DoD to be assured of materials which are critical for their activities. Not only must the total supply and location of the natural resource be known, but the material must be handled/processed in a manner which will comply with all Federal, State and local ordinances and standards.

Thus, a study should be initiated to positively identify the critical materials, to determine the total environmental impact of their refinement, to identify the necessary instrumentation to be assured of non-polluting processes and compliance with all applicable standards, and to ascertain the void in the instrumentation/monitoring or the metallurgical process itself so that improved state-of-the-art technology can be applied to correct any deficiency.

5.5 References

1. "Stockpile Report to the Congress, July - December 1971", Office of Emergency Preparedness, Washington, D.C., p. 1.
2. Ibid, p. 6-8.
3. "What Mining Means to the United States", American Mining Congress, Washington, D.C., p. 15-16.
4. "Towards a National Materials Policy, Basic Data and Issues, An Interim Report", April 1972, The National Commission on Materials Policy, Washington, D.C., p. 2.
5. Ref. 3, p. 2-3.
6. Ref. 4, p. 24.
7. Ref. 4, p. 27
8. "Mineral Facts and Problems", 1970, U.S. Bureau of Mines, p. 614.
9. Ref. 4, p. 32.
10. Ref. 8, p. 341.
11. Ref. 4, p. 45.
12. Ref. 8, p. 731.
13. Ref. 8, p. 393-394.
14. Ref. 4, p. 34-35.
15. Ref. 4, p. 37.

## 6.0 Management for Environmental Impact

The conclusion that OAS has drawn is that an effort should be funded to evaluate the management and administrative requirements of pollution problems related to DoD activities. This conclusion arises from considering the multi-factor aspects involved in today's ongoing programs.

The determination of the environmental impact assessments and remedies involves almost all activities which expend energy or handle material. As a consequence, one can logically conclude that almost all aspects of life are involved with pollution.

Within the DoD, from the project level to the Office of the Secretary of Defense, the subtle effects of environmental assessment and remedy permeate. While one could prescribe an organization to administer these problems similar to those which utilize classified material, public acceptance is an aspect to be considered with today's environmental conscience public. Therefore, careful consideration must be given to the administration of the technological problems.

## 7.0 Support Need for Future Environmental Impact Statements

The current study effort is directed toward identifying the research that is needed to support future environmental impact statements. Assessment and evaluation of the issued impact statements is used as the vehicle to determine the areas of potential difficulties.

The technical factors which enter into evaluating the environmental impact clearly show the need for a data base. Most of the activities of DoD are not military-unique and thus could be readily assessed if results were available from non-DoD organizations. However, topics such as:

Mustard Gas Disposal

Project Sanguine

Over-the-Horizon Radar

Safeguard Ballistic Missiles

Disposal of Anti-Crop Biological Agents

Disposal of Anti-Personnel Agents and Toxic Materials

plus others, are definitely military-oriented and pollution abatement efforts and evaluations are the direct responsibility of DoD. DoD needs a data bank and environment impact prediction facility to assist in the formulation of a proposed activity and to determine the total environmental impact which is a consequence of that action.

In the following sections, a few of the areas for future study are briefly described. Although all these study areas are not uniquely

DoD-oriented, answers are needed and this information should be available to the tri-services. More detailed requirements are presented in Section 8.0 in the Future Study Area portion of each environmental impact statement.

### 7.1 Air Quality

1. New sensors for monitoring agent,  $\text{SO}_2$ , HCl and other emissions, should be investigated and evaluated. The recent advances in spectrophotometric, mass spectrometric, electroanalytical and other instrumental methods should be readily applied to these problems. It seems to be desirable to directly monitor HCl in the stacks as  $\text{SO}_2$  may be scrubbed at a different efficiency than HCl.
2. Additional studies should be established to determine scalar diffusion processes in the high altitude atmosphere. At present, very little is known about its flow field and its effects on the eddy diffusion processes. The molecular diffusion rate is expected to be much higher than that of the sea level atmosphere due to the vast differences in the mean free path length but more experimental verification is needed.
3. Determine techniques to eliminate sulphur oxide emittants from the stacks of heating plants which are burning sulphurous fuels. The solution may be by either removal of the sulphur oxide by after-burning of the fuel or by the removal of the sulphur from the fuel prior to burning.

4. A system is needed for accurately measuring the carbon monoxide emittant at any temperature in the stack and automatically adapting the burning of the fuel so that an expected efficiency level of combustion is maintained. Smoke detectors, carbon monoxide monitors, and procedures to compensate for system malfunction are needed.

5. Particulate emissions should be analyzed in more detail than weight/unit time. The presence and quantities of trace metals such as lead, cadmium, etc. . . . , as well as polynuclear aromatic hydrocarbons, should be investigated.

6. A study of the total expected engine emissions for a typical peak operating and maintenance period at a military airport should be undertaken. The ambient air quality in the vicinity of the airport may show degradation even though the individual source emissions are not excessive.

7. Undertake a study of the emittants from the incineration of solid wastes, particularly plastics. Standards exist only for the six predominant emittants from conventional organic and paper wastes. Criteria for standards for the less common, but perhaps toxic, emittants are needed.

## 7.2 Economic

Initiate studies to evaluate the environment, as it exists, and as it may be affected by a project-induced change. A consistent set of evaluation criteria measurable in dollars would be well suited for such a purpose. Using this situation as the example: the land is arid, and agriculture depends upon irrigation. Consequently, water has a premium value.

The 440 acres of land to be inundated for the evaporation ponds (refer to PB 199 018-F) is presently only marginally productive in crops and grazing and represents a ratable low tax. However, the availability of 1.45 million gallons of irrigation water daily, if the San Luis Drain water is treated, might increase the value of a significant portion of that land, or other land nearby. Plainly, it will be difficult to place a dollar value on the improvement of the environment. However, such an evaluation is necessary if a choice is to be based upon an economic criterion.

## 7.3 Electromagnetic

1. Both radio interference and microwave radiation safety are discussed in terms of ground effects. Ground radiation is due to sidelobes of the main steered radar beam. Thus, since most power is contained in steered beam directions, hemispherical zones in the air should be established for the safety of all aircraft - especially low flying small aircraft.

Therefore:

- a. A study should be conducted for designing a warning alert system for aircraft entering dangerous zones.
- b. As radar detection range increases, beam energy density at the source increases. Considering the future tendency of going toward longer detection ranges, studies to determine other detection modes which do not require designation of dangerous regions in a populated area (currently or potentially), should be conducted. One obvious way is to replace backscattering with a forward scattering method. In this mode of operation, active antennas can be located at isolated areas. Thus, more radar research should be expended to examine the full potential of the forward scatter radar in this application.

2. RF monitor: A multi-spectral radio frequency signal level monitor is needed that is automatic, located afield, and sounds an alarm when a tolerable level is exceeded.

#### 7.4 Hazardous Materials

1. An improved monitoring method for mustard should be devised incorporating a high sensitivity detector and a rapid cycle sampling system. Electron-capture detectors have high sensitivity for halo derivatives, such as mustard, and could be used as part of a rapid cycling GLC system. Microcoulometers might also be used.

2. Monitoring of emissions and liquid wastes for herbicide or harmful breakdown products may be needed. Phenolic materials could be present in either case. When private facilities are involved, they should be amenable to a complete survey of emissions and wastes.

3. Liquid wastes could be held and evaporated to dryness using techniques similar to those described for the TDS (PB 202 308-D) and Project Eagle (PB 200 540-F). The salts could then be disposed of when a safe, approved method is decided and established. The feasibility of this technique should be studied.
4. Absolute filtrations of all vented gases from fermentation and biodegradation, prior to incineration, should be investigated.
5. Constant improvements should be sought in tests for residual antigens and in other bio-assay methods.
6. While needs for explosive storage space increase, it is obvious that means of containing explosives in smaller spaces should be found. Investigations should be advanced to ascertain the feasibility of deep earth storage magazines for ammunition. In addition, safety methods of handling and storing dangerous explosives should be continuously investigated to update the safety technology and to lessen the danger of accidental explosions.

#### 7.5 Land Use

1. Extensive research and development of underground electric power systems has been in progress for many years and continues with renewed emphasis because of requirements for such service in some urban areas. Assuming costs will become manageable and reasonable,

there will be a need to evaluate the underground transmission system, as opposed to aerial transmission, in rural areas and in terms of its environmental impact. This evaluation can, and should, be done now.

2. Large housing developments usually maximize the number of building plots on a tract for economic reasons. As a model, Federal housing projects, such as this Air Force housing, should undertake a study of development plans which will offer optimum complementary roles to natural environment and to housing, with a minimum of pavement. The houses should still have ample free space around them and be adequately serviced by roads. However, the traditional foursquare formula (standard rectangular block arrangement of houses) need not be adhered to.

#### 7.6 Noise

1. At present there are little data available on the effects of acoustical energy on structures other than aircraft. High frequency and high intensity noise has been documented as the cause of metal fatigue in many cases. Low frequency and high intensity noise has been observed to cause windows, light aluminum and other sheet metals to vibrate. This is where the technology gap exists. There is little valid information concerning the interrelationship between acoustical energy and vibration and the possible effects on buildings, machinery and equipment. A study should be initiated to determine these effects of a sonic boom.

2. Methods for abatement of noise emissions from VTOL/STOL aircraft must be found, evaluated, and employed. With an increasing number of urban communities, the VTOL/STOL will be the most important and fastest means of transportation for civilians and the military. More wide-spread and general use of these aircraft appear imminent and unless noise control techniques are developed, the noise level about these airports will be extremely high.

3. Certain noise abatement devices for aircraft engines hinder operation (silencers) or are of limited effectiveness (baffles). Regulation of flight patterns and schedules to accomodate sleeping residents and adverse sound transmission conditions also hinder operations. Large buffer zones of undeveloped land, or forested areas are effective, without hindrance to military operations, but may be costly. A combined study to optimize the effectiveness of noise abatement procedures, their cost in terms of operations, capability, and their alternatives should be part of the overall study.

4. Military airport noise: The extensive run-ups, engine tests, and training flights associated with a military airport produce patterns and persistence of noise different from commercial aviation. A study of the total diurnal and long term impact of the military aircraft noise should be made at a typical military airport, which includes surrounding residential and commercial community areas.

## 7.7 Waste Disposal

1. Specimen incineration: The incinerator should be, without doubt, fully protective of the community against emissions which may contain pathogenic or allergenic emittants or noxious odors. However, the Federal and state regulations may not be adequately protective. A study should be established to determine the quantities, types, and containments (pathogenic, noxious, or chemical) of the specimens to be incinerated, the end products of the incineration, and demonstrate that none of the emittants will be humanly or environmentally harmful. The incinerator construction and operation, including specimen handling prior to incineration, should be included. Then criteria should be established such that Federal and state standards can be promulgated for this type of operation and adapted to similar hospital facilities.

2. A study of means (during dredging operations) to oxidize the sediments during settling in the diked areas or while in transport to them, would be worthwhile. The inability to grow deep rooted trees in the previous disposition of sediments might be due to a combination of the oxygen demands and the fine particle size which prohibits natural aeration.

3. The present method of cleaning deactivated ship hulls requires the hulls to be flushed with sea water, at an approximate cost of \$25,000 per ship. In addition, the cleansing operation requires more

than three (3) weeks of work and even then the ship's fuel lines are not free of oil. More efficient cleaning methods should be investigated. Possibly an ultrasonic cleaning technique would be a more practical and economical solution.

4. The disposal of contaminated sediments from dredging operations is a widespread problem and worthy of a special study on sediment disposal methods. Special facets of the study would consider the effects of turbidity, sedimentation, toxicity, and other parameters. Alternatively, the fine clays and silts might be useful industrially in the making of bricks.

#### 7.8 Water Quality

1. Municipal and state regulations regarding sewage are recognized as being inadequate when special substances (e. g. pathogens or allergenic emittants) are present in the effluent. A study should be initiated to determine criteria for standards of special substances.

Chemicals in sewage (e. g. chlorine compounds, compounds that alter the pH) can delay the oxygenation such that the effluent pours out of the treatment plant with too large an oxygen demand, and consequently contaminates the surrounding waters. Measurement techniques and standards are needed.

2. A study should be undertaken of the extent of the spilled fuel, oil, and grease that is dropped on the ground from the aircraft during maintenance and operation, and the manner in which rainfall carries these contaminants into the natural drainage waters. It is not known if this is a significant environmental impact, although the evidence on the airport apron indicates that the amounts may be significant. Controlled drainage or catchments would eliminate the problem.

3. A study should be initiated to ascertain the impact of fuel oil at various depths in the ocean. (This study is directly applicable to the problem of sinking target hulls, as the ships are slowly releasing oil as they sink to the ocean bottom - refer to PB 202 335-F).

4. A study is needed to determine the diffusion processes in the ocean with special emphasis on parameters such as the descending rate of the pollution source and the flow field conditions.

5. Determine and evaluate techniques for economic water purification if the water is high in TDS. A disposal method or a utilization of the brine or the precipitate salts derived from the purification process should also be considered.

6. Determine the percentage of ships of the various categories in the U. S. Navy which have been provided with sanitary sewage collection facilities and can be connected with a shore disposal system. Estimate

the quantity of sewage that will be discharged directly into the harbor because of a lack of sewage collection facilities on board ship, and quantity of sewage that will be discharged into the Navy's sewerage system.

7. Determine the effluents from ships, other than sanitary sewage and cooling water, which can be discharged directly into the harbor.

## 8.0 Environmental Impact Statements

This contract study is concerned with the impact of DoD operations on the environment. In a memorandum to the Deputy Director (Research and Advanced Technology) dated 31 March 1972, Mr. John A. Busterud, Deputy Assistant Secretary of Defense (Environmental Quality) stated that:

"this study would best serve the needs of the Department of Defense if it were directed primarily to an evaluation of environmental impact statements previously prepared by the Defense Components as required by P. L. 91-190 'National Environmental Policy Act' with the aim of defining those common areas of research wherein little or inadequate information is known to truly assess the actual environmental consequences of actions to be undertaken."

Thus, the environmental impact statements were addressed to derive a listing of priority needs for future Department of Defense research and development endeavors in the environmental sciences. The natural order of priorities for pollution problems are:

1. Ones that can cause shutdown of essential activities and services of the Department of Defense.
2. Ones that are unique to the Department of Defense.
3. Ones that are more naturally relevant to other Federal or civilian agencies.

Therefore, although effort was made to determine all the areas where there appeared to be weaknesses in the current theory or technology, the prime objective was to ascertain those areas where DoD has a unique

requirement or where pollution problems are not being adequately addressed by others.

## 8.1 History

Public awareness, conservation, environmental enhancement, and cultural improvement were the prime motivations for the development and specification of the environmental impact statement. This document is required of every agency that proposes an action that might have an impact on the environment. The impact statement's purpose is specified in Section 102c of the National Environmental Policy Act (NEPA) of 1969 (P. L. 91-190) which states that, for any proposed action of significant environmental impact, a responsible official of the proposing agency must prepare a detailed statement which includes the following:

1. The environmental impact of the proposed action.
2. Any adverse environmental effects which cannot be avoided should the proposal be implemented.
3. Alternatives to the proposed action.
4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
5. Any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented.

In support of NEPA, President Nixon issued Executive Order 11514 on March 5, 1970 which directs all Federal Agencies to evaluate, monitor, and control activities for enhancement of the environment and to issue timely information to the public on the proposed actions so that comments might be obtained. Although Executive Order 11507 of February 4, 1970 had already committed the Federal Agencies to set performance standards for actions which might be adverse to the environment, it did not provide for public notification of the proposed actions.

A set of guidelines<sup>1</sup> for the generation of an Environmental Impact Statement (EIS) was formulated by the President's Council on Environmental Quality (CEQ) on April 23, 1971. These guidelines list the pertinent items and the format required for an EIS. An impact statement must include a description of the proposed action, its impact on the environment, adverse environmental effects, alternatives to the proposed action, and a list of irretrievable or irreversible commitments of resources.

Since the environment includes not only the natural but also historical and cultural aspects, Executive Order 11593 was issued on May 13, 1971. This Executive Order states that an impact statement must include and

---

1. "Guidelines for Federal Agencies Under the National Environmental Policies Act", CEQ Memorandum, April 23, 1971. "Council on Environmental Quality -- Statements on Proposed Federal Actions Affecting the Environment: Guidelines", Federal Register 36, pp. 7724-7729, (September 23, 1971).

evaluate any impact that the proposed action may impose on historic sites or on the cultural environment.

The CEQ memorandum, dated May 16, 1972<sup>2</sup>, clarified the earlier guidelines for the generation of an EIS and took note of recent court decisions. Currently, the environmental impact statement has to detail the full range of environmental consequences even though they may be outside of the proposing agency's control. Also, the EIS must evaluate adverse and beneficial environmental effects and set forth any conflicting views.

The rapid growth of the environmental concern is evident by a perusal of the environmental impact statements which have been issued over the last 18 months. They have developed from a mere reporting of the proposed action and its consequences, to a comprehensive analysis and study of the proposed action. With several exceptions<sup>3</sup>, all the environmental impact statements that have been issued are unclassified. These are available to the public from the National Technical Information Service.

The EPA has established a new part 6 to the Code of Federal Regulations Title 40 (40 CFR part 6). The purpose is 1) to establish EPA policy and procedures for the identification and analysis of the

- 
2. "Memorandum to Federal Agencies on Procedures for Improving Environmental Impact Statements", Council on Environmental Quality, May 16, 1972.
  3. For example, "Operation Red Hat" (transportation of chemical munitions from Okinawa to Johnston Island) Draft, 27 November 1970.

environmental impact of proposed Federal agency actions and 2) to present guidelines for the preparation and processing of EIS when significant environmental impacts are anticipated.

[A more complete history of the Environmental Impact Statement and the procedure for the generation of the Tri-Services EIS's is presented in Appendix B.]

## 8.2 Issued Environmental Impact Statements

The environmental impact statements that have been issued by the Department of Defense are tabulated in Appendix C. To date, of the forty-nine impact statements that have been identified as being issued by the Tri-Services, forty-one have been received and reviewed at our facility.

Comments on these statements follow and the impact statements are arranged in alphabetical and numerical order.

For each impact statement, all pertinent data, such as acquisition NTIS number, draft (D) or final (F) statement, title of the action, issuing agency plus an abstract of the environmental action involved, the environmental factors involved, and a section which details future study areas, are given. A great percentage of the suggested future study areas are for environmental topics and problems which are not unique to the military community. However, these areas should be explored by some agency/facility/laboratory to provide data and conclusions which could be utilized in future environmental evaluation of a similar action.

Land Outlease for Wastewater Treatment Facilities  
Tyndall Air Force Base, Florida

Department of the Air Force

EIS-FL-72-5015-F

Abstract

"The action to be taken is the outlease of 150 acres of land on Tyndall AFB, Florida, in the area of Military Point to Bay County, Florida. The land will be used for the construction and operation of secondary wastewater treatment facilities for four municipalities and two industries.

The environmental impact of the action will involve the discharge of approximately 35 MGD of treated wastewater with an estimated BOD of 23 mg/l to the Class III waters of St. Andrew Bay. This complies with current published State standards. The lessee will be required to comply with any more stringent requirements established by the State or EPA for discharge to St. Andrew Bay. This is considered a beneficial impact, as it upgrades the current primary treated industrial waste effluent and the septic tank treatment for domestic waste. Some adverse impact in the immediate Military Point area will result from the change in land use from the natural state to a sewage lagoon and the loss, in that area, of the use and production of the natural resources--forests, fish and wildlife, and recreation." (ISSUING AGENCY'S ABSTRACT)

## Environmental Factors Involved

EIS-FL-72-5015-F

A. Air Quality: A comment by the Department of the Interior states that the Kraft pulp mill wastes produce offensive odors, even during aeration. These offensive odors would obviously hinder the quality of the air and the quality of the fishing waters.

B. Water Quality: Concern was expressed in the comment from the Environmental Protection Agency about the point of discharge for the proposed treatment system. Two alternatives to Bay discharge were proposed: spray irrigation and Gulf discharge. These were considered not practical as there was not sufficient experience and data to validate the techniques. Experimental data from the Bay was used to justify the Bay discharge method.

## Future Study Areas

The problems presented in this environmental impact statement are not unique to the military, unless the treatment plant is to be used for the disposal of military-unique materials. The disposal of this type of material is not considered in this impact statement. However, to fully answer EPA's future inquiries/comments, DoD should be able to completely specify the dispersion rate and pattern from the point of discharge. This could readily be accomplished by a numerical model. Thus, numerical modeling software and facilities should be available to DoD.

Relocation of Harry Diamond Laboratories  
White Oak, Maryland

Department of the Army

EIS-MD-72-4449-F

Abstract

The United States Army Materiel Command proposes to construct new facilities for the Harry Diamond Laboratories (HDL), which will consist of three major laboratory buildings and twelve smaller buildings, on a 137 acre tract of dense woodland located near Washington, D. C., and in White Oak, Maryland. The land is government owned. The laboratories will be primarily engaged in development of electronic instrumentation, electromagnetic wave research and study of the effects of nuclear radiation. (reviewer's abstract)

Environmental Factors Involved

A. Air Quality:

Heating plant: The daily total estimated emissions from the five boiler units are given in the impact statement in terms of pounds of sulphur dioxide (281), particulates (98), and nitrogen oxides (275). Since it is not stated, one must presume that this is in accordance with the D. C. Air Pollution Control Act (PL 90-440) or its equivalent for Maryland.

B. Water Quality:

EIS-MD-72-4449-F

1. Sanitary Sewage: A moratorium on sewage connections within the Anacostia drainage basin (jurisdiction of Washington Suburban Sanitary Commission) has existed since May 1970. HDL is not subject to this moratorium by virtue of prior application. The impact statement reports that the sewer lines are adequate.

2. Toxic Wastes: Toxic wastes entering the sewage are adequately described and appear to present no problem.

3. Storm Drainage: It is indicated that a system has been planned to adequately control storm water run-off.

4. Brook Siltation: The environmental impact statement indicates that brook siltation is prohibited and that control and abatement procedures are the responsibility of the contractor.

C. Solid Waste Disposal: The internal handling of solid wastes appears to be adequate, with compacting and storage facilities provided. Approximately 50 cubic yards of compacted waste will be generated weekly.

D. Radiation Hazards: The Harry Diamond Laboratories will have a gamma radiation facility and a high intensity x-ray facility, each in their own building. The latter is not yet designed; the former appears to provide adequate protection to the external environment.

Radio frequency emissions are mentioned and appear to be well

controlled and, in most cases, not likely to interfere with radio, television and other services.

E. Traffic and Transportation: Automotive traffic due to HDL is an adverse effect on the environment. However, this situation seems to be adequately alleviated by road widening and new traffic patterns.

F. Noise:

1. Heating plant: Air conditioning compressors, exhaust fans and other machinery can produce a low level of noise which is objectionable by its persistence. The intended siting of the plant in a natural depression of the land with 180 feet of buffer zone containing trees is a distinct advantage in abating noise transmission.

2. High pressure air facility: This facility will simulate characteristics of missiles and artillery in flight. Sound power levels of 130 to 145 dB are expected at the source, with a planned utilization of two hours per normal working day.

#### Future Study Areas

A. Noise Simulation: One of the outdoor facilities at HDL simulates artillery and missiles in flight with resultant objectionable noise levels. A technique is needed to model these sounds within a laboratory space to test the instruments which track and operate on these sounds.

- B. Heating Plant Carbon Monoxide Emission: A system is needed for accurately measuring this emittant at any temperature in the stack, and automatically adapting the burning of the fuel so that an expected efficiency level of combustion is maintained. Smoke detectors, carbon monoxide monitors, and procedures to compensate for system malfunction are needed.
- C. Research Laboratory Staff Movement: Many federally sponsored research centers incorporating multiple buildings on large land areas exist, and the trend is likely to continue. A study should be made of staff movement to determine optimum siting of buildings on a typical large flat tract of land. Inter-building spacing should be large from an esthetic and landscaping viewpoint; small, from staff requirements to communicate with each other. Some facilities, such as library and cafeteria need maximum communication, and some require minimum, such as garages, heating plants, and shops.
- D. RF Monitor: A multi-spectral radio frequency signal level monitor is needed that is automatic, located afield, and sounds an alarm when a tolerable level is exceeded.

500 Units of Military Family Housing  
Shaw Air Force Base, South Carolina

Department of the Air Force

EIS-SC-72-4568-D

Abstract (reviewer's)

The U. S. Air Force proposes to purchase about 100 acres of land which is contiguous to existing base housing at Shaw Air Force Base, South Carolina. It is further proposed to construct 500 units of military family housing on a plot comprising this 100 acres plus 27 acres already in Base ownership. The project includes paved streets, sidewalks, sanitary and storm sewers and water, gas and electric services. The proposed development is adjacent to 1205 units of existing family housing.

Environmental Factors Involved

A. Air Quality: No significant impact owing to natural gas fuel in the homes, and a prohibition against burning of construction wastes. During construction, dust abatement procedures will be instituted.

B. Water Quality:

1. Sanitary sewage: The new houses are to be connected to the new Base sewage treatment plant being built for the purpose.

2. Storm drain: Computations based on a 100 year storm, and allowing for the increased run-off from the developed lands, indicates

flooding of the brook passing through the site to a level lower than that necessary to affect any housing.

C. Land Use: The site is 1/3 arable land, partially farmed, and 2/3 forest. Of the 127 acres total, 22 acres are to remain unaltered, 70 acres graded, and 35 acres rendered impervious by buildings and pavement.

Erosion control will be accomplished by berms at junctures of graded and undisturbed grounds, and mulching immediately after grading is completed.

D. Noise and Traffic:

1. Construction noise: Noise will be heard at the nearby residences 300 to 400 feet from the construction site.

2. Traffic: Although traffic access to the new housing is principally through one roadway, the net effect on area traffic will be beneficial in that a traffic reduction will be felt at the southern Base entrance.

E. Fish and Wildlife: The existing site is a fringe area to suburban development harbouring small wildlife. This will be displaced.

F. Adverse Environmental Effects:

1. Two families must be relocated; the new homes will be of better quality than the existing homes.

2. Housing and pavement, loss of 40 acres of crop land, clearing 26 acres of forest, and noise and emissions of 500 families are adverse, but not irreversible effects.

3. Construction contract specifications will control any polluting activities of the contractor.

Future Study Areas

A. Air Quality: Undertake a study on the cumulative emissions from domestic heating plants in densely populated single family dwelling areas. The heating plants should have been in use several years and in typically encountered stages of worthiness. The purpose of the study is to evaluate the carbon monoxide and unburned hydrocarbon levels and, if significant, propose a procedure for annual test and compulsory cleanings by local certified repair men.

B. Water Quality: Study the impact on sewage plant operations by the use of domestic garbage disposal units in kitchen sinks. This might prove eventually to be a satisfactory means of eliminating some refuse pick-up and can be readily installed in a large construction project, such as this one of 500 houses.

C. Land Use: Large housing developments usually maximize the number of building plots on a tract for economic reasons. As a model, federal

housing projects, such as this Air Force housing, should undertake a study of development plans which will offer optimum complementary roles to natural environment and to housing, with a minimum of pavement. The houses should still have ample free space around them and be adequately serviced by roads. However, the traditional foursquare formula (standard rectangular block arrangement of houses) need not be adhered to.

Land Acquisition, Naval Security Group Activity  
Homestead, Florida

Department of the Navy

Abstract

The Navy proposes the Acquisition of 567.97 acres of unimproved swampland surrounding the Naval Security Group Activity, Homestead, Florida. Purpose of acquisition is to prevent commercial encroachment into the area which would cause electronic interference and erroneous radio directional indications. (ISSUING AGENCY'S ABSTRACT.)

Environmental Factors Involved

The placing of 568 acres of natural terrain into a permanent buffer zone will provide long range benefits to fish, wildlife, and other natural resources.

There will be no adverse effects of humans, wildlife and aquatic life and plant life.

The soil is generally a marl material and is not considered to be productive.

Future Study Areas

Initiate a study to evaluate the total impact and the boundaries of this facility as it relates to the environment. Then, if a relocation or a new

establishment of a similar operation is required in the future, establishment of the environmental impact zones of the current operation will be very useful in selecting another site.

Range Operations, Air Force Blair Lakes

Department of the Air Force

Abstract

The U. S. Air Force proposes to operate a 32,000 acre bombing and gunnery range on an uninhabited, low fertility, poorly accessible plain at Fort Wainwright, Alaska to replace the present operation at Fort Greely which is inadequate and also dedicated to other purposes, such as hunting and Army training. The Blair Lakes site at Fort Wainwright does not experience the high winds of the Fort Greely site, thus minimizing dangers from frostbite to the ground crew. Practice will include bombing, rocket firing, and strafing using live and inert ordnance from F-4 and similar aircraft of the Alaskan Air Command. Practice will be principally during daylight hours and will be conducted approximately 100 days per year.

(reviewer's abstract)

Environmental Factors Involved

A. Airspace: An airspace ten miles wide and forty miles long is restricted for the Range use. The area is bordered by mountains on the south and west. No residential or commercial areas are in the range zone.

B. Land Use:

1. Land was withdrawn from public domain in 1941 and restricted as an aerial bombing and gunnery range.

2. Habitat: The area is under U. S. Army control and is inaccessible except by aircraft and tracked vehicle. Mostly scrub black spruce, of small trunk diameter, is growing on the land. Moose, caribou and bears are on the Army land (647,000 acres), but not on the portion to be dedicated for Air Force use. Rabbits and wild fowl are found on the Range.

3. Erosion: Erosion, should it begin, will be controlled by placement of gravel and muskeg. The land is tundra, with very little rainfall and offers little opportunity for erosion.

4. Fire hazard: Accidental fires from explosives may occur in summer. The target area will be protected by firebraks and a tracked fire truck and a fire fighting helicopter will be stationed at the Range.

C. Water Quality:

1. Sanitary sewage: A septic tank and drainage field will be used, suitable for the size of the projected staff, and sufficiently distant from the potable water well.

2. Vehicle maintenance area drainage: An oil separator will be used, following which water will enter the sanitary sewer.

D. Solid Waste: Solid wastes will be flown to Eielson Air Force Base for disposal.

E. Air Quality: No change in air quality is expected in that the aircraft

emissions at Fort Greely, 45 miles away, will cease as the operation is transferred here.

F. Noise: Noise levels will be high during operations, but no human habitation exists within 22 miles of the Range.

G. Adverse Environmental Effects: The only adverse effect is the closing of the air space and the closing of the land area to hunters and trappers. Flight patterns are over uninhabited areas, hence accidents will have minimal impact on population.

The regrowth of vegetative cover after bomb damage is considered superior to present cover of terminal vegetation in that the regrowth will support more wildlife.

### Future Study Areas

#### Wildlife and Natural Habitat

A study of the ecology of the Range area prior to commencement of the Range activity, and a monitoring of this ecology for several years afterward would prove a worthwhile data base for this type of activity in the future.

Land Acquisition, Naval Submarine Base  
New London, Connecticut

Department of the Navy

PB 198 690-F

Abstract

"Acquisition of less than 36 acres of wooded and swamp area is to increase the existing explosive safety zone for naval magazines.

The acquired land will be preserved in its natural state.

The present environmental conditions will essentially remain unchanged. There will be future environmental benefits in that the area will be preserved in a natural state." (ISSUING AGENCY'S ABSTRACT)

Environmental Factors Involved

The environmental impact statement states that "the additional magazines are simply storage facilities and will cause no air or water pollution."

The taking of this land for a safety buffer zone will result in a loss of \$3000 in tax money each year.

Future Study Areas

While needs for explosive storage space increase, it is obvious that means of containing explosives in smaller spaces should be found. Investigations should be advanced to ascertain the feasibility of deep earth storage magazines for ammunition. In addition, safety methods for handling

PB 198 690-F

and storing dangerous explosives should be continuously investigated to update the safety technology and to lessen the danger of accidental explosions.

1550th Air Training and Test Wing  
Hill Air Force Base, Utah

Department of the Air Force  
Washington, D. C.

PB-198 764-F

Abstract

"Consolidation of all Air Force advanced helicopter training at Hill AFB, Utah. Major training areas will be in Weber, Davis, Salt Lake, Box Elder, and Tooele Counties.

This new mission will create an approximately 4% increase in average daily air traffic in the Salt Lake Valley, with consequent increase in aircraft engine emissions. There will be some air pollutant emissions from the fire-rescue training area and visible smoke emitted during the training period. To avoid annoyance from the noise generated by helicopter operation, operational routes have been established to fly in areas of least residential construction, avoid mink and chicken ranches, and avoid bird and wildlife refuges." (ISSUING AGENCY'S ABSTRACT)

Future Study Areas

A. This impact statement discusses the percentage increase of pollution above the ambient. According to comments from the EPA, the subject area is already polluted. Therefore, methods and techniques must be found to reduce the ambient pollution level.

B. The amount of jet fuel burned at the fire training pits is estimated at 4500 gallons per day for ten days each month. On the basis of negligible overflow and the fact that the local ground water is high in salt and therefore not suitable for drinking without extensive pretreatment, this impact was deemed not important.

In times of extended rains, the washing of similar facilities by the rain could have an impact on the local wildlife, vegetation, and, possibly, result in the eventual contamination of drinking water in deeper ground or in a nearby water source. Therefore, fire training pits should be designed and constructed to prevent overflow and seepage. Thus, various types of pits should be evaluated to determine the most effective pit.

C. Although the Department of Transportation is presently funding CIAP, additional research in the minimization of aircraft exhaust pollutants should be initiated.

D. At present, noise level contours are being determined for various airports in CONUS. The use of pollutant concentration contours, for various aircraft exhaust emissions, should be investigated for various aircrafts and airports. This information would be useful in the development of surrounding communities with respect to runway orientation. In addition, this data model should be developed in terms of the various operational modes of the airfield, the general weather pattern, and the terrain.

E. Methods for abatement of noise emissions from VTOL/STOL aircraft must be found, evaluated, and employed. With an increasing number of urban communities, the VTOL/STOL will be the most important and fastest means of transportation for civilians and the military. More wide-spread and general use of these aircraft appear imminent and unless noise control techniques are developed, the noise level about these airpaths will be extremely high.

F. The impact statement states that 4500 gallons of jet fuel are burned each day for ten days a month. The amounts of CO<sub>2</sub>, NO<sub>x</sub>, and particulates released into the atmosphere will increase the ambient pollution level. Therefore, burning techniques must be formulated and established which account for the present ambient pollution level, prevailing winds, and surrounding terrain and which insure the complete burning of the jet fuel so that the pollution emission level is reduced.

Anti-Personnel Biological Agents and Weapons

Department of the Army

PB 198 900-F

Procedures for the safe disposal of anti-personnel biological agents at Pine Bluff Arsenal, Arkansas are described. Total containment of the hazardous material throughout demilitarization and disposal is stressed most heavily. Verification of the total detoxification of the agents is emphasized, coupled with strict inventory procedures for the demilitarized items. The types of materials to be destroyed are:

1. Liquid agents stored as frozen pellets.
2. Bulk dry materials.
3. Bulk stocks of toxins.
4. Biological munitions (filled and unfilled).

The demilitarization procedure is always preceded by statistical sampling of each lot. The samples are assayed for viability and identified. Prior to final disposal, the inert material resulting from the demilitarization procedure will be compared and assayed for verification of complete destruction/detoxification. Each lot assay will be documented.

The frozen materials are thawed, drained into a holding vessel where they are pasteurized, then passed to a tank where they are sterilized, sampled and verified for complete destruction prior to final disposal (biodegrading and evaporation to dryness). The cans holding

the material are decontaminated (DS, a solution of quaternary ammonium chlorides (0.05%) and sodium hydroxide (0.1%), is used for decontamination in most steps of the procedure and for all emergency situations.)

The dry bulk material is handled similarly. The agent container is sampled; then DS is added with shaking. After standing for 16 hours \*\*, the material is added to a holding tank with DS rinsing. It is then pumped to a sterilizing tank and is sterilized for 3 hours at 280°F. A sample is taken for verification. If destruction is not verified, the sterilization is continued until verification is attained.

These procedures are carried out in the same buildings and laboratories where the agents were manufactured. Inert atmospheres are provided to prevent dust explosions and absolute biological filter systems and other safety measures prevent escape of hazardous material. All containers and hardware are decontaminated with DS and automatically cleaned before leaving the area.

Tests for destruction of infective or toxic activity are carried out with animals. The disposal problem includes incineration of dead test animals. The biological operations lead to four types of liquid effluents. Of greatest concern is the agent demilitarization waste. This waste is obtained from the above sterilization and decontamination procedures. After verification, it is biodegraded in existing plant vessels, by

\*\* Formaldehyde is added for decontamination during the standing period.

inoculation with a mixed culture from raw sewage and river water, until BOD is less than 300 ppm. It is then reesterilized for 3 hours at 280<sup>o</sup>F, verified and autoclaved after placing in drums. It is then taken to a commercial facility, further biodegraded until BOD is less than 25 ppm. After biodegradation, the solution is evaporated and the dried material returned to the base for use as a soil conditioner.

Packing waste, materials used in the procedure and animal carcasses are disposed of by incineration after decontamination. Vent gases from sterilization and biodegradation processes are incinerated at 1000<sup>o</sup>F. Stack effluents are monitored to verify total containment of pathogens. Tests and calculations have been carried out to ascertain that no excessive levels of pollutants will be generated.

#### Environmental Factors Involved

Carrying out the demilitarization procedure in the same complex where manufacturing was done assures that qualified personnel and properly designed facilities, equipment and safety features are available. The use of absolute biological filters is essential. The repetition of sterilization and verification procedures before the material leaves is a good feature of the procedure.

The two stage biodegradation of the material after sterilization prevents excessive biological oxygen demand resulting from the demilitarization procedure.

The incineration procedures, if carried out at rates previously calculated and properly monitored, should cause no stress to the environment.

The use of quaternary ammonium chlorides in decontaminating solutions is judicious as these materials have good biocidal properties as well as being useful detergents. They can replace ABS in cleaning formulation, thereby avoiding problems in biodegradability.

The use of *Bacillus Globigii* as a tracer organism to verify sterility is a good feature of this procedure and the anti-crop agent procedure.

#### Future Study Areas

1. Constant improvements should be sought in tests for residual antigens and in other bio-assay methods.
2. Absolute filtrations of all vented gases from fermentation and biodegradation to other tanks prior to incineration, should be investigated.
3. Improved scrubbing and monitoring systems for all incinerators should be devised.

Land Acquisition, Sewage Disposal Facility  
Naval Air Station, Lemoore, California

Department of the Navy

PB 199 018-F

Abstract

The water effluent from the sewage treatment plant at the U. S. Naval Air Station, Lemoore, California, contains a very large quantity of dissolved inorganic salts. The salts are principally chlorides and sulphates of the alkali metals and derive from the earth. They are leached out by ground waters and pass through the sewage treatment unaffected. No malfunction or inadequacy can be attributed to the sewage collection and treatment process itself. The infiltration of ground waters into the sewer lines is within engineering expectation for the size of the Lemoore sewer system. Since the effluent after treatment contains a TDS (total dissolved salts) and individual ion concentrations much in excess of the limit tolerated by the California State Water Quality Control Board for Class 1 irrigation water, the effluent cannot be discharged into the Kings River. The Kings River is used for both irrigation and recreational purposes and is a valuable water resource.

The water quality of the Kings River is superior to the Class 1 irrigation water standards. However, its flow, particularly in summer, is insufficient for adequate dilution of the Lemoore effluent. Consequently, the effluent must have the TDS levels reduced by physical or chemical means before entering the Kings River or the effluent must be disposed

elsewhere. The method accepted was disposal by evaporation. The environmental impact statement justifies the choice from an engineering economy standpoint, and discusses the environmental impact of the proposed 400 acre evaporation pond. (reviewer's abstract)

### Alternatives Considered

Four alternatives for effluent treatment or disposal were considered. Three of the treatment methods produce water of a quality superior to the Class 1 irrigation water standard, which can be discharged into the Kings River, and a brine which must be disposed of. The fourth method, the evaporation ponds, totally evaporate the water and leave the dissolved salts on the bottom as a precipitate. The latter method has the further advantage that secondary sewage treatment can be accomplished in oxidation ponds within the evaporation pond area thereby eliminating the continued need for that portion of the existing plant. The decision for the evaporation ponds was made on the basis of engineering economy, a summary of which is given in the following table which was extracted from the impact statement:

<u>Process</u>	<u>Degree of Treatment</u>	<u>Cost Per 1000 Gal.</u>	<u>Daily Cost for 1.45 Mgd</u>
Distillation	99%	\$0.83	\$1170
Electrodialysis	93%	0.46	660
Ion-exchange	98%	0.53	765
Ponds	100%	0.26	370

## Environmental Factors Involved

PB 199 018-F

1) Outdoor recreation: The Kings River recreational facilities are located sufficiently distant from the oxidation ponds to preclude foul odors from reaching them. The low organic loading rate of the ponds is also favorable for minimizing odors. If necessary, sewage dilution is a means provided to alleviate odoriferous conditions.

2) Wild life and plant life: It is indicated that the flooding of the land for the evaporation ponds would destroy the habitat for pheasant and upland game and create a new habitat for water fowl and other wildlife.

3) Natural resources and land use: The change in the land usage does not specifically devalue any natural resources. If the pond is eventually abandoned, the alkali salt precipitate of the bottom would remain as a dry lake bed, a common characteristic of the arid regions.

## Future Study Areas

A. Conduct a study on the four methods which were presented in this environmental impact statement to determine the daily cost of operation of the sewage treatment plant in each of the aforementioned alternatives and to determine if the cost is offset by the value of the irrigation water which can be obtained as a consequence of the process. In this instance, a unique situation exists in that the aquatic habitat appears to be superior to the land. With irrigation, the superiority could well be with the land and not the pond. (It is rare that one encounters a project which has the potential

for environmental improvement, much less alternative possibilities of improvement.) Consequently, future situations might merit a comprehensive study of the environmental enrichment aspects of the project.

B. Initiate studies to evaluate the environment, as it exists, and as it may be affected by a project induced change. A consistent set of evaluation criteria measurable in dollars would be well suited for such a purpose. Using this situation as the example: the land is arid, and agriculture depends upon irrigation. Consequently, water has a premium value.

The 400 acres of land to be inundated for the evaporation ponds is presently only marginally productive in crops and grazing and represents a ratable low tax. However, the availability of 1.45 million gallons of irrigation water daily, if the San Luis Drain water is treated, might increase the value of a significant portion of that land, or other land nearby. Plainly, it will be difficult to place a dollar value on the improvement of the environment. However, such an evaluation is necessary if a choice is to be based upon an economic criterion.

C. Determine and evaluate techniques for economic water purification if the water is high in TDS. A disposal method or a utilization of the brine or the precipitate salts derived from the purification process should also be considered.

Western Medical Institute of Research, Phase II

Department of the Army

PB 199 312-F

Abstract

The U. S. Army Medical Research and Development Command proposes to construct and operate a new medical research institute, the Western Medical Institute of Research (WMIR), on the existing military facility known as The Presidio in San Francisco. The building is to be appended to the Letterman General Hospital and share power plant, parking, and waste disposal facilities. The staff of approximately 700 persons will be principally engaged in research in the fields of disease, infection, medicine, biology, nutrition, military performance, psychiatry, and allied disciplines. The institute will comprise three stories of above ground space, totaling 520,000 square feet, and will be connected to Letterman General Hospital by an elevated bridge and a corridor.

In addition to the common environmental considerations of air and water quality, solid waste disposal, and traffic, the Environmental Impact Statement examines the special problems of esthetic architecture within the city, the keeping of animals for research, and the disposal of medical waste. (reviewer's abstract)

Environmental Factors Involved

A. Air Quality:

1. Energy Services: The impact statement indicates that the existing plant facilities, specifically a gas-fired boiler plant, serving Letterman General Hospital, is adequate for WMIR's needs and will not present an environmental degradation or increased emissions to the atmosphere.

2. Specimen Incineration: The impact statement states that specimen incineration will comply with all federal and state regulations.

3. Animal Odors: Animal odors will be removed from the air by filtration by charcoal.

4. Photochemically Reactive Emittants: The environment impact statement reports that such emittants occur in negligible quantities.

B. Water Quality:

1. Sewage: WMIR intends to comply with municipal and state regulations and it will connect to the municipal sewage system. The impact statement indicates that there will be a chemical treatment of the sewage, if necessary, and a proposed dilution of contaminants.

C. Solid Wastes: Solid wastes from WMIR, some pre-treated with chemicals to neutralize pathogens and other offensive materials, are to be disposed of by commercial dumping.

D. Traffic: The problem of automobile traffic and parking was considered and it was noted that WMIR will not aggravate traffic conditions significantly over that of Letterman General Hospital and that the overall parking situation will actually be improved.

#### Future Study Areas

##### A. Air Quality:

1. Additional energy services: A heating plant the size of that of WMIR and Letterman General Hospital consumes considerable energy in the form of heating, air conditioning, hot water, electricity, and steam. The additional load due to WMIR does represent increased emissions into the atmosphere with the emissions not necessarily distributed uniformly over the day or the season. There is no reason to believe that the increased emissions will be detrimental to the environment; however, a study should be made for the days of adverse atmospheric circulation in the Presidio area to determine if there is any adverse channeling of emissions into the San Francisco downtown area where they might aggravate air quality conditions.

2. Specimen incineration: The proposed incinerator will be, without doubt, fully protective of the community against emissions which may contain pathogenic or allergenic emittants or noxious odors. However, the Federal and state regulations may not be adequately protective. A study should be established to determine the quantities, types, and containments (pathogenic, noxious, or chemical) of the specimens to be incinerated, the end products of the incineration, and demonstrate that noe of the emitants will be humanly or environmentally harmful. The incinerator construction and operation, including specimen handling prior to incineration, should be included. Then criteria should be established such that Federal and state standards can be promulgated for this type of operation and adapted to similar hospital facilities.

3. Animal odors: The principle of air filtration by charcoal, or any other means, should be studied to show that for the volume of air to be processed and the efficiency of the processing, there is no possibility of viruses and other contaminants being released to the atmosphere.

B. Water Quality:

Sewage: Municipal and state regulations regarding sewage are recognized as being inadequate when special substances are present in the effluent. A study should be initiaed to determine criteria for standards of special substances.

Chemicals in sewage, (e. g. chlorine compounds, compounds that alter the pH) can delay the oxygenation such that the effluent pours out of the treatment plant with too large an oxygen demand, and consequently contaminates the surrounding waters. Measurement techniques and standards are needed.

C. Solid Wastes: A study should be undertaken of solid wastes pre-treated with chemicals to neutralize pathogens and other offensive materials which are to be disposed of by commercial dumping. The effect on the environment on the dumping site is the important consideration in the study.

New Walter Reed General Hospital  
Walter Reed Army Medical Center

Department of the Army  
Office of the Assistant Secretary  
Washington, D. C.

PB 199 314-F

### Abstract

The U. S. Army, Walter Reed Army Medical Center (WRAMC), proposes to construct and operate a new Walter Reed General Hospital (WRGH) on the grounds of the present complex which is located in a residential area of Washington, D. C. The construction will serve 1280 in-patients and 3300 out-patients daily. A staff of nearly 6000 is presently employed and the projection is for 7000 staff personnel when the new WRGH is completed. Of this total, only about 250 are resident staff. The balance commute from outside the complex.

The proposing agency recognizes that the new WRGH will have an impact on the scenery and traffic. It is the intent to improve traffic circulation and to provide an architecture consonant with the older WRAMC structures. The architecture is consistent with the WRAMC master plan and the National Capital Planning Commission restrictions and recommendations. (reviewer's abstract)

### Environmental Factors Involved

A. Air Quality: A preliminary air pollution survey undertaken at WRAMC during June 1-3, 1970 is included in the environmental impact

statement. This survey was in compliance with the Army instruction on environmental pollution abatement, AR 11-21. Some of the recommendations have been incorporated in the new WRGH by the planners.

The heating plant for the new WRGH, which is an expansion of the present plant, will be operated in accordance with the D. C. Air Pollution Control Act (PL 90-440), and will provide for the later addition of air pollution control equipment in the event that the air pollution standards become more restrictive.

Independently of other solid waste disposal, special incinerators are operated to dispose of animal wastes, pathological wastes, and classified paper. The U. S. Army Environmental Hygiene Agency air pollution survey indicated that approximately 1000 pounds of such waste are burned daily.

**B. Water Quality:** Connection will be made to the existing municipal sewage system. Storm waters will be fed into an existing storm sewer. Land erosion by storm run-off will be controlled by the Corps of Engineers.

The siltation of Rock Creek from soil erosion and storm run-off during construction is considered and will be controlled.

**C. Solid Waste Disposal:** Present solid waste disposal is accomplished by a contractor who either incinerates or land fills the refuse. For the new WRGH, solid waste is to be incinerated at a special incinerator. This will be constructed by the National Institute of Health at Forest Glen, three

miles northwest of WRGH.

D. Radioactive Wastes: The environmental impact statement reports that the handling and disposal procedures of radioactive wastes are adequate and safe.

E. Traffic: A report from the U. S. Army Transportation Engineering Agency, Fort Eustis, Va., is included in the environmental impact statement. The report is a parking and circulation study of present and projected conditions at WRAMC. At present, 2234 parking spaces exist and over 500 parking places in the surrounding residential streets are utilized by the WRAMC staff. The study reported a projected need for 4500 parking spaces on the WRAMC complex.

A prime consideration in planning was the elimination of on-street parking. Thus, 400 temporary parking spaces are being provided to offset the loss of 500 spaces during a five year construction period, and in addition, some need for parking space is being eliminated by the relocation of the commissary and community service facilities. However, as determined in the aforementioned traffic report, there is still a need for an additional 2000 parking spaces.

Extensive improvement of the traffic patterns is being undertaken with widening of roadways and use of turning lanes as part of the program.

The U. S. Army Transportation Engineering Agency report notes that there is the public bus service adjacent to WRAMC and that the new

subway system (Washington Metro) will have a station 1/2 mile from WRAMC. With a projected staff of 7000 and an out-patient load of 3300 at the new WRGH, plus visitors for the in-patients, more than 10,000 people will be traveling in and out of WRAMC daily.

Future Study Areas

A. Determine techniques to eliminate sulphur oxide emittants from the stacks of heating plants which are burning sulphurous fuels. The solution may be by either removal of the sulphur oxide by after-burning of the fuel or by the removal of the sulphur from the fuel prior to burning.

B. Model the atmospheric circulation for Washington, D. C. With this model, all the major urban areas of the United States can be evaluated to determine the distribution of emittants over the city and the impact on urban air quality by DoD activities and actions.

C. Initiate a study to determine the potential threat to human life and the environment by ineffective incineration of pathological and animal wastes. In addition, the study should determine and recommend monitoring instruments which will verify the complete destruction of pathogens and will detect the emission of any harmful chemicals.

D. Develop a practical means to separate the several types of hospital solid waste (e. g. plastic, paper, food) prior to disposal such that each can be disposed of in the best manner. Also, determine what pollutants

are emitted when plastic wastes are incinerated and the potential hazards involved.

Other questions which this project might answer are:

1. What are the best techniques for disposing of classified papers, animal waste and pathological waste on a separate basis?
2. What quantities of these materials can be expected?
3. What safeguards should be maintained?
4. How will safe transport, safe storage, and safe disposal be monitored?
5. What emittants, particularly chemical, can be expected and what is their environmental impact?
6. Are foul odors or noxious emissions likely (even though they may not be harmful to humans)?
7. Is pre-treatment necessary to eliminate foul odors?
8. What is the possibility of pathogenic agents being harboured in the refuse?

At present, there are no standards which are directly applicable to this type of incineration. Therefore, the study should verify that conformance to a general stack emission standard, which is principally concerned with particulate matter, is useable and adequate for this application.

E. Conduct a study of the composition of sanitary sewage from a hospital/ medical research facility to determine the possibility of transport of pathogenic materials and disease vectors through sewage treatment plants and into the rivers, lakes, or other ultimate receptors of the water effluent. Considering that medical research is part of a hospital's mission, does this, or any other operation, contribute any unusual substances, such as pathogens, to the sewage effluent? If pathogens are present, is pre-treatment warranted, and if so, what type and to what extent?

**Sanguine System for Validation and Full-Scale Development:  
Research, Development, Test and Evaluation.**

Department of the Navy  
Naval Electronic Systems Command  
Washington, D.C.

PB 199 732-F-1,2

**Abstract**

A proposal to enter the Validation and Full-Scale Development Phases for the Sanguine System (a proposed Extremely Low Frequency military communications system) is expected to have no significant environmental impact. These phases essentially are systems engineering studies and prototype design and test activities, respectively, and involve no major construction. Future phases of work (post-1976), if subsequently approved, would involve a temporary environmental impact similar to that generally associated with the construction of buried public utilities such as power distribution lines and telephone lines. The Validation and Full-Scale Development Phases include major environmental protection studies and planning to ensure future minimum adverse environmental impact from an operation Sanguine System, and the selection of an operational site. (Reviewer's abstract).

## Environmental Factors Involved

The electromagnetic radiation produced by the Sanguine System interacts with the total environment. The total environment has been divided into essentially five categories:

1. The Existing Electromagnetic Environment.

This category includes TV and radio stations, power lines, etc. The technology needed to estimate the effect of the Sanguine System on the electromagnetic environment is well understood theoretically, but experimentation is required before evaluation and assessment.

2. The Physical Environment.

This category can be viewed as the land and water available to humans, animals and plants. The land requirements for the Sanguine System, water resources required, material disposal, and pollution are included in the physical environment. The information needed for this area requires no technical development for evaluation and assessment.

3. Man's Social Environment.

This category includes telephone systems, power systems, pipelines, rail systems, home appliances, etc. It also includes Geo Economic factors such as the availability of labor, transportation systems available, and general demographic considerations. The technology needed to determine the effect of the Sanguine System on telephone systems and rail systems is known, but experimentation in this area is required. Considerations of the geoeconomic factors require no technical development for evaluation and assessment.

4. The Biological Environment.

This category includes all biological systems - human, animal, and plant. The impact of the Sanguine System radiation on tissue, chromosomes, fertility, growth and development, etc. has been investigated relying heavily on the published literature. The technology needed to assess the impact on the biological environment is well understood and research is required in the area for evaluation and assessment.

5. The Ecological Environment.

This category includes that area of biology dealing with the mutual relations between organisms and their environment. An ecological survey was performed to determine the general appearance and survival of forest trees, soil organisms, and herbaceous ecosystems under the impact of the Sanguine System. The technology needed to assess the impact on the ecological environment requires research and experimentation before evaluation and assessment.

The following three pages abstract the reports which have been issued by the Environmental Standards Committee, Wisconsin Project Sanguine Committee, which was convened by the Governor of Wisconsin to evaluate the effects of Project Sanguine.

Project Sanguine  
An Analysis of Biological and Related Research

Environmental Standards Subcommittee  
Wisconsin Project Sanguine Committee

January 1971

Abstract

Three subcommittees of the Wisconsin Project Sanguine Committee were assigned to consider Interference Mitigation, Environmental Standards, and Socioeconomic Effects. The primary purpose of this report is to present the results of the Environmental Standards Committee of analyses of the studies covered in the final research report made by Hazelton Laboratories, Inc.\*

Other sections include, in considerably less detail, an analysis of the report by Biggs and Marier on the feasibility of Project Sanguine, other Project Sanguine supporting research, general remarks on Project Sanguine, and its potential ecological impact on the local environment, and the status of the Environmental Standards Subcommittee. (Reviewer's abstract).

---

\* Coate, William B., et al., 1970. Project Sanguine - Biological effects test program pilot studies. Final Report prepared for the Department of the Navy, Naval Electronic Systems Command Headquarters, Washington, D.C., Hazelton Laboratories, Inc., Falls Church, Virginia.

Notes and Commentary on the Draft Environmental Impact  
Statement with Annexes A through D.

Environmental Standards Subcommittee  
Wisconsin Project Sanguine Committee

August 1971

Abstract

This committee concludes that the assertions made in the Draft Environmental Impact Statement that a Project Sanguine design can be developed which would result in an operable system that would have no significant adverse environmental effects are neither proved nor disproved.

To the present, the pilot biological studies and ecological surveys have been aimed solely at acute effects and none of these experiments has been convincing even concerning such short-term acute effects, at any EM level. The need for long-term study of possible subtle effects has been repeatedly stressed, particularly concerning multiple or cross stresses, factors which are critical to survival in a free-living organism in the natural environment. Without the inclusion of results from such studies, a final Environmental Impact Statement would be unacceptable to our subcommittee. (Reviewer's abstract).

**Appraisal of Sanguine System**

**Final Environmental Impact Statement  
for Research, Development, Test, and Evaluation  
(Validation and Full-Scale Development)**

**Environmental Standards Subcommittee  
Wisconsin Project Sanguine Committee**

**June 1972**

**Abstract**

**This appraisal consists of three parts:**

- 1. Comparison of Project Sanguine Draft Environmental Impact Statement of March 1971, and the final Environmental Impact Statement for Validation and Full-Scale Development of April 1972.**
- 2. Detailed Review of the Technical Annexes, April 1972.**
- 3. A Review of the final Environmental Impact Statement of April 1972 based on our critique of the Technical Annexes, April 1972.**

**The three parts of our appraisal follow in the order listed above.**

**In making our appraisal under Part 2 and 3, we have attempted to maintain a position of nonadvocacy. Where we have defended our views vigorously the response has been to the technical issue. Our effort was primarily concerned with the biological and ecological aspects, and only secondarily to physical aspects of the natural environment. (reviewer's abstract)**

## F-14 Fighter Aircraft

Department of the Navy

PB 199 851-F

### Abstract

The F-14 is a two engine, variable sweep high wing, fighter aircraft to replace the F-4J, which is almost twenty years old. The superior performance and speed characteristics are required to meet the Soviet challenge. This aircraft is presently making demonstration and test flights and is expected to serve with an operational capability by the mid-seventies. The F-14 aircraft is a replacement for present fighters and will not represent a significant increase in numbers of planes in service. It will be based on aircraft carriers and at naval air stations.

(reviewer's abstract)

### Environmental Factors Involved

A. Air Quality: The quantity of emissions from the F-14 aircraft engines, F401, is less than that from the F-4J aircraft engine, J-79, which it replaces, because of more efficient engine operation.

1. Smoke: The smoke emission in flight is essentially invisible. No data is presented on smoke emission during take-off. For in-flight conditions, the smoke level is given as 70% less than that of previous engines. This measurement was taken using optical reflectance of captured smoke particles.

2. Carbon monoxide: The emission is much lower for the J-401 engine than for the J-79, 1/4 at full speed, 1/2 at idle speed. The specifications indicate a significant advance in engine technology and this technology should be exploited for other applications.

3. Unburned hydrocarbons: At idle speed, where the engine is not operating efficiently, the unburned hydrocarbon emission, which is principally hexane, is 1/2 that of the J-79 engine, and at full speed, it is negligible. This is a significant gain. Owing to the small number of fighter aircraft, the totality of unburned hydrocarbon emission has no environmental impact of significance. However, commercial aircraft are significant. Can this technology advance be exploited by the commercial airlines?

The EIS indicates that efforts to reduce raw fuel spillage (during maneuvers, shut downs, and false starts) are being undertaken.

4. Nitrogen oxides: The necessity of high performance in a fighter engine is not compatible with low nitrogen oxide output within present technology. Since fighter aircraft are not a significant environmental impact of themselves, this can be tolerated.

B. Water Quality: The EIS addresses the problem of a crash over water and the resultant loss of fuel.

C. Noise:

1. Run-up and test: Specific consideration has been given to ground operations of the F-401 engine. The engine is much quieter than comparable fighter engines. It uses several techniques characteristic of the turbo-fan engine which result in lower noise levels. Since the persistence of air-field noise is annoying, a sound muffler is being developed which can be attached to the engine to lessen the noise output. No quieting figures are yet available.

2. Take-off and landing: The transition from high thrust (military) operation to afterburner thrust is done in several stages to minimize noise levels. (The afterburn is necessary to insure complete combustion of the fuel and its products. Its usefulness exceeds its adverse effect on noise.)

3. Flight noise, sonic boom: The need for this aircraft function precludes noise abatement procedures that hinder operations. Consequently, flight operations must be scheduled away from populated areas.

D. Unavoidable Adverse Effects, Alternatives, and Controversy: The fact that the F-14 replaces the F-4 aircraft, and that it is a more efficient airframe and engine, indicates that it presents no increase in environmental pollution. There appears to be no serious pollution problem, especially considering the small numbers of these aircraft to be built.

Future Study Areas

The format of the EIS, which is based on guidelines issued by the CEQ, does not seem to favor the presentation of an aircraft environmental impact. One single aircraft is hardly a pollution threat.

Therefore, a study should be conducted to determine if impact statements generated for aircraft should offer information on:

- i. Potential number of aircraft to be built.
- ii. Their frequency of flights.
- iii. The density of a single base operation.
- iv. The location of the bases.

Possibly, with this additional information, the impact can be assessed in terms of the total environment.

Projec. Eagle - Phase I  
Disposal of Chemical Agent Mustard  
at Rocky Mountain Arsenal, Colorado

Department of the Army

PB 200 540-F

Abstract

Proposes disposal of 3071 tons of excess mustard chemical agent at Rocky Mountain Arsenal (RMA), Denver, Colorado, by incineration. The incineration will be carried out under controls assuring that any emissions will be below permissible levels (state and Federal air quality standards). For mustard, the standard established by the Department of the Army is below the minimum detectable level using the most sensitive detection equipment.

This method replaces the originally planned disposal by sea burial\* which was recommended against by the National Academy of Sciences. Alternatives to disposal by incineration include electrochemical, chemical and biodegradation methods. These all had similar disadvantages, including: by-product formation creating greater disposal problems; dilution necessary, involving very large volumes of liquids; and procedures not sufficiently developed at the present time.

Project EAGLE - Phase I involves the disposal of 3,407 one-ton containers containing 3,071 tons of mustard, using a procedure based on

\* Operation CHASE, NAS panel recommended burning in a incinerator.

the NAS panel's recommendation. The emphasis is on safety and minimization of adverse effects on the environment rather than project cost.

The basic process involves draining the ton containers of their mustard (ca. 170 gallons of H [crude] or HD [vacuum distilled]), decontaminating the empty steel cylinders and incinerating the mustard under conditions such that emissions of mustard and combustion products such as  $\text{SO}_2$ , HCl etc. . . . are kept below levels presenting any hazard to personnel, surrounding population or the environment. The pollutants in the product gas effluent are scrubbed by sodium hydroxide leading to the formation of a solution containing sodium sulfate, sodium sulfite and sodium chloride, which are subsequently spray dried and stored for sale or other disposition after verification that they are mustard-free.

The Incinerator-Scrubber system operates at  $1400^{\circ}$ - $1600^{\circ}$ F (0.3 seconds) in decomposing the drained mustard. The containers are freed of residual mustard and impurities (mostly sulfur) by incineration at  $800^{\circ}$ F (2 hours).

The complete procedure is described in detail with emphasis on protective measures for personnel and continuous monitoring techniques for agent and for  $\text{SO}_2$ /HCl in the stacks and in the perimeter monitoring stations. A full operating manual is presented. Pilot runs with simulated mustard (thionyl chloride-fuel oil) and then with mustard will precede

full scale operation of the system. These runs will serve to:

1. Prove out equipment, processes and instrumentation;
2. Verify laboratory test results and theoretical calculations for equipment efficiencies;
3. Train personnel under operating conditions;
4. Verify anticipated stack emission rates;
5. Prove out safety and operating procedures and the instruction manual.

When these runs have been made and analysis has shown that the types and quantities of solid and gaseous effluents are at the levels prescribed in the plan, full scale disposal operation will begin. The operation, on a continuous basis, should take about 5 months and produce about 7900 tons of the dried salt mixture. (reviewer's abstract)

#### Future Study Areas

1. An improved monitoring method for mustard should be devised incorporating a high sensitivity detector and a rapid cycle sampling system. Electron-capture detectors have high sensitivity for halo derivatives, such as mustard, and could be used as part of a rapid cycling GLC system. Microcoulometers might also be used.
2. Particulate emissions should be analyzed in more detail than weight/unit time. The presence and quantities of trace metals such as

lead, cadmium, etc...., as well as polynuclear aromatic hydrocarbons, should be investigated. New sensors for monitoring agent, SO<sub>2</sub>, HCl and other emissions, should be investigated and evaluated. The recent advances in spectrophotometric, mass spectrometric, electroanalytical and other instrumental methods should be readily applied to these problems.

It seems to be desirable to directly monitor HCl in the stacks as SO<sub>2</sub> may be scrubbed at a different efficiency than HCl.

The Transportable Disposal System (TDS) being developed at Tooele, Utah is projected as being capable of handling any mustard disposal problem. This should be investigated.

Disposal of Anti-Crop Biological Agent  
Beale Air Force Base, California and  
Rocky Mountain Arsenal, Colorado

Department of the Army

PB 201 259-F

Abstract

Procedures for the destruction of an anti-crop biological agent are described. The agent is not a human pathogen and does not present any danger to personnel or animals. The agent is treated with "carboxide" (10% ethylene oxide, 90% carbon dioxide) to render it inactive. This is done with the lids of the drums containing the agent remaining sealed. The carboxide is introduced by a hypodermic needle through a rubber diaphragm. Five doses of 0.5 lb over a five day period are used. Each lot is then sampled and tested for activity. Upon confirmation of inactivation, the drums are emptied and the material conveyed to a multiple hearth gas-fired incinerator. The incineration occurs at 1400<sup>o</sup>-1800<sup>o</sup> F. The ash is loaded into drums and assayed and, after destruction is certified, it will be spread over the soil and plowed under to act as a soil conditioner.

The procedures to be used at Rocky Mountain Arsenal and at Beale Air Force Base are designed for total containment of the material.

Tests have proven the inactivation procedure is effective. Viability assays are to be performed on samples of dry material after

inactivation. These are based on appearance of germ tubes on agar plates. If less than 10 tubes appear, a 99.96<sup>+</sup>% kill is indicated. The sterility of the ash sample is assayed by standard procedures. The ash sample is also examined microscopically for typical shapes (to indicate total loss of identity of the material).

The incinerator system has an effective scrubber that has been shown to reduce pollutant emissions from the furnace to acceptable levels. The pollutants emitted include: SO<sub>x</sub>, NO<sub>2</sub>, Cl<sup>-</sup> and F<sup>-\*</sup> as well as particulates. The air exiting from the operating areas is filtered through absolute filter precluding escape of agent in this manner.

(reviewer's abstract)

#### Environmental Factors Involved

The method used does not pose environmental hazards if properly carried out. The total containment of the agent during destruction and the careful assay procedures before and after incineration should prevent any biological problems with the ash. The use of the ash as soil conditioner should not endanger water supplies in the area in terms of its trace element make-up. Emissions from the incinerator system are scrubbed,

\* Only if Freon is used with ethylene oxide, no F<sup>-</sup> if CO<sub>2</sub> is used.

and the scrubbing process will be adjusted to meet the system's needs.

Future Study Areas

1. Monitoring of the incinerator emissions should include examination for viable agent.
2. Particulates should be assayed for trace element concentration and for polynuclear aromatic hydrocarbons. Control measures for these pollutants may be indicated.

# The Development of the F-15 Aircraft

Department of the Air Force

PB 201 710-F

## Abstract

The F-15 aircraft is being developed to fill the Air Force need for a superior fighter plane. It will be a single place, fixed wing, twin engine craft in the 40,000 pound weight class, having a speed capability in excess of Mach 2. Weaponry will include medium and short range missiles, and a rapid fire gun. The F-15 will be a high altitude, high speed, easily measurable aircraft to replace the 20 year old F-4 design and regain superiority over the new Soviet fighter aircraft. (reviewer's abstract)

## Environmental Factors Involved

### A. Air Quality:

1. Smoke: No visible smoke emissions will exist in flight by virtue of an advanced engine design. At sea level, take-off conditions, the smoke level is 1/2 to 1/3 that of other high performance engines, which is an advancement in the state of the art.
2. Carbon monoxide: The engine (F100) is again an advancement in the state of the art for reduced levels of emission of carbon monoxide.
3. Unburned hydrocarbons: The F100 engine is a significant

improvement over other engine types especially at idle speed, and is within the tolerances of the environment. Further improvement is being sought for the case of raw fuel spillage, which accompanies engine shutdown.

4. Nitrogen oxides: These emissions do not appear to exceed any environmental tolerances, although they are admittedly large in quantity because of the high temperature of engine operation. A need for a self contained fuel exists, supplying its own oxygen, or alternatively a means to eliminate the oxidation of nitrogen in engines. However, the application to fighter planes, whose impact on air quality is so small, is not warranted.

B. Water Quality: Not applicable.

C. Noise: The F100 engine produces a loud noise, an adverse factor which must be contended with in order to utilize the superior performance of that engine. The appendix to the EIS lists many noise abatement research projects for aircraft in which the Air Force is engaged.

1. Run up and test: Exhaust mufflers to attach to the engines during ground operations are to be provided. For close work to the aircraft, staff will be required to wear ear plugs or muffs.

2. Take-off and landing: The after-burner, which produces considerable noise, is designed to be introduced in stages so as to preclude sudden

changes in noise level. The EIS claims that the F-15 aircraft can take-off and land without use of the after-burner thus minimizing noise.

3. Flight noise: The F-15 aircraft is probably noisy in low altitude flight. At supersonic speeds, the F-15 is restricted to altitudes in excess of 30,000 feet. Flight schedules are to be rigidly controlled so as to minimize the exposure of any one community to excessive noise.

## B-1 Aircraft

Department of the Air Force

PB 201 711-F

### Abstract

The B-1 aircraft is a proposed four-engine bomber to replace the B-52, which is almost 20 years old. The B-1 will satisfy an urgent military need for a modern bomber capable of supersonic speeds at high altitude, subsonic speeds at low altitude, long range and large payload. Compared to the B-52, it will be two-thirds the size, carry twice the ordnance, and require shorter runways. The airframe and the engines are presently in the design and development stage, and three test aircraft are to be delivered. The EIS is presented for the eventual introduction of the B-1 into the Air Force operations. (Reviewer's abstract).

### Environmental Factors Involved

#### A. Air Quality

1. Smoke: The impact statement indicates no smoke emission owing to improved fuel flow and combustion in the engine, and the use of a smoke abatement fuel additive.
2. Unburned hydrocarbons: Programs will be supported to monitor water vapor, particulates and other emittants derived from fuels in the atmosphere in flight operations comparable to the B-1. The B-1 engine should lessen some of these emissions. The B-1 engine contractor is attempting to minimize unburned hydrocarbon emissions during idle conditions.

3. Nitrogen oxides: It is stated that reductions of nitrogen oxide emissions by as much as 70%, using newly developed water injection techniques, will be possible.

B. Noise

1. Engine noise: The utilization of noise baffles and suppressors on run-up pads is a workable solution to the noise problem. Since this is a proposed aircraft in a developmental stage, it is hoped to receive some results from the Propulsion Acoustic Technology Program, which is an Air Force Research Program whose objective it is to reduce propulsion noise with minimum penalty on engine weight and performance.
2. Flight noise: The impact statement presents information on flight patterns which will minimize offensive noise on the ground during fly-over.

Future Study Areas

A. Smoke Emission.

Determine if the elimination of smoke by the use of a smoke abatement fuel additive produces other pollution elements or compounds.

B. Carbon Monoxide

Study techniques of obtaining more complete combustion of the fuel to reduce carbon monoxide emissions.

C. Water

Initiate a study to evaluate the effect of ground operation of the B-1 bomber on the environment. The B-1, and especially a squadron of B-1's, may drop considerable quantities of oil, fuel, and grease on the air field. These contaminants may then be carried into the local streams and sewers in times of heavy rain. Therefore, a study should be considered to evaluate the seriousness of this effect on the environment.

Land Acquisition, Naval Station  
Norfolk, Virginia

Department of the Navy

PB 201 855-F

Abstract

The U.S. Navy proposes to acquire 508 acres of land from the Norfolk and Western Railway Company for the purpose of an addition to the Sewells Point Navy Complex. The land is presently in use as a classification yard and as an overflow storage yard by the railroad, supplementing other more modern facilities. Two commercial sections along highways through the land provide services such as restaurants and shops. The projected usage of the land will be for airfield runway extension, aircraft parking, air terminal, new berthing space for naval ships, warehouse and cargo facilities, and a new boat pool. (Reviewer's abstract).

Environmental Factors Involved

A. Water Quality

1. Sanitary sewage: Sewage from all projected construction on shore and from all ships to be berthed at the new piers is to be conveyed by the Navy's sewerage lines to the Hampton Roads Sanitary District for treatment and disposition.

2. Storm sewage: Existing drainage facilities into Willoughby Bay are to remain intact. For future construction, a supplemental drainage system into the Elizabeth River will be required. There is no present or projected effect on the ground water level.

B. Solid Waste

Solid waste generated by berthed ships, and by facilities to be constructed on the new land will be incinerated at the Naval Station Salvage Waste Heat Incinerator, which will have been modified to comply with the Virginia Air Pollution Standards.

C. Air Quality

The above mentioned incinerator does not presently comply with Virginia Air Pollution Standards, but it is being modified by the installation of electrostatic precipitators.

D. Land Use

The Navy utilization of the land will be an environmental enhancement owing to the elimination of the railroad yards, elimination of grade crossings, elimination of present unsightly commercial structures, and improved safety of the Air Station operations in that one runway of inadequate length will be extended. New construction will include administrative, supply, training and waterfront facilities of superior esthetic impact to the present land usage.

E. Ship Traffic

No significant increase in ship movements is expected for the area. The new facilities are used to relieve conditions at other nearby berths.

## Future Study Areas

### A. Water Quality

1. Ship-originated sewage: Determine the percentage of ships of the various categories in the U.S. Navy which have been provided with sanitary sewage collection facilities and can be connected with a shore disposal system. Determine the frequency of each type of ship's visits to Sewells Point. Estimate the quantity of sewage that will be discharged directly into the harbor because of a lack of sewage collection facilities on board ship, and the quantity of sewage that will be discharged into the Navy's sewerage system.
2. Ship effluents: Determine the effluents from ships, other than sanitary sewage and cooling water, which can be discharged directly into the harbor.

### B. Solid Waste

Estimate the projected quantities and composition of the refuse from the future construction and from berthed ships to determine if the capability of the Naval Station Salvage Waste Heat Incinerator can handle it. The incinerator facility itself may need expansion to satisfy the required capacity.

### C. Air Quality

1. Incinerator: Undertake a study of the emittants from the incineration of solid wastes, particularly plastics. Standards exist only for the six predominant emittants from conventional organic and paper wastes. Criteria for standards for the less common, but perhaps toxic, emittants are needed.
2. Heating plant: Conduct a study of the emissions from the entire heating facility, the plant and the incinerator, circulation and combination with discharges from other similar facilities in this industrial

area. Although each facility may satisfy the absolute emission standards, in combination, on days of adverse meteorological conditions, the total emissions may be obnoxious or harmful to man.

3. Expansion of the Naval Air Station: Expand the present studies of the exhaust emissions from the aircraft, particularly those on run-up and test in the new construction area to determine the effect on air quality in that area.

#### D. Land Use

Park land: Conduct a study on the usefulness of small parks in industrial areas. In this instance, a Fleet Recreation Park already exists adjacent to the land to be acquired. The expansion of this facility may prove environmentally beneficial in that parks in urban areas are known to provide downdrafts of clear air from higher altitudes, thus establishing a vertical air circulation pattern.

#### E. Noise

Air Station: Measure the background noise levels associated with the Naval Air Station in terms of the projected usage of the land and of consideration for the berthed ships as residences of crews.

Transportable Disposal System

Department of the Army

PB 202 308-D

Abstract

The Transportable Disposal System (TDS) is being developed as an alternative to Operation CHASE\* and to minimize the risks inherent in the transportation of mustard (H, HD and HT), GB and VX in bulk or munitions. It should be applicable to other toxic materials such as Orange herbicide.

An extensive series of tests are described that have been or will be carried out to determine the optimum design of the system that will preclude hazards to the operating personnel and the surrounding population. The design will further ensure that no pollutants will be emitted to an extent violating any state, local or Federal standards or adversely affecting the ecology of the surrounding area.

The major parts of the TDS are:

1. Explosive containment cubicle (ECC): For removal of explosives. Designed to safely contain blast pressure and prevent escape to the atmosphere of all fragments and agents in the event of an explosion.
2. Projectile Demilitarization Facility (PDF): Agent is removed and the empty hardware is decontaminated.

\* Sea disposal recommended against by NAS and others.

3. Bulk Item Facility (BIF): Agent is removed from non-explosive containing bombs and cylinders and empty hardware is decontaminated.
4. Deactivation Furnace (DF): Propellant explosives and casings are burnt.
5. Deactivation Furnace Scrubber System (DFSS): Pollution control of Deactivation Furnace effluent.
6. Metal Parts Furnace (MPF): Thermal decontamination of all empty metal parts that previously contained or may have been contaminated by agents.
7. Air Pollution Control System (APCS): Scrubs gaseous effluent of Metal Parts Furnace.
8. Agent Incinerator-Scrubber System (AISS): Incinerates agent and reduces pollutant to acceptable low levels prior to release to the atmosphere.
9. Dunnage Incinerator (DI): It is used with the scrubber for burning non-toxic combustibles.
10. Sludge Removal and Treatment System (SRTS): This removes the explosive materials from used decontaminating solutions and evaporates the water.

The TDS provides for the combustion of GB, VX and mustard with air as the oxygen source. The products will be scrubbed and reacted with  $\text{Ca}(\text{OH})_2$  and/or  $\text{NaOH}$ , forming calcium and sodium salts. Any explosives involved in the demilitarization of the munitions are also incinerated and scrubbed. The resulting salt solutions are dried and stored for disposal.

Agent vapor emissions are minimized by operating under negative pressure in critical areas and by stringent filtering of exhaust air through

parallel separate systems. Monitors will activate the parallel system and indicate a need for replacement. Similarly, the emissions from the scrubber systems will be monitored and set to alarm at low levels.

The incineration of the various agents forms industrial pollutants such as  $\text{SO}_2$ ,  $\text{HCl}$ ,  $\text{HF}$ ,  $\text{NO}_x$ ,  $\text{P}_2\text{O}_5$ . The systems have been designed to scrub all of these with high enough efficiency to meet all air quality standards. Continuous monitoring of the output of these pollutants will be provided for.

A complete perimeter monitoring network for wind, total oxidant, particulates, anticholieresterase, total fluorides,  $\text{HCl}$  and total chlorides,  $\text{SO}_2$  and  $\text{NO}_2$  is proposed and described in detail.

No liquid wastes are released as a consequence of the various decontamination steps. The solutions of calcium and sodium salts are evaporated and the water vapor is released to the atmosphere. A substantial quantity of decontaminated scrap metal will accrue as a result of the process, as well as fiberglass and fly ash in some cases.

Laboratory tests of incineration and scrubbing methods for GB and HD (mustard) indicate that all the emissions of unreacted agent would be kept well below the hazardous level for personnel or surrounding population. Emissions of other pollutants were shown to be held well below the established maximum levels. While less laboratory tests have been carried out with VX, no additional problems are indicated.

The first full tests of the TDS are scheduled for Tooele Army Depot in Utah. (reviewer's abstract)

Environmental Factors Involved

The on-site decontamination and destruction of toxic chemical agents and munitions containing them is highly desirable. It eliminates the hazards involved in transportation, especially near urban areas. The use of incineration in specially designed modules with full control of possible hazards, is preferable to transport to commercial incineration sites or other alternatives. An especially useful feature of the system is the non-release of liquid wastes from scrubbing and decontamination procedures. A minimum disruption of the environment is occasioned as the salt solutions are dried. Ideally, the dried salt mixtures (properly free of agent) should have commercial value. This method of handling generated salt solutions is much superior to discharge into the environment.

Incineration-scrubbing combinations that have been developed are capable of controlling emissions of agent and pollutants to well below the safe limits. (refer to Table 8 on page 83 of the environmental impact statement)

Current Allowable Emissions

<u>Pollutant</u>	<u>Allowable Emissions</u> <u>(lb/min)</u>	
Flourides (as HF)	0.0006	
H <sub>3</sub> PO <sub>4</sub>	0.092	} max. when only acid is present
HCl	0.103	
SO <sub>2</sub>	0.662	
NO <sub>2</sub>	2.3	
Particulates	0.1 grain/scf	
Mustard	0.0038	
GB	0.00046	
VX	not determined yet	

The use of continuous monitoring systems within the TDS, especially in stacks where emission occurs, and in a perimeter system should suffice for safe operation of the system. The anti-choloriesterase monitors are especially important.

Future Study Areas

A. Development of improved sensors for stack agent emissions appears desirable. New methods, such as reaction gas chromatography and improved sensitivity detectors for the chromatographic systems in present use, should be investigated. Sampling methods for perimeter

systems could be improved and auto analyzer techniques may be complemented by sensors such as IR, mass spectrometry, and GC/MS. Preconcentration on cooled packed columns linked with these methods could greatly extend their sensitivity.

B. Important points that should be investigated are:

1. Are there any emissions of volatile hydrocarbons generated by pyrolysis of propane that are not burned completely? These could easily escape the present scrubber system and lead to atmospheric pollution.
2. Particulates should be collected efficiently to determine the presence of trace metals, polynuclear aromatics and other serious pollutants. If present in excess of safe levels, modification of the control system is in order.

## Use of Target-Ship Hulls in Exercises at Sea

Department of the Navy

PB 202 335-F

### Abstract

The Navy proposes "the sinking of approximately 15 obsolete, deactivated naval ship hulls per year in ocean waters in excess of 6000 feet deep, more than 50 miles from the nearest land, and clear of all shipping lanes. The sinkings are by conventional weapons for the purposes of combat readiness training and weapons evaluation. Ships are normally of destroyer-escort size and are specially prepared to ensure that fuel tanks and lines are essentially free of petroleum." (ISSUING AGENCY'S ABSTRACT.)

### Environmental Factors Involved

Direct impact on the environment is, essentially, in two forms:

A. Marine Life. The damage/harm to marine life is limited primarily to fish in the immediate target area. Since most marine life will be alerted by the first sound impacting on the ship's hull or by the explosion in the water, therefore, the expected total effect to marine life is considered minimal.

B. Water Quality. The designated target hulls receive special cleaning preparation and inspection to determine that they have been defueled and that all tanks and lines are essentially free of petroleum.

There still remains the possibility of contamination due to petroleum residues in the fuel lines of the target ships, even though the lines have been essentially cleaned. This will have a direct impact on the water quality as it might affect marine life. After break-up of the ship's hull, the trapped fuel residue slowly releases into the sea water.

#### Future Study Areas

A. The present cleaning method requires the deactivated ship hulls to be flushed with sea water, at an approximate cost of \$24,000 per ship. In addition, the cleaning operation requires more than three (3) weeks of work and even then the ship's fuel lines are not free of oil. More efficient cleaning methods should be investigated. Possibly an ultrasonic cleaning technique would be a more practical and economical solution.

B. A study should be initiated to ascertain the impact of fuel oil at various depths in the ocean. (This study is directly applicable to this problem as the sinking target hull is slowly releasing oil as it sinks to the ocean bottom.)

Minimum Facilities for Air Cavalry Combat Brigade Test  
Fort Hood, Texas

Department of the Army  
Office of the Assistant Chief of Staff  
for Force Development (OACSFOR)

PB 202 796-F

Abstract

The Directorate of Facilities Engineering (Army) at Fort Hood, Texas, proposes to build a heliport for 410 helicopters. The construction will include bituminous maintenance aprons, storm sewers, private vehicle parking, latrine, water, sewer, and gas services at the helipad site. At a separate site, personnel and administrative space will be provided by altering and rehabilitating five permanent buildings, with associated parking areas and access road.

The principal environmental impact encountered is that of aircraft noise. A remedy of scheduling operation is proposed so that noises are minimum at night. Soil erosion and dust generation are important considerations also treated in the Environmental Impact Statement.

The only alternative to the proposed action considered was another site at Fort Hood (which is a large facility, 218,000 acres). The accepted site proved superior because of terrain and existing domestic services.

(Reviewer's abstract).

## Environmental Factors Involved

### A. Land Usage

The intended heliport site is located approximately 3/4 mile from the nearest residential areas; Army housing to the southwest and the city of Killeen to the south. The land surrounding Fort Hood is used for livestock grazing, grain crops, and poultry farms.

### B. Water Quality

The Fort Hood area is generally dry with occasional heavy rains. The storm water will be carried off by the runoff channels into Nolan Creek. The present capacity of the sanitary sewage system is sufficient for the projected need.

### C. Air Quality

The aircraft parking will be on steel planking laid over earth, with native grasses growing between the steel elements. Dust conditions are not expected. However, if present, they will be ameliorated by the application of polliatives such as asphalt emulsions.

### D. Noise

Aircraft noise is the principal adverse impact on the environment in the proposed action, and consequently receives the greatest emphasis in the impact statement. An appended report by the U. S. Army Environmental Hygiene Agency (Edgewood Arsenal, Maryland) evaluates the impact of the aircraft noise on the city of Killeen, which is the nearest inhabited area to the proposed heliport. It was concluded that acceptable levels of noise were not to be exceeded in Killeen during nighttime takeoff and landing and during daytime runup activities.

The measurements of noise level were made on days when the winds were towards and from Killeen. However, not all climatic conditions were investigated.

The impact statement presents substantial argument that the background noise level in Killeen, and in Harker Heights, which is 4-1/2 miles distant, is unusually high. The major contributors to the ambient noise level are other Fort Hood military training activities, freight trains, civilian aircraft, and highway traffic.

#### E. Wildlife

No-flight zones have been established wherever hatcheries, poultry farms, stock pens, and built up areas exist. Also, the nesting places of a rare bird species, the yellow-cheeked warbler, are located some 15 miles from the Hood Army Airfield and are protected.

### Future Study Areas

#### A. Noise Abatement

The present procedure of abating excessive noise is to reschedule aircraft operations (principally runups and tests). Noise measurements are taken using standard field noise measuring instrumentation. An instrumentation package should be developed which can continuously measure the noise level at a position in the field and transmit the measured and recorded noise level to a central monitor. This technique will allow corrective action to be instituted immediately.

#### B. Oil and Grease Particles

Develop a technique to remove the oil and grease which is deposited on the ground in the operations area and permit their separation from the wash water. Naturally, separation must occur before the water enters the drainage system.

C. Noise Tolerance by Wildlife

The effect of noise of various levels on wildlife, particularly small game such as squirrel and racoon, is not well documented. Undertake controlled experiments in a natural area using noises characteristic of aircraft and traffic to ascertain the effects of noise on wildlife.

D. Dust Polliatives

Initiate a general study of the effect of dust polliatives on the soil, on the ground water, and on the ecology of the land adjacent to its application.

National Guard Use of Arnold Engineering Development Center

Department of the Air Force

PB 203 238-F

Abstract

The U. S. Air Force proposes to make 2500 acres of land available to the Tennessee National Guard, 2nd and 3rd Battalions of the 117th Infantry (Mechanized) at Arnold Engineering Development Center (AEDC) for training of mechanized units. Normally, training is three weekends per month in March, April, May, August, September and October, with no more than 1000 persons (350 average), using 25 wheeled and 25 tracked vehicles, and no live ammunition. The environmental impact consists principally of dislocation of upland game, elimination of 200 acres of crops which are partly planted for the wildlife, and the impairment of the growth of marketable hardwoods on 1950 acres. Other environmental impacts are considered insignificant. Military requirements for adequate training at the company level stipulates a centralized area of 2500 acres, or more.

This land at AEDC is relatively flat, most of it forest covered with pine and hardwoods, with some open spaces of agricultural fields, partly abandoned, and covered with young trees and native vegetation. There are no permanent streams on the property, which is part of a larger tract managed by the Tennessee Game and Fish Commission.

Reforestation of the open spaces (other than 200 acres leased to farmers) is in progress, with pines being planted, and hardwoods propagating naturally. No land utilization is anticipated outside the aforementioned training periods. The total AEDC tract size is 32,000 acres. (Reviewer's abstract).

### Environmental Factors Involved

#### A. Land Usage

1. Forest land: The land usage is evaluated in terms of the dollar value of the standing timber and the potential tree damage by the vehicles.
2. Agricultural land: Agricultural operations on 200 acres (out of the 2500 acre tract) would be terminated and the land left to natural growth.
3. Military vehicle movement: The projected vehicle movements would be by existing roads in the tract, with random maneuvering areas in the hardwood forest.

#### B. Water Quality

Since no streams exist on the tract, only compaction of the soil and destruction of ground cover affects the hydrology of the area.

#### C. Air Quality

The effect of the military vehicle exhaust is likely insignificant compared to that of the vehicles on an interstate highway nearby.

D. Noise

Although military vehicle noise is substantial, its total impact outside the tract is negligible owing to attenuation by the trees and masking by other noise sources such as the highway.

E. Wildlife

Owing to the absence of streams or ponds on the land in question, wildlife is quite sparse.

F. Adverse Environmental Effects

No permanent environmental damage is likely from the proposed action. The loss of cropland, recreational facilities (principally hunting), and timber value is not significant.

Future Study Areas

None

Safeguard Ballistic Missile Defense System  
North Dakota and Montana Deployment Areas

Department of the Army  
Army Safeguard System Office  
Arlington, Virginia

PB 203 321-F

Abstract

"The first two deployments of the Safeguard Ballistic Missile Defense System will be located in the Minuteman Fields near Grand Forks, North Dakota, and Malmstrom AFB, Montana. Each deployment will consist of two radar sites and four remote launch sites."

(ISSUING AGENCY'S ABSTRACT).

Future Study Areas

A. Up to 200 gallons per minute evaporation rate from cooling towers is investigated from the point of view of ground fog. Other effects, e.g., excess humidity and excessive heat of condensation, are not investigated. For normal growth, the ratio of water uptake to water transpired must be greater than unity. Usually site quality improves with increasing amounts of available soil moisture. There is, however, a limit to the amount of soil water which is desirable; and, if this limit is exceeded, unfavorable conditions for plant growth result because of deficient aeration and related phenomena. The extent of this effect is dependent on the soil structure and constituents ("Forest Soils",

L. Chandler, Wiley, 1947). Research in plant physiology and agronomy has demonstrated that nutrient salt and water absorption is improved by good soil aeration. Thus, an environmental impact study of cooling tower evaporation should be studied for the effects of excessive heat of condensation and excess humidity.

B. Recognizing the adverse effect of diesel engine exhaust (nitrogen oxide) into the atmosphere by the independent power source, an experimental research program is being funded to the manufacturer for finding solutions. Emission from diesel engines can be improved by either improving the engine performance or the method of exhaust. At the present time, the first technique is being investigated. Thus, it is recommended that the latter method, technique of exhaust, also be examined and evaluated.

C. Although parameters of the radar (e. g. , power output, antenna area, etc. ) are not presented, the following consideration should be examined. Both radio interference and microwave radiation safety are discussed in terms of ground effects. Ground radiation is due to sidelobes of the main steered radar beam. Thus, since most power is contained in steered beam directions, hemispherical zones in the air should be established for the safety of all aircraft - especially low flying small aircraft.

Therefore:

1. A study should be conducted for designing a warning alert system for aircraft entering dangerous zones.
  
2. As radar detection range increases, beam energy density at the source increases. Considering the future tendency of going toward longer detection ranges, studies to determine other detection modes which do not require designation of dangerous regions in a populated area (currently or potentially), should be conducted. One obvious way is to replace backscattering with a forward scattering method. In this mode of operation, active antennas can be located at isolated areas. Thus, more radar research should be expended to examine the full potential of the forward scatter radar in this application.

Demilitarization of Toxic Munitions  
at U. S. Army Materiel Command Installations

Department of the Army

PB 203 509-D

Abstract

This plan has been devised for the on-site disposal of small quantities of leaking or defective chemical munitions by chemical treatment using procedures that effectively contain the agents during detoxification.

The procedure for demilitarizing projectiles, mortar rounds, etc... is to place the munition under a decontaminating solution (10% sodium carbonate for GB and 10% calcium hypochlorite for VX and mustard), drill two holes through the sidewall and pump the solution into the munition.

Agent vapors are removed from the air using a hood connected to a gas-particulate filter (charcoal) that is highly efficient before release to the atmosphere. The air flow rate and effluent air stream composition will be monitored continuously. Liquid wastes (salt solutions resulting from the decontamination reactions) will be evaporated with the residual salts stored in drums until a final disposition method is determined. The decontaminated explosive components will be detonated and other components stored for incineration or scrap metal disposal.

Three separate detoxification units will be used:

1. **Portable Detox Unit:** For detoxification of artillery and mortar projectiles and the M23 Land Mine. A plexiglass hood and gas-particulate filter unit are part of the assembly.
2. **Rocket Detox Unit:** Used for GB and UX filled M55 Rockets.
3. **Bomb Detox Unit:** Largest and most complex unit. A small steel building with a spill pan. After the bomb is drilled, the agent is pumped under vacuum into a one-ton container where it is stored. A decontaminating solution, contained in 55 gallon drums, is then pumped into the munition. The spill pan covers the entire drill area. The building has 2 gas-particulate filter units to prevent agent emission.

Laboratory tests indicate that the most effective use of HTH for destroying VX and HD is by adding the HTH powder in four equal portions at forty-five minute intervals. Reaction times for effective detoxification are three hours with HD and VX and one hour for GB. Detailed descriptions of the detoxification procedures are included in the impact statement.

(reviewer's abstract)

### Environmental Factors Involved

On-site detoxification of defective munitions eliminates hazards occasioned during transportation. Since these facilities are small and flexible, they present no great commitment of resources, while making possible the prompt disposal of hazardous material. By carrying out disposal only under favorable meteorological conditions, any dangers to base personnel or surrounding populations are further minimized.

Agent emissions are controlled by high efficiency filter systems whose effluents are monitored by highly sensitive detection systems.

Liquid wastes are not released to the environment. All solutions resulting from the various decontamination reactions are evaporated to dryness in a mesh-covered tank. The residual salts are stored pending disposal.

The system is a temporary installation and causes no long-term disruption of the environment. While this disposal system is not as sophisticated as the TDS, the benefits of prompt decontamination of leaking or defective munitions are great. The modest scale of operation is an additional safety factor.

#### Future Study Areas

1. The use of parallel filter systems that could be automatically activated (as described for the TDS) would be desirable.
2. Serving systems should be continually upgraded in sensitivity and reliability. Systems based on gas chromatography with effective sampling systems and high sensitivity detectors (EC, microcoulometric and others) are most promising.

When the TDS is completely operational, it may be useful to consider an intermediate size transportable system for small scale munitions demilitarization.

Kahoolawe Island Target Complex

Department of the Navy

PB 203 876-F

Abstract

"Kahoolawe, one of the eight main islands in the Hawaiian Archipelago and located about seven miles southwest of Maui, is proposed for continued use as a naval target complex. Approximately 7750 acres, centrally located and comprising one-fourth of the Island, is used for training in air-to-ground weapons delivery and shore bombardment, using both live and inert ordnance. The central location affords a measure of safety, allows maximum noise abatement, and is considered to be the part of the Island least environmentally affected by ordnance use.

The environmental impact consists of explosions and fragmentation of metal shell and bomb casings on very infertile soil. The adverse effects are cratering, camouflets, sprays of shell and bomb fragments, ground disruption, water pollution, air pollution, destruction of vegetation and animal life, and other related effects in varying degrees confined to the target area and not extending to the neighboring populated islands."

(ISSUING AGENCY'S ABSTRACT.)

### Environmental Factors Involved

A. Water Pollution. Chemicals released by explosives are absorbed by the ground soil. The chemicals are either absorbed by the rain water which then percolates downward into the soil or are carried off in the surface run-off to the surrounding ocean. In addition, surface ground water changes its pattern of flow because of terrain changes caused by the explosions. The impact of this effect is the generation of green craters.

B. Soil Pollution. The presence of unexploded ordnances and the accelerated soil erosion are environmental impacts of this action.

### Future Study Areas

A. Water. Determine the extent of the surface ground water and ocean water pollution. This can be assessed by analyzing the soil pollution immediately before and after a target practice.

B. Air. Initiate a study to take air samples and determine the diffusion parameters about this facility during such an action. With these inputs, it will then be possible to assess the impact of the air pollution as generated by naval vessels, airplanes, and explosives.

C. Noise. Initiate a study to compare the marine life of the surrounding sea at Kahoolawe and other islands to determine if the noisy activity may have changed the behavioral pattern of the marine life.

Safeguard Ballistic Missile Defense System  
Missouri and Wyoming Deployment Areas with the NCA Option

Department of the Army  
Army Safeguard System Office  
Arlington, Virginia

PB 204 162-D

Abstract

"The Safeguard Ballistic Missile Defense System will deploy a third site within the Minuteman Field near Whiteman AFB, Missouri, and a fourth site either within the Minuteman Field near Warren AFB, Wyoming, or near the National Command Authority, Washington, D.C." (ISSUING AGENCY'S ABSTRACT).

Future Study Areas

A. Up to 200 gallons per minute evaporation rate from cooling towers is investigated from the point of view of ground  $\phi$ . Other effects, e.g., excess humidity and excessive heat of condensation, are not investigated. For normal growth, the ratio of water uptake to water transpired must be greater than unity. Usually site quality improves with increasing amounts of available soil moisture. There is, however, a limit to the amount of soil water which is desirable; and, if this limit is exceeded, unfavorable conditions for plant growth result because of deficient aeration and related phenomena. The extent of this effect is dependent on the soil structure and constituents ("Forest Soils",

L. Chandler, Wiley, 1947). Research in plant physiology and agronomy has demonstrated that nutrient salt and water absorption is improved by good soil aeration. Thus, an environmental impact study of cooling tower evaporation should be investigated for effects of excess humidity and excessive heat of condensation as well as ground fog.

B. Recognizing the adverse effect of diesel engine exhaust (nitrogen oxide) into the atmosphere by the independent power source, an experimental research program is being funded to the manufacturer for finding solutions. Emission from diesel engines can be improved by either improving the engine performance or the method of exhaust. At the present time, the first technique is being investigated. Thus, it is recommended that the latter technique (method of exhaust) also be examined and evaluated.

C. A study should investigate and answer the following questions with respect to water quality and water source:

1. What is the effect of waste stabilization ponds on the ground water quality?
2. Is overflow of waste ponds during storms a problem?
3. Water pollution does not end at the natural drainage course. What impact does liquid waste containing concentrated solids and chemicals of this type of facility have on the water quality?

D. Although parameters of the radar (e. g. , power output, antenna area, etc. ) are not presented, the following consideration should be examined. Both radio interference and microwave radiation safety are discussed in terms of ground effects. Ground radiation is due to sidelobes of the main steered radar beam. Thus, since most power is contained in steered beam directions, hemispherical zones in the air should be established for the safety of all aircraft - especially low flying small aircraft.

Therefore:

1. A study should be conducted for designing a warning alert system for aircraft entering dangerous zones.
2. As radar detection range increases, beam energy density at the source increases. Considering the future tendency of going toward longer detection ranges, studies to determine other detection modes which do not require designation of dangerous regions in a populated area (currently or potentially), should be conducted. One obvious way is to replace backscattering with a forward scattering method. In this mode of operation, active antennas can be located at isolated areas. Thus, more radar research should be expended to examine the full potential of the forward scatter radar in this application.

Relocation of Target Facilities from Aqua Cay to Cross Cay  
Atlantic Fleet Weapons Range

Puerto Rico

Department of the Navy

PB 206 051-F

Abstract

"The U. S. Navy proposes to relocate the air to ground target facility presently located on Cayo Del Aqua (Aqua Cay) to Cayo Lobo (Cross Cay). The present target facility on Aqua Cay will be abandoned after the fixed facilities are removed and the area cleaned up. The construction on Cross Cay for a new target facility consist of: clearing a boat ramp in a small cove; preparing a short, unpaved roadway from the beach up to the top of the hill; constructing a new 70-foot diameter helicopter pad; constructing a 12' x '2' concrete block house to contain instrumentation; the clearing of a 150-foot radius target range area and clearing a 100-foot wide run-in line across the island.

The purpose of the existing facility and that of the new facility is to provide a target for development of proficiency in air to ground bombing and rocket firing by Navy and Marine Corps pilots.

The assessment of probable impact on the environment, by relocation of this target facility, was divided into four parts to thoroughly analyze the proposed actions: the impact of the blasting required in

the small cove to clear a boat ramp and the blasting on shore to provide an access road up the hill; the impact of the proposed construction of fixed facilities and the proposed land clearing; the impact of continuing use of Cross Cay as a target for aerial bombardment with inert practice projectiles; and the impact on Aqua Cay by relocating the target from there." (ISSUING AGENCY'S ABSTRACT.)

#### Environmental Factors Involved

A. Blasting - Underwater. A boat lane into the cove on Cross Cay is to be constructed by blasting boulders away from the existing bottom contour. The bottom is dead coral and marine life is small in quantity; hence, insignificant danger to natural life will occur.

B. Blasting - On Shore. Steep cliffs, about 25 feet high, one to be blasted to clear on over for landing boats. The island is uninhabited, has no reptiles or mammals, and no adverse effect on the area environment will be made.

C. Target Facilities. A new helipad with soil cement stabilized shoulders will be built, along with a 12' x 12' concrete banker. The target will be a 150-foot diameter circle, cleared of shrubs and covered with loose soil. The run-in line across Cross Cay will be cleared of shrubs, but grasses will remain. No adverse effects on the environment will occur.

D. Bombardment. Only inert and practice bombs and rockets (containing smoke markers) will be used. About 1100 drops per month will be made. Experience of Aqua Cay indicator grass rapidly cover the impact over which is only disturbed earth ( no explosives '.

E. Long Term Effects. There are no adverse long term environmental effects.

#### Future Work

A. Fish Warning. The effectiveness of firing warning explosives in the vicinity of a blasting area to cause fish to move away should be investigated by controlled observation.

B. Shaped Charges. The shock wave transmitted outwards into the water from shaped charges used to blow up boulders is not the same as from a print charge of the same weight. It would appear to be substantially low. Considering the concern for the impact on fish, a study might be in order.

## Disposition of Orange Herbicide by Incineration

Department of the Air Force

PB 206 061-D

### Abstract

Plans for the commercial incineration of large stocks of herbicide material are outlined. Use of the materials, Orange and Orange II was suspended when it was discovered that one of the components 2,4,5-T (or probably an impurity "DIOXIN" in the 2,4,5-T) caused teratogenic effects on mice and rats (severe birth defects). The ban on these materials left 2,300,000 gal. of Orange and Orange II to be disposed of, as well as 22,500 gal. of iso octyl 2,4,5-T and 16,400 gal. of n-butyl 2,4,5-T. These are ingredients of Orange II and Orange respectively that had not yet been compounded.

Both Orange and Orange II are very effective systemic herbicides that are effective on a wide variety of plant species. Contact with the liquid or the vapor will kill plants. The herbicides are of low toxicity to man, wildlife and fish.

The teratogenic effects on rats and mice have been linked to the impurity "DIOXIN", 2,3,6,7-tetrachlorodibenzo-p-dioxin. This material was found to be present in 20 ppm in a 2,4,5,-T sample that caused teratogenic effects. Tests on DIOXIN itself showed the same level of teratogenic activity.

Incineration would be carried out in Deer Park, Texas (near Houston) and/or Sauget, Illinois at commercial installations. Transportation involves shipment from South Vietnam and from Gulfport, Mississippi and is not considered hazardous. Combustion at 2500<sup>o</sup>F should completely convert all the components into CO<sub>2</sub> and HCl. Both incinerator plants have this capability but deal with the combustion products differently. The Deer Park plant uses sodium hydroxide scrubbing to convert the hydrochloric acid into sodium chloride. The sodium chloride solution is discharged into an adjacent bayou. The Illinois plant uses water scrubbing that allows 5% HCl to emerge, the remaining HCl solution is diluted with water and discharged into a municipal waste treatment plant. The empty drums are to be chemically decontaminated, crushed and buried.

The procedure at both sites is planned to conform to all regulations on emissions of pollutants.

No additional fuels are needed in this process as the herbicide is readily combustible. (reviewer's abstract)

#### Environmental Factors Involved

The necessity to transport large quantities of herbicide by sea and land transport poses some hazards, if rigorous safety procedures

are not followed. However, these are being enforced. The herbicide is of low toxicity to man and animals and can safely be recovered or destroyed in case of spills on land.

The incineration process is carried out at high enough temperatures and residence times to completely destroy the herbicides and any DIOXIN impurities. Scrubbing at the commercial facilities is rated sufficiently effective to reduce emissions of pollutants below local air quality regulation levels.

The discharge of liquid wastes from the scrubbing process conforms to local water quality regulations at both sites.

#### Future Study Areas

1. It could be useful to improve the scrubbing procedures, particularly at the Illinois plant so that substantially all HCl emissions are forestalled. Use of HaOH solutions instead of water at the Sauget facility might be a good start.
2. Monitoring of emissions and liquid wastes for herbicide or harmful breakdown products may be needed. Phenolic materials could be present in either case. While private facilities are involved, they should be amenable to a complete survey of emissions and wastes.
3. Liquid wastes<sup>\*</sup> could be held and evaporated to dryness, using techniques similar to those described for the TDS and project Eagle. The salts could then be disposed of when a safe, approved method is decided and established.

\* Use of NaOH scrubbing required.

Airfield Complex, Campbell Army Airfield, 3 Phases  
Fort Campbell, Kentucky

Department of the Army

PB 206 761-F

Abstract

The total construction effort is to provide required facilities at Campbell Army Airfield to support the increased activities of the operational and training mission. A total of 498 aircraft, compared to the current 82 aircraft, will be stationed at the complex when the construction is completed.

Other than noise, unavoidable adverse effects are not anticipated since training will be confined, with a few exceptions, to the Fort Campbell installation and/or government owned lands. (reviewer's abstract)

Environmental Factors Involved

A. Air Quality

Out of the 498 aircraft, only ten are estimated to be emitting exhaust pollutants into the air at any given time.

Gasoline vapor from the 50,000 gallon storage tanks is minimized by pressure and vacuum breather valves.

## B. Water Quality

Erosion and sedimentation will be monitored during construction activities. Control measures, including resodding as construction progresses, will be instituted. Adequate drainage will be provided by the construction to preclude an adverse effect on the hydrology of the land.

The preventive maintenance program shall be continued to keep oils, toxicants and pollutants out of the sanitary system. Oils and solid waste are collected at the property disposal facility and disposed of in accordance with established procedures for sale and/or disposal of such waste.

## C. Noise

Aircraft noise is considered to be the major factor resulting from this construction that will have a significant impact upon the environment. While this impact cannot be completely eliminated due to the operational and training mission of the division, a study was made to reduce the total impact on the environment.

Noise levels created by the larger aircraft will exceed the 67 DBA tolerance level by 2 DBA. It is estimated that night-time flights will not exceed four per month by these aircraft. Hovering, a prime source of noise pollution, will be limited to operational requirements. Aircraft noise will affect the environment within the confines of Fort Campbell.

#### D. Wildlife

Waterfowl refuges and wildlife management areas exist near the Fort Campbell Reservation. Wildlife regulations preclude aircraft flights below 2,000 feet over the bird sanctuaries between 1 October and 15 April. Helicopters are required to avoid these areas at all times. While accidental violations could occur they would be infrequent and adverse effect to waterfowl and other wildlife in these isolated instances would be a minor disturbance of a temporary nature.

#### E. Air Traffic

Aircraft traffic patterns under direct control of Campbell Army Airfield will be limited to a five mile radius. It is estimated that the maximum number of aircraft in a traffic pattern at any given time would be approximately 10 aircraft. Of these 10 aircraft, the maximum number to be in a flight formation would be 8 aircraft.

### Future Study Areas

A. Military airport noise: The extensive run-ups, engine tests, and training flights associated with a military airport produce patterns and persistence of noise different from commercial aviation. A study of the total diurnal and long-term impact of the military aircraft noise should be made at a typical military airport, which includes surrounding residential and commercial community areas. The following

would be some of the input and output information of the study:

1. Existing data: Various studies have been made on specific problems, such as aircraft flight patterns, to minimize noise in a residential area at night, and the efficiency of noise baffler on engines during run-up. This data should be assimilated and applied to the study.
2. Total noise impact: This is a catalogue of effects which are to be considered for total impact. It includes:
  - a. hearing loss of workers close to the noise sources.
  - b. loss of worker effectiveness due to annoyance and due to lack of communication, through impaired speech intelligibility.
  - c. effect on wildlife through impairment of reproduction and food acquisition activities.
  - d. impact of level and persistence of aircraft noise on humans, animals, and birds as it affects these classes when grouped according to age, species, health condition, location within habitat (open area, nest, etc.) and activity (feeding, sleeping, etc.)
  - e. effect of ambient conditions of topography, vegetation and trees, weather, time of day, season, etc. on the noise impact on the aforementioned groups.
3. Classification of noise sources: The aircraft engine noise, airfoil noise, shop machinery noises and all other noises at the military airport are to be classified according to type (broad band, tonal, pitch) of noise, location of source, sound level, moving or fixed, persistence, hours of operation, and other pertinent parameters.
4. Effectiveness of noise abatement procedures: Certain noise abatement devices for aircraft engines hinder operation (silencers) or are of limited effectiveness (bafflers). Regulation of flight patterns and schedules to accomodate sleeping residents. Adverse sound transmission conditions also hinder operations. Large buffer zones of undeveloped land, or forested areas are effective, without hindrance to military operations, but may be costly. A combined study to optimize the effectiveness of noise abatement procedures,

their cost in terms of operation, capability, and their alternatives, should be part of the overall study.

B. Air Quality: A study of the total expected engine emissions for a typical peak operating and maintenance period at a military airport should be undertaken. The ambient air quality in the vicinity of the airport may show degradation even though the individual source emissions are not excessive.

C. Water Quality: A study should be undertaken of the extent of the spilled fuel, oil, and grease that is dropped on the ground from the aircraft during maintenance and operation, and the manner in which rainfall carries these contaminants into the natural drainage waters. It is not known if this is a significant environmental impact, although the evidence on the airport apron indicates that the amounts may be significant. Controlled drainage or catchments would eliminate the problem.

Sonic Booms  
(Supersonic Flight Producing Sonic Booms)

Department of the Air Force

PB 207 467-D

Abstract

The Air Force, in order to perform its mission, and then only when necessary, conducts operations which involve supersonic flight. The sonic booms generated by this supersonic flight are the subject of this statement. For the calendar year 1970, a typical year, Air Force flight operations resulted in approximately 1,637,000 nautical miles of supersonic flight across the United States. Over half of these miles were accumulated by the Strategic Air Command's high flying reconnaissance aircraft, the SR-71.

The elements of the environment subjected to sonic booms are animal, both man and the group of lower animals of the land and sea, and structures. Three possible adverse environmental effects can be identified:

1. The cumulative physiological-psychological effect on animal life. Further study is required to evaluate this effect.
2. The annoyance and startle associated with sonic booms and the adverse effects of related events.
3. The damage to structures, including archaeological sites.

(ISSUING AGENCY'S ABSTRACT)

### Environmental Factors Involved

In this environmental impact statement, sonic booms are studied extensively for their effect on ground inhabitants and structures. A study of the effects on marine life is being planned.

Although the sonic boom as the cause of a snow avalanche has been investigated and concluded negative, experiments were done at the time when the likelihood of a naturally occurring avalanche was rare. Thus, one can still assume that when a naturally occurring avalanche is a possibility, a sonic boom might be enough to trigger the avalanche.

### Future Study Areas

At present there are little data available on the effects of acoustical energy on structures other than aircraft. High frequency and high intensity noise has been documented as the cause of metal fatigue in many cases. Low frequency and high intensity noise has been observed to cause windows, light aluminum and other sheet metals to vibrate. This is where the technology gap exists. There is little valid information concerning the interrelationship between acoustical energy and vibration and the possible effects on buildings, machinery and equipment. A study should be initiated to determine these effects of a sonic boom.

Over-the-Horizon (OTH) Radar System  
Continental United States

Department of the Air Force

PB 207 572-D

Abstract

This is a draft environmental statement for the CONUS Over-the-Horizon Backscatter OTH-B radar. This radar uses ionospheric refraction techniques to illuminate targets beyond the optical horizon. Two sites are proposed: one in Maine and the other in Washington. Both radars would operate in a northerly direction.

Alternates to the proposed action are:

1. Pulse Doppler type radar versus a Frequency Modulation (FM) Continuous Wave (CW) type radar.
2. Monostatic versus bistatic locations for the radar configuration.
3. More than 20 different sites on the East and West Coasts have been evaluated in the last three years.

(Reviewer's abstract)

Environmental Factors Involved

A. Radiation. Recent Aerospace Medical Division (AMD) experiments indicate that radiation in the 3 - 30 MHz frequency range will be hazardous to personnel and wildlife within 180 feet of the antenna.

Beyond this distance and up to 5100 feet from the antenna, radiation is hazardous only to personnel wearing cardiac pacemakers.

Transmitter sites will be located to avoid population centers, airfields, airways, waterways, and highways, to minimize the radiation impact.

B. Air Quality. Diesel fumes from a 6 MW standby power plant at each site will exhaust into the atmosphere. However, diesel exhaust fumes will be treated catalytically and/or filtered prior to emission into the atmosphere.

C. Noise. The diesel generator plants will radiate noise. However, mufflers will be installed to reduce the diesel exhaust noise.

D. Land Usage. The clearing of trees and shrubs from approximately 600 acres of land at each radar site could possibly cause soil erosion and disrupt the activities of the wildlife. The environmental impact statement states that all areas of land which are cleared of trees will be stabilized to prevent soil erosion.

E. Water Quality. No environmental impact is anticipated on the water quality.

The environmental statement places emphasis on the electromagnetic environment with accompanying theory and experiment as to the impact. While the degree and details could be subject to comments, this will not be done here because the emphasis is on the overall impact. In this respect, the treatment of the physical, social, biological, and ecological environments received secondary considerations.

To a great extent this can be justified because:

1. The final site selections have not yet been accomplished, and hence the detailed impact for the exact locations cannot be made.
2. The environmental impacts of other causes than electromagnetic are not unique to this effort.

This latter point can be seen from the site specifications.

There is to be a transmitter, receiver, and operations site. The technical requirements require the transmitter site, which is the high power radiator, to be in a remote, unpopulated area at least 50 miles separated from the receiver. The environmental impact evaluation of the transmitter site should therefore include not only the electromagnetic effects, but the impact of establishing, supporting, supplying, and communicating with such a remote site.

The receiver site could be located close to the operations area, but the high ambient r-f noise usually associated with operations areas, require a reasonable separation of about 10 miles. The operations site

could be located on existing DoD property. The impact here is somewhat better predictable.

Future Study Areas

The technical factors which enter into evaluating the environmental impact clearly show the need for a data base. The activities, other than the severe electromagnetic environment, are not unique to this effort and hence could be readily evaluated if these results were available. Without such a data base, the need will remain not only to satisfy critiques of those factors unique to this effort, but also those which have commonality to other projects.

Advanced Ballistic Reentry Systems (ABRES)  
Radioactive Sensors

Department of the Air Force

PB 207 577-D

Abstract

The ABRES (Advanced Ballistic Reentry System) Radioactive Sensors Program "will conduct flight tests on the Western Test Range and on the White Sands Missile Range of reentry vehicles having radioactive sensors imbedded in the nosetip and heatshield. Flights will be launched from Vandenberg AFB, California, with impact near Kwajalein in the Marshall Islands, and also from Green River, Utah, with impact on the White Sands Missile Range in New Mexico.

The adverse environmental effects will be the dispersion of a small amount (less than 3 Curies) of Cobalt 57 or Tantalum 182 into the upper atmosphere from material ablation. As stipulated in Title 10, Code of Federal Regulation, the maximum permissible concentrations in air are  $1 \times 10^{-9}$  microcuries per milliliter for TA-182 and  $1 \times 10^{-7}$  microcuries per milliliter for Co-57. A volume of air contained by a cylinder 100 meters in diameter and 400 meters long would be sufficient to achieve this concentration for 3 Curies. Since flight tests are in free air space, much larger volumes of air are involved; therefore, this action is not considered to have an adverse effect on the environment.

The ABRES Program is conducting research to obtain the ablation data in ways not using radioactive materials; but to date, no satisfactory alternatives have been found. The other alternatives which have been considered would not be universally applicable to the wide variety of materials under test and would require many more tests at greatly increased expense." (ISSUING AGENCY'S ABSTRACT).

#### Environmental Factors Involved

The amounts of pollutants are clearly described and analyzed. Safety procedures for recovering radioactive debris are detailed and the techniques appear to be technologically feasible and safe.

#### Future Study Areas

1. More studies should be established to determine scalar diffusion processes in the high altitude atmosphere. At present, very little is known about its flow field and its effects on the eddy diffusion processes. The molecular diffusion rate is expected to be much higher than that of the sea level atmosphere due to the vast differences in the mean free path length, but more experimental verification is needed.
2. A study is needed to determine the diffusion processes in the ocean with special emphasis on parameters such as the descending rate of the pollution source and the flow field conditions.
3. A study should be conducted to determine the effects of radioactive pollutants which are lying on the bottom of the deep ocean. While they may not be able to directly affect human life, they can spread considerably during their dangerous period (half-life in excess of 115 days) and affect aquatic life.

4. If an air pollution numerical model is not available or adequate to evaluate the effect and extent of rocket debris scatter after an abort, a study which includes such parameters as descending rate of pollution source, wind condition and exploding power should be initiated.

Maintenance Dredging of Basins and Channels  
Military Ocean Terminal, Sunny Point  
Southport, North Carolina

Department of the Army

PB 207 726-D

Abstract

The Army proposes the "Removal of approximately 3.2 million yards of material every two years and occasional minor quantities of undisturbed material from existing basins and channels at the Military Ocean Terminal, (MOTSU), Sunny Point in Brunswick and New Hanover Counties, North Carolina. The material will be deposited in dike areas to be constructed on Federal property."

"Minor disturbance of bottom communities, short term increases in turbidity and decreases in dissolved oxygen associated with the dredge cutter head; loss of biotic communities in 800 acres within the diked areas; reestablishment of safe navigation depths for the continued operation of MOTSU with attendant beneficial impacts on regional socio-economic factors and national defense commitments" is anticipated.

(ISSUING AGENCY'S ABSTRACT)

### Environmental Factors Considered

The sediments which are to be dredged up are very fine silts with a high oxygen demand and offer no worthwhile contribution to the environment. They are of no engineering value in that they cannot support structures and of no land value in that they are contaminated and basically impervious to water when consolidated.

A. Effect of Dredging: The effects of dredging the Cape Fear River have been considered and found to be of no significant overall environmental impact as far as the River is concerned. The following were some of the considerations:

1. Turbidity: Dredged sediments will be physically removed from the River. However, the motion of the dredge will stir up a small quantity of sediment. Tests indicate that this sediment will settle in 8 hours and will be dispersed by the flow.
2. Benthos: The river bottom supports very little life. Transplanted seed systems will be destroyed. However, harvesting is prohibited due to high coliform count. A comparison to a similar project in Chesapeake Bay indicates that the removal of toxic sediments cause an increase in benthic life forms after a few months elapsed time.
3. Effect on Fish and Aquatic Fowl: None. Anadromous fish do not spawn in the area to be dredged.

B. Effect of Sediment Disposal: The sediments disposed of within the diked areas will eliminate a highly varied habitat; however, this is only a very small portion of the total of such habitat in the area.

Consideration was given to:

1. Hydrology: The presence of the large fill areas will change the balance of fresh water pond and salt marsh habitat.
2. Contamination: The salt water surface flow from the diked area will return to the River without problems. The underground salt water leakage will temporarily contaminate the ground water.
3. Wildlife: The lengthy operation time for the project will give all wildlife a chance to move to adjacent habitat. There is no significant reduction in total habitat, although the fill area is large, 800 acres.

C. Long Term Effect of Project: The diked areas will eventually support shallow rooted vegetation such as some grasses and sedges.

Trees will not grow in these areas, as experience from previous operations of this type has shown.

D. Other Considerations: Land use outside MOTSU will not be affected. River transportation will be improved, and as a consequence, greater employment is expected in the area. The EIS also discussed the historic and archeological heritage of the area, which is great but are not affected by the proposed project. Air quality was the only parameter affected by the proposed open burning of natural debris (e. g. trees), which is permitted by state law in this area. There will be no adverse effect on ambient air quality.

Future Study

A. The source of the sediments upstream should be located in a geological study of the area. The study may reveal other means of controlling future shoaling instead of dredging, such as dams, or erosion control. (The diked areas are expected to be filled in 15 to 20 years by the annual maintenance dredging of the MOTSU area.)

B. The disposal of contaminated sediments from dredging operations is a widespread problem and worthy of a special study on sediment disposal methods. Special facets of the study would consider the effects of turbidity, sedimentation, toxicity, and other parameters. Alternatively, the fine clays and silts might be useful industrially in the making of bricks.

C. The combination of river flow control and the use of the hydraulic power would be worthwhile of consideration in a total cost effectiveness study. A low head hydroelectric plant, for example, might not produce economical electricity, but when coupled with the saving in dredging costs, might prove economical in total sense.

D. A study of a means to speed up the settling of sediments in the diked areas would also have a general application in industrial usage.

E. A study of a means to oxidize the sediments during settling in the diked areas or while in transport to them, would be worthwhile. The inability to grow deep rooted trees in the previous deposition of sediments might be due to a combination of the oxygen demand and the fine particle size which prohibits natural aeration.

F. The feasibility of mixing coarser soil with the upper layer of the diked material should be studied in order to enhance the possibility of plant and tree growth.

Exercise Exotic Dancer V  
Commander in Chief, Atlantic  
Norfolk, Virginia

Department of Defense

PB 207 741 - F

Abstract

"Exercise EXOTIC DANCER V, a JCS directed joint exercise, conducted by the Atlantic Command, is scheduled to take place in May 1972."

"The proposed action will consist of a coordinated effort to evaluate the capability of assigned Army, Navy, Air Force, and Marine Corps units to operate in a joint service environment as part of the Atlantic Fleet. The exercise will enhance the capability of the Atlantic Command to protect the nation in the event contingency operations are directed by national command authority. All facets of joint military operations on land, on and under the sea, and in the air are included. Complex and coordinated command and control procedures, as well as simulated combat operations, and simulated fire support operations are planned." (AGENCY'S STATEMENT.)

Environmental Factors Involved

The cumulative effects of several factors, each of which is not considered to have a significant effect on the quality of the human environment, are as follows:

1. Minor intermittent increases in local ambient air and water pollution levels.
2. Minor intermittent increase in the production of noise, solid wastes, rubbish, sewage, and garbage production levels due to increased air, water, and land vehicle, and personnel concentrations.
3. Minor increased statistical probability of accidents with potential environmental consequences.
4. Minor waterway sediment disturbance due to fording streams.

Steps taken to minimize potential hazard includes:

1. Restrictions on the use of live amunition and military tracked vehicles (tanks).
2. Forest fire avoidance, detection, and abatement procedures.
3. Provisions to minimize the air, water, and noise pollution problems.

#### Future Study Areas

A survey of all the total environmental impact of this exercise was conducted both before and after the operation and the findings are presented and update this environmental impact statement.

The result of this study, plus studies undertaken for future operations, should enable DoD to minimize the total environmental impact, as this type of operation is necessary in the future.

Land Acquisition, Naval Ammunition Depot  
Oahu, Hawaii

Department of the Navy

PB 207 911-D

Abstract

The Navy proposes the "acquisition of fee title or long-term easement to approximately 1,777 acres of land adjacent to the West Loch Branch of the Naval Ammunition Depot, Oahu, Hawaii. Purpose is to prevent development of the land which is now within the explosive safety zone required for loading/unloading ammo ships. Land is now primarily agricultural and Navy will outlease for continued agriculture use. No funds are requested, for the acquisition as the acquisition/leasing will be by land exchange.

Major environmental effect is the prevention of residential and industrial development of a specific area. Offsetting this, however, will be the return of federally held land for private/state purposes."

(ISSUING AGENCY'S ABSTRACT.)

Environmental Factors Involved

At present, most of the privately-owned land within the explosive hazard safety distance is zoned by the State of Hawaii and the County zoning

code as a Restricted Agricultural District, and is used by Oahu Sugar Company as a small part of the total acreage under sugar cane cultivation to supply their raw sugar mill.

A. Effects on Humans. If the zoning of this area were to remain as Restricted Agricultural (AG-1), the Use Regulations of the State of Hawaii and the County's Comprehensive Zoning Code would permit a maximum of one dwelling to each two acres but more significantly would permit construction of high density public gathering places such as churches and schools. It is therefore considered imperative in the interest of limiting the potential hazard to life and property and the consequent liability of the Federal Government that the use of the area within the blast hazard zone be under complete Navy control. There are no plans for Navy development of the land to be acquired by this project. Long-term agricultural leases will be negotiated to insure continued and maximum use of the land compatible with the ammunition blast hazard imposed on the area.

B. Wildlife and Aquatic Life. All of the wildlife and aquatic life within the land to be acquired are common species of no particular scientific, aesthetic, or recreational value.

The proposed acquisition of this land will have no effect (either beneficial or detrimental) on the wildlife and aquatic life within this area.

C. Plant Life. The proposed acquisition of this area, assuming the continuation of the lease for sugar cane production, will have no effect on the plant life of the area.

D. Natural Resources. With the exception of those items previously mentioned (wildlife, aquatic life, and plant life), there are no significant natural resources such as oil or mineral deposits within the area, nor are there any known archeological or historic sites.

E. Effects on Land Use. The Navy has no plans for construction, development or use of the area to be acquired. In general, acquisition will have no impact on the current land use since the Navy intends to outlease the area for agriculture. Planning envisions long-term outleasing for the growing of sugar cane required to support the sugar industry on Oahu.

#### Future Study Areas

Conceptual studies of alternative ammunition handling facilities should be continued with a possible emphasis on underground storage.

Outlease of Land to Gulf Power Company at Eglin Air Force Base,  
Florida.

Department of the Air Force

PB 207 922-F

Abstract

The growth of electric power demand in the Eglin Air Force Base and Fort Walton Beach area is such that present loads, especially in summer, strain the power transmission system. The loss of a transmission line and the outage of any one major substation, could result in a loss of power to the area. The proposed action involves the transfer of property for the installation of a new above-ground 230,000 volt power transmission line. This added electric service will follow a right-of-way 50 to 150 feet wide and 48 miles long, comprising 813 acres. The transmission line would interconnect several power substations and the load center, and would relieve a situation presently considered critical. Gulf Power Company, Pensacola, Florida, is the electric company.

The environmental problems considered are loss of land usage, loss of esthetic value, impact on vegetation and ground water, fire hazard, and release of ozone into the atmosphere. The terrain traversed is forest, farm, and suburban in the uplands, and lowland forest and wetlands. (Reviewer's abstract).

Environmental Factors Involved

High tension electric transmission lines using aerial suspensions between high towers are long established as part of the environment. This environmental impact statement presents authoritative information on the effects of the proposed action. Except for esthetics, the aerial lines will have no significant adverse environmental effects.

A. Water Quality

No changes in the area hydrology (wetlands or upland) will be made except for temporary erosion due to removal of ground cover along the right-of-way. The erosion will be insignificant as new ground cover will become established in a short time.

B. Air Quality

The high voltage transmission lines give off ozone under certain atmospheric conditions. To date, no adverse effect to the air quality has been observed due to this concentration of ozone around the transmission lines.

C. Noise

Singing and crackling noises during certain atmospheric conditions are a familiar sound, audible only in the near proximity of the transmission line.

D. Fire Hazard

Fallen lines represent a serious fire hazard if not de-energized. System instrumentation is utilized to detect grounded lines instantly

and de-energize them. Thus, the danger of fires is greatly reduced.

E. Wildlife

The replacement of the high forest canopy with low vegetation along the right-of-way will provide better protection for small upland game such as fox, rabbit, raccoon, etc. Accidental electrocution of birds, especially large raptorial birds, is precluded by using adequate clearance between wires.

F. Recreation

The right-of-way is a benefit to hunters as it provides them access to otherwise inaccessible areas. The unsightliness of the towers and lines is a minor recreation/landscape detriment.

G. Land Usage

Except for tower support bases, the land is open. Regulations prohibit permanent structures on the right-of-way, but fences may cross and farming and grazing are unrestricted.

H. Adverse Environmental Effects

The one outstanding adverse environmental effect is the unsightliness of a transmission line. This impact on man has been minimized by designing low profile towers and routing the lines beside existing lines in built up areas. Alternative actions to the proposed transmission lines that were considered are:

1. underground lines
2. conversion of an existing 115,000 volt line to 230,000 volt service
3. different routings of the line
4. no action at all.

The proposed action was superior to the first two alternatives by virtue of much lower cost, the third alternative had essentially the same adverse effects, and no action at all threatened the economy of the area and the mission of Eglin Air Force Base.

#### Future Study Areas

Extensive research and development of underground electric power systems has been in progress for many years and continues with renewed emphasis because of requirements for such service in some urban areas. Assuming costs will become manageable and reasonable, there will be a need to evaluate the underground transmission system, as opposed to aerial transmission, in rural areas and in terms of its environmental impact. This evaluation can, and should, be done now.

Pacific Cratering Experiments (PACE)

Department of the Air Force

PB 208 369-D

Abstract

The Air Force Weapons Laboratory proposes to conduct an eight-phase program of detonation of high explosive charges at the air-ground interface on selected islands of Eniwetok Atoll in the Marshall Islands. Its purpose is to provide data from which empirical methods will permit the extrapolation of the original nuclear explosion data to that of detonations in the megaton levels, both of Eniwetok, and at any other strategic site of differing geological conditions. The eight phases evaluate the geology of the old nuclear craters and relate it to companion high explosive (HE) tests; using geophysical techniques such as drilling and sampling, seismic profiling, etc., define the geology and hydrology of the possible HE event sites; detonate small yield HE charges at various heights to develop prediction data and verify techniques; repeat with intermediate yield HE charges at selected sites; using geophysical techniques, develop the complete geology of Eniwetok Atoll; using geophysical techniques, investigate the old nuclear craters; conduct the high yield HE events (note: non-nuclear); and conduct a test event based on the 1958 Cactus Event (nuclear) on Runit Island, Eniwetok.

(Reviewer's abstract).

Environmental Factors Involved

A. Air Quality. Detonation of the high explosive events will, for the largest charges, raise detonation clouds to 10,000 feet with a diameter of approximately 4000 feet, and contain particles from the soil and coral sand of the crater. Particle sizes will range from 50 microns to one millimeter in diameter and will settle back to the ground within two hours and within 15,000 feet of the charge site. The contaminants affecting air quality are TNT detonation products and the re-suspension of old radioactive material. The former are typical combustion products, of no concern here because of their limited duration, and the latter is unlikely to be of consequence owing to a site selected for low measured radioactivity. Nevertheless, continuous monitoring during the tests will safeguard personnel.

B. Water Quality

1. Ocean and lagoon water. Material falling into the water from the shots will be rapidly assimilated and offers no adverse environmental effect.
2. Ground water. The ground water of coral islands is typically a critical balance between rainwater and displaced seawater forming a "lens". The water in the lenses of the test island is brackish, unfit for human consumption. If the detonation crater penetrates the water lens, water quality is impaired. Otherwise, there is no effect. The test sites will have six feet of overburden removed, which contains the bulk of the old radioactive fallout. Any radioactive material entering the ground water because of the detonation will be inconsequential, it

being of very low level. Soluble chemicals from the explosives, which are not anticipated, will be washed out of the ground water by the tidal action and the rainfall in, at most, a few years.

C. Land Use

1. Vegetation removal. All vegetation will be removed from the test sites and heaped, for natural decay. After the tests, the land will be replanted, possibly with coconut trees. There is no original vegetation here as nuclear tests stripped the area years ago.
2. Overburden removal. All the old radioactivity has been shown to decrease rapidly with depth. Removal of overburden leaves a clear site for the high explosive events.
3. Ejecta. No contamination by material thrown out of the craters is anticipated. If any radioactive scrap is revealed, it will be measured, and placed in a marked area for later disposition.
4. Reef damage. No damage to reefs is expected since ejecta from the craters will fall only on areas of old coral reefs that are no longer alive.

D. Wildlife

1. Fish. No significant impact since most shots are on land; the reef shots affect only a small percentage of the fish province.
2. Rodents. Some may be killed, but no significant effect on the population is expected owing to their tolerance of extreme environments, lack of predators, and the fact that removal of overburden will cause them to move elsewhere.

3. Birds. Some may be killed, but bird population depends upon food level, which is fish, and hence unaffected. No rare birds are involved.
4. Land crabs. The test sites do not support significant populations of crabs. Islands to the south, which do have large crab colonies, will not be affected by the tests.

E. Alternatives to the Proposed Action. The PACE Program is necessary from a military science viewpoint and cannot be abandoned. The other alternative, testing on other islands, has been shown to be less beneficial to science, less meaningful to the military, and more harmful to the environment than on Eniwetok.

#### Future Study Areas

This program is being conducted in close association with the Eniwetok Marine Biological Laboratory and with other scientific organizations whose purpose is monitoring the natural environment. It appears that all aspects of the environmental problem will be taken under consideration.

## APPENDIX A

### Persons and Agencies Visited

To gain insight into the state-of-the-art in pollution detection, monitoring, control, and abatement instrumentation and to determine the current level of theory and technology in pollution endeavors, several conferences and symposia on pollution control, abatement, and detection were attended.

In addition, staff members of Ocean & Atmospheric Science, Inc., visited many facilities, DoD agencies, non-DoD federal agencies, and industrial and educational laboratories to review their environmental effects program and to evaluate their present and proposed efforts in terms of DoDs requirements.

The dates, places, and personnel visited are given in the following tabulation.

<u>Date</u>	<u>Attendees</u>	<u>Location/Discussion</u>
15 May 1972	Col. Bell Environmental Officer for the Air Force Mr. Julius Woolf*	Pentagon, Washington, DC  Discussion of Environmental Impact Statements and their use as a vehicle to predict new programs
24-28 May 1972	Mr. Meninger Mr. J. Woolf* Dr. B. Harris*	Livermore, California  High-flying airplane - SST - and its relationship to environ- mental impact
6-8 June 1972	Mr. C. West Mr. R. Woodall Mr. J. Woolf*	Johns Hopkins University  Relationship of pollution to water and ocean platforms that might relate to water pollution monitoring
24 June 1972	Mr. Morris Smith Dr. Uri Shafrir* Dr. B. Fabricand* Dr. E. Kuo* Mr. R. Harris* Mr. J. Woolf* Mr. J. Brakl* Mrs. J. Latham* Mr. H. Battestin*	OAS  General information meeting on current standards, techniques and impact environmental studies
28 June 1972	Dr. E. Posmentier* Dr. U. Shafrir* Mr. J. Woolf* Mr. H. Battestin*	New York University  Ascertain numerical modeling studies that are required to predict environmental actions.

---

\* Signifies OAS Staff Member.

6 July 1972	Dr. E. Posmentier* Dr. B. Harris* Mr. Henry Battestin*	New York University  Further discussions on numerical modeling requirements for pollution studies.
6 July 1972	Dr. Oswald Roels* Dr. Eric Posmentier* Mr. Julius Woolf* Mr. Henry Battestin*	Lamont/Doherty Geophysical Laboratory  Determine the need for numerical models to describe the dispersion and diffusion of pollutants from electric power generating plants.
11 July 1972	Mr. Robert Lundquist Mr. Irving Forsten Mr. Gerald Eskelund Mr. Lawrence Gregory*	Picatinny Arsenal Dover, New Jersey  To discuss the method of generation of an impact statement by the U. S. Army Materiel Command.  To determine the extent of the pollution endeavor at Picatinny Arsenal and their immediate need for sensors/instrumentation.
12 July 1972	Dr. Oswald Roels* Mr. Henry Battestin*	Lamont/Doherty Geophysical Laboratory  To determine and evaluate the need and data from recent pollution studies in New York City waters in reference to electric power plant pollution and abatement.
18 July 1972	Mr. Edward Porr Mr. Joseph Zebrowski Mr. Lawrence Gregory*	McGuire Air Force Base  To discuss the method of generation of an environmental impact statement by the Air Force.  To determine the extent of the pollution endeavor at McGuire Air Force Base, and their immediate needs for sensors/instrumentation.

20-21 July 1972	Dr. C. Grosch* Dr. B. Fabricand* Dr. B. Harris* Mr. J. Woolf* Dr. R. G. Joiner, ONR Dr. S. Ruby, ARPA	ARPA  General outline of pollution program.
21 July 1972	Mr. Maurice Ringenback Mr. Julius Woolf*	NOAA, Rockville, Maryland  To discuss instrumentation requirements for effective pollution measurement and analysis.
22 July 1972	Mr. P. W. Breaux Mr. George Ames Mr. Henry Battestin*	Olin Chlor-Alkali Plant Charleston, Tennessee  To discuss the extent of their pollution problems with special emphasis on mercury plus their present abatement and measurement techniques.
26 July 1972	Mr. Stanley Peterson Office of Secretary of Defense Director of Ocean Control  Mr. Harry Sonnemann Office of Asst. Sec. of Navy for R&D  Mr. Julius Woolf*	Pentagon, Washington, DC  Review of pollution program and suggestions for possible future programs
26 July 1972	Mr. James J. Gallagher Mr. Leslie Greiner Mr. Lawrence Gregory*	U. S. Naval Underwater Sound Center, New London, CT  To ascertain the needs of the facility for pollution sensors/instrumentation and their current program for abatement and measurement of pollutants.

31 July 1972	<p>Mr. Robert Bennin  Mr. Jack Friedlander  Mr. Joseph Brakl*  Mr. Julius Woolf*  Mr. Henry Battestin*</p>	<p>Office of the Director of Noise  Abatement, New York City</p> <p>To discuss current noise  methodology and future  requirements for noise  studies/instrumentation.</p> <p>To determine the necessary  legislation required for effective  control of pollution and the status  of the City's endeavors in noise  pollution abatement.</p>
2 August 1972	<p>Mr. Jack Pruden  Mr. Julius Woolf*  Mr. Henry Battestin*</p>	<p>Management Systems Branch  EPA, Waterside Mall  Washington, DC</p> <p>To discuss the status of their  current management program  and to determine the end product  of their study.</p>
2 August 1972	<p>Mr. William Holmberg  Mr. Julius Woolf*  Mr. Henry Battestin*</p>	<p>Office of Federal Activities  EPA, Waterside Mall  Washington, DC</p> <p>To discuss EPA's program and  liaison effort with other Federal  activities and to learn of this  office's proposed monitoring  program.</p>
2 August 1972	<p>Mr. George A. Cunney, Jr.  Dr. Stanley Ruby, ARPA  Col. Robert M. Shaw, Jr.  Mr. John S. Pace  Mr. Bruce Hildebrande</p>	<p>U. S. Army Materiel Command  Washington, DC</p> <p>To present the endeavors/aims  of OAS's pollution study and  obtain permission to discuss  freely the pollution problems  on this command's facilities.</p>

--continued...

... continued

	Mr. Donald R. McChesney Mr. R. G. Joiner, ONR Mr. Jon Sugrue Mr. James Tragesser Mr. William Slater Mr. Julius Woolf* Mr. Henry Battestin*	To learn the program presently being undertaken by the U. S. Army Materiel Command to control/abate pollution and measure the emission level of any pollutants.
3 August 1972	Dr. Guilford Quarles Chief Scientist of Army Engineers  Mr. Julius Woolf*	Forestal Bldg., Washington, DC  Briefing on Army Engineers pollution program.
22 August 1972	Mr. Rudy Black Mr. Julius Woolf*	ARPA  Energy study relating to pollution.
29 August 1972	Mr. Ray Davis Office of Installation & Logistics, Office of Secretary of Defense  Major Don Rogers Dept. of Environmental Quality, Dep. Asst. Sec. for Environmental Quality, Director for Categorical Programs  Donald Lawyer, Director for Planning & Natural Resources, Asst. Sec. for Health & Environment  Mr. Julius Woolf*	Pentagon, Washington, DC  Critical materials.

6 September 1972	Dr. Stanley Ruby, ARPA Mr. R. C. Joiner, ONR Dr. Bernard Harris * Mr. Julius Woolf * Mr. Henry Battestin *	ARPA, Washington, DC  To inform ARPA and ONR of the progress made and directions taken by OAS in fulfillment of the pollution study contract.
11 September 1972	Mr. James Murray Mr. Julius Woolf * Mr. Henry Battestin *	Grumman Aircraft Bethpage, New York  To discuss the pollution problems associated with the manufacture of the F-14 fighter and to determine the critical materials/sources of supply which are required for the construction of the fighter.
13 September 1972	Mr. Henry Battestin *	IEEE Conference "Oceans '72" at Newport, R. I.  To attend the two technical sessions which were on the technical/environmental aspects of Project Sanguine.
20 September 1972	Mr. Thomas Dashiells Mr. Julius Woolf * Mr. Henry Battestin *	ODDR&E, Pentagon Washington, DC  To discuss DoD's present and future efforts in control and abatement of pollution.
20 September 1972	Col. Herb Bell Mr. Julius Woolf * Mr. Henry Battestin *	AF/PREV, Pentagon Washington, DC  To discuss the Air Force's pollution endeavors and to determine future area requirements for additional study.

20 September 1972	Lt. Col. Sal LaMole Mr. Julius Woolf* Mr. Henry Battestin*	Pentagon, Washington, DC  To ascertain the Air Force's present modeling capability at Vandenberg AFB and the extent of their program for future modeling studies.
21 September 1972	Cdr. Robert Bartlett USN  Mr. Henry Battestin*	Office of Federal Activities EPA, Waterside Mall Washington, DC  To determine the endeavor of EPA with the Federal Activities monitoring program, the need for a data base, and the present extent of the pilot program.
21 September 1972	Mr. George Morgan  Mr. Henry Battestin*	Office of Research & Monitoring EPA, Waterside Mall Washington, DC  To determine the experts in air and water instrumentation for EPA pollution monitoring programs.
21 September 1972	Mr. Stephen Hurley  Mr. Henry Battestin*	Naval Facilities Engineering Command Bureau of Yards & Docks Annex Arlington, Virginia  To learn of the U. S. Navy's Environmental Protection Data Bank at Port Hueneme, California
30 September 1972	Mr. Tom Dashiells DDR&E  Mr. Julius Woolf*	Pentagon, Washington, DC  Prediction of new research programs related to data base, tri-service activities, and area coordinating paper. Discussion of critical materials.

4 October 1972	Maj. R. L. Hanson Mr. Vincent Iacampo Mr. Edward Meineke Mr. John H. Gilbert Mr. Anthony B. Fanale Mr. Morton I. Greene Mr. J. J. Canavan Mr. W. J. Coogan Mr. A. A. Carotti Mr. Lawrence Gregory* Mr. Julius Woolf* Mr. Henry Battestin*	Picatinny Arsenal, Dover, NJ  To learn of the pollution problems and endeavors at Picatinny Arsenal and their particular need for pollution sensors/instrumentation and analysis techniques.
10 October 1972	Dr. Smagorinsky Dr. Kirk Bryan Dr. William Holland Dr. Eric Posmentier*	Princeton Geophysical Fluids Dynamics Laboratory NOAA, New Jersey  To discuss state-of-the-art and their efforts in numerical modeling and to ascertain the possible extent of their cooperation in an ARPA program.
11 October 1972	Dr. S. Brainin Mr. E. Moser Mr. Walter Dunbar Mr. Scott Kennedy Dr. Bernard Harris* Mr. Henry Battestin*	Navy Environmental Protection Data Bank, N. E. P. D. B. Port Hueneme, California  To learn about the Navy's Environmental Protection Data Bank, their present objectives, work, and surveys and their plans for the future.

## APPENDIX B

### B.0 Pollution Abatement Efforts

### B.1 History of the Environmental Impact Statement

On June 7, 1971, the U.S. Commerce Department announced that beginning July 1 of that year, all environmental impact statements of all U.S. government agencies would be available for public subscription from the National Technical Information Service (NTIS), and that there would be an accession list published semi-monthly in the Series 68 Announcement, "Environmental Pollution and Control." Thus began the rapid development of a formal document which revealed the inter-relationship of man and his environment as it applied to specific government sponsored projects and which attempted to evaluate the benefits and the costs of those projects in terms of the environment.

A rapid glance at the environmental impact statements in chronological order will reveal a remarkable advance in the level of science and technology applied to environmental evaluation during the first year. Also, the extent and the depth of the environmental consideration increased markedly as successive impact statements became available, and as earlier ones were modified and reissued.

The environmental impact statement (EIS) is a formality of the public awareness to conservation and improvement and, as such, it has

a formal legislative beginning. The authority derives from the National Environmental Policy Act (NEPA) (Public Law 91-190), signed by President Nixon on January 1, 1970, and from the President's Executive Order 11514 of March 4, 1970. NEPA, in Section 102c, states that every Federal agency must include in every recommendation or report on proposals for legislation and other major Federal actions which may significantly affect the quality of the human environment, a detailed statement by the responsible official on:

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented.

In support of this legislative mandate, Executive Order 11514 directs all Federal agencies to direct their plans, policies, and programs so as to meet the national goals for the environment.

The history of the environmental impact statement follows that of the Council on Environmental Quality (CEQ), which was created by the same National Environmental Policy Act. The Council was given the responsibility of appraising Federal programs affecting the environment

and making recommendations to the President regarding program policies. To this end, investigation and documentation of changes in the environment and in ecological systems were to be undertaken. The responsibilities of the CEQ were further delineated in Executive Order 11514, with specific directions to issue guidelines and instructions to Federal agencies, "for the preparation of detailed statements on proposals for legislation and other Federal actions affecting the environment." Consequently, in April of 1971, the CEQ issued "Guidelines for Federal Agencies under the National Environmental Policies Act," which provides the guidelines for preparing detailed environmental statements. The memorandum included procedures for interagency coordination and cooperation regarding Federal programs to comment on the various environmental impacts. Some of the types of environmental impact which were included are air and water quality, noise, hazardous substances, wildlife, and land use.

The "Guidelines" directed that the following points must be covered in every environmental impact statement (this listing has become the format for many environmental impact statements):

1. A description of the proposed action including information and technical data adequate to permit a careful assessment of environmental impact by the commenting agencies.
2. The probable impact of the proposed action on the environment, including ecological systems such as wildlife and fish.

3. Any probable adverse environmental effects which cannot be avoided, such as pollution, land use, congestion, etc.
4. Alternatives to the proposed action. Specifically, a rigorous exploration and objective evaluation of alternative actions that might avoid some or all of the environmental effects is essential.
5. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
6. A list of the irreversible and irretrievable commitments of resources which would be involved in the proposed action.
7. A discussion of problems and objections raised by other Federal, State, and local agencies. (The comments of the Environmental Protection Agency should be requested specifically.)

The "Guidelines" also delineated the distribution of the impact statements in draft form to the jurisdictional agencies and to the CEQ. Upon receipt of the agency comments, the originator must reply and include the replies as modifications in the final form of the statement. Using these instructions as a basis, each of the armed forces prepared guidelines of their own which were more intimately related to their military mission.

It is recognized that the standards and the laws by which man fixes his environmental goals are not necessarily recent in origin. The environmental impact statement is a recent formulation of older ideas. Even today, the standards might not be scientifically sound nor applicable to the specific situation which is encountered. It is

the role of the impact statements to establish the proper perspective for evaluation when there is a conflict between man and his environment or when there is an anticipated change in the environment, albeit beneficial. Consequently, as the technology, the standards, and the understanding of the environment progress, the composition of the EIS changes. The changes are partly a natural evolution on the part of the staff preparing material for the EIS and partly the result of memoranda issued by the CEQ.

The effectiveness of the EIS as a means to achieve Federal control over actions potentially harmful to the environment is an ongoing Congressional concern. An amendment to the National Environmental Policy Act (Public Law 91-190) was proposed to legislate the content and submission procedure of an EIS (HR 11288, February 1972). Dr. G. J. F. MacDonald, member of the CEQ, testified to the concerned Congressional committee that the CEQ "Guidelines" accomplish the purpose of HR 11288. In addition, the "Guidelines" have the additional advantage of centralizing the preparation of an EIS in the one agency which is most concerned. Consequently, HR 11288 was not enacted. However, new and more specific details on the preparation and submission of an EIS have appeared in recent CEQ memoranda.

In a statement issued in February of 1972, Mr. Russell Train, Chairman of the CEQ, drew attention to the need to consolidate the number of impact statements into fewer, but broader and more meaningful reviews. Additionally, it was determined that a need existed to

identify the types of environmental actions that require an impact statement and the ones for which an EIS was unnecessary. The key words in the National Environmental Policy Act (Sec. 102c) are "Federal actions significantly affecting the quality of the human environment." The word "significantly" received emphasis in the statement by Mr. Train. Lesser impacts on the environment could well be handled at lower agency levels. Consequently, Mr. Train announced a series of prospective meetings between the CEQ and Federal agency staffs to review possibilities to improve procedures to carry out the National Environmental Policy Act. As a result of these actions, the CEQ prepared a new memorandum on the submission of an EIS which, with the earlier "Guidelines," formulates the environmental impact statement as it appears today. Also, the procedures employed by the Federal agencies in determining an environmental assessment and, if necessary, upgrading that assessment to an EIS, were more formally structured. (These procedures as they apply to Department of Defense agencies are discussed in Section B. 3.)

The new memorandum from the CEQ is entitled "Memorandum to Federal Agencies on Procedures for Improving Environmental Impact Statements," and it was issued on May 16, 1972. This memorandum clarifies earlier CEQ procedures, and more importantly, takes note of recent court decisions\* interpreting the National Environmental Policy

---

\* 1. EDF v. Corps of Engineers, 2 ERC 1260, 1267 (E. D. Ark. 1971)  
--EIS must alert President, CEQ, public, and Congress to all known possible environmental consequences.

(--continued)

Act and presents compatible guidelines for the Federal agencies. Specifically, the agency preparing an environmental impact statement has the following points to consider:

1. The duty to disclose the full range of environmental consequences of the proposed action and all alternative actions, even though this may lead to the consideration of effects and options outside the agency's control.
2. The duty to weigh adverse environmental effects against the benefits of the proposed action.
3. The duty to set forth the opposing views on the proposed action.

The preparation and distribution of the EIS was also delineated, with adequate times stipulated for review by the CEQ, the public, and interested agencies.

---

\* --continued

2. *Calvert Cliffs v. AEC*, 2 ERC 1779, 1782 (D.C. Cir. 1971)  
--purpose of EIS is to aid agency in its decision and to fully inform other interested agencies and the public of environmental consequences.
3. *EDF v. Hardin*, 2 ERC 1425, 1426 (D. D. C. 1971)  
--agency must undertake research in planning stage adequate to expose potential environmental impact.
4. *NRDC v. Morton*, 3 ERC 1558, 1562 (D. C. Cir. 1972)  
--EIS is for guidance of ultimate decision makers; Congress and the President, as well as agency, must provide discussion of all reasonable alternatives.
5. *Greene County v. FPC*, 3 ERC 1595, 1600 (2nd Cir. 1972)  
--EIS must present a single coherent and comprehensive environmental analysis.

An important feature, the pre-draft stage was suggested so that interested persons and agencies could make relevant information available to the proposing agency. Finally, the May 16th memorandum points out that the approval of the Environmental Protection Agency (EPA) does not preclude the necessity of obtaining CEQ approval for the proposed action. (Some court decisions to the contrary are being appealed.)

At the same time as the CEQ was issuing the new memorandum to improve the EIS, the 92nd Congress was considering amendments\* to the National Environmental Policy Act which would provide for citizens' suits and class actions. This would afford citizens the right to influence those proposed actions which may aggrieve some segment of the public, either directly or through deterioration of the environment. The Congress had already set a precedent in the "Clean Air Amendments of 1970," (P. L. 91-604, December 31, 1970), in which citizens may sue Federal or private entities to enforce air pollution standards. The new CEQ procedures for the pre-draft and draft stages of the impact statement, provide for public participation in the formulation of the EIS material.

The environmental impact statement is an effective tool in pollution abatement. It stipulates the public concern with scientifically

---

\* HR 8331, HR 5074, S1032: All in committee as of this writing.

supported facts regarding the environmental tolerance and deterioration which might result from the proposed actions. The Environmental Protection Agency is indirectly charged with the responsibility to see that an EIS is accurate and complete (see Section B.2). The public right of access to a complete and authoritative EIS was established prior to the formulation of an EIS. The "Freedom of Information Act of 1966" requires that data (as distinct from opinions and policies) must be available to the public from all Federal agencies. For example, the U.S. Court of Appeals\* upheld the right of the public to review factual and investigatory reports in the controversy over the SST aircraft. The Court\*\* also indicated that the public has a right to review an EIS to insure that the analytical procedures are adequate to truly evaluate an environmental impact. Consequent to these and similar actions, the EIS has evolved from a routine administrative document to an informative and authoritative working document for the Federal agencies and for the public.

---

\*Soucie v. David, 2 ERC 1626, 1 ELR 20147 (D. C. C. 1971).

\*\*Wilderness Society v. Hickel, supra note 4: Environmental Defense Fund v. Corps of Engineers, 329 F. Supp. 728, 749 (E. D. Ark. 1971).

## B.2 The Role of the Environmental Protection Agency

The CEQ "Guidelines" directed that an environmental impact statement was to be submitted to selected Federal agencies which, by virtue of law or expertise, were able to comment on it. The Environmental Protection Agency (EPA) was specified as one agency to comment on all impact statements. This specific directive reflects the authority and the accomplishment of the EPA. Although the authority of the EPA is recent, its accomplishment derives from a long experience, mostly accumulated before the EPA was established as a viable organization.

The prominent public concern of the mid-sixties that something meaningful be done to preserve and improve our environment brought about both the National Environmental Policy Act of 1969 and the establishment of the EPA. Although the influence was common, the EPA was not created by the Act. The "Reorganization Plan No. 3 of 1970," sent to Congress on July 9th of that year by President Nixon, was the initiating directive for the EPA. This document, which was recommended by a special presidential council, implemented a part of the general re-organization of the Executive Department as it related to the environment. The "Ash Council," as it was popularly known after its chairman, Mr. Roy L. Ash, recommended that the numerous government bureaus be replaced by organizations which will:

1. Establish and enforce environmental standards;
2. Analyze and measure man's long-term effect on the environment; and

3. Supervise the projects and plans of the Federal government as they relate to the environment.

Three organizations were created to satisfy these needs. They were, respectively, the Environmental Protection Agency (EPA), created by "Reorganization Plan No. 3 of 1970," the National Oceanic and Atmospheric Agency (NOAA), created by another presidential directive, and the Council on Environmental Quality (CEQ), created by the "National Environmental Policy Act of 1969."

Since the EPA was constituted out of existing agencies, it was a workable and effective organization immediately following its establishment on December 2, 1970.\* It has the responsibility to lead a broad, objective, and comprehensive attack on pollution within the states, municipalities, and industries. (The same responsibility for the Federal government was given to the CEQ.) Specifically, it is charged with setting standards of tolerance on air, water, solid waste, pesticide, and radiological pollutants, and enforcing these standards by regulations,

---

\* Federal Water Quality Administration and Gulf Breeze Biological Laboratory - from the Department of Interior; National Air Pollution Control Administration, Bureau of Solid Waste Management, Bureau of Water Hygiene, Bureau of Radiological Health (environmental radiation programs) - from the Department of Health, Education, and Welfare; Federal Radiation Council.

Also transferred to EPA were responsibilities and authorities for: establishing standards for environmental chemicals - from the Atomic Energy Commission, establishing tolerances for pesticide chemicals - from the Department of Health, Education, and Welfare; registration and labeling of pesticides - from the Department of Agriculture; conducting research on pesticides - from several departments; conducting research on ecological systems - from the Council on Environmental Quality.

which have the force of law. The "Noise Abatement and Control Act of 1970" added another pollutant, noise, to the responsibilities of the EPA.

For convenience of operation, the EPA organized ten regional offices out of its pre-existing network of offices, laboratories and staff. These regional offices are large enough to deal with environmental matters that overlap jurisdictional and political boundaries, yet small enough to specialize in the unique environmental characteristics of their respective geographical areas. Except for environmental problems of national impact, all EIS are presented to the regional office nearest to the planned action for comment.

The EPA has control over Federal actions in addition to that of expert comment on the EIS. It was inherited from the bureaus combined earlier to form the EPA. On February 4, 1970, President Nixon issued Executive Order 11507, which directed that all Federally owned or leased facilities be designed, operated, and maintained so as to conform with present and future air and water quality standards. Federal facilities are to establish and to comply with air and water quality standards that are presently legislated or if such standards are not sufficiently stringent or not yet legislated, then these agencies must determine new standards which are acceptable to the Secretary of Interior and the Secretary of Health, Education, and Welfare. These responsibilities of the secretaries were transferred to the EPA. Now, the EPA is

responsible for the adequacy of the standards by which environmental impact is measured in proposed Federal actions.

The "Clean Air Amendments of 1970" (P.L. 91-604, Sec. 309) broadened the scope of the EIS in a proposed action to consider environmental effects beyond the jurisdictional or political boundaries of the action area (e. g., power plant emissions might be within legal limits at the plant site but might aggravate air quality conditions in a nearby city). Similarly, amendments to the "Federal Water Pollution Control Act of 1956" are proposed. As a consequence of both broadening the scope of the EIS and presenting a higher level of scientific, ecological, and technical information within the environmental impact statement, the demands made upon the proposing agency are often beyond the technical capability of that agency's staff. The EPA regional offices, therefore, have made provision for technical assistance to the proposing agencies.

The various directives, laws, and amendments discussed thus far combine to effectively make the EPA responsible for a thorough analysis and evaluation of an impact statement. Specifically, the EPA is required to make public any determinations of unsatisfactory or adverse effects on public health, welfare, or environmental quality. Although this role does not take a direct intervening action, it is, nevertheless, a dominant role. The CEQ considers all evidence and by virtue of its own directive, it particularly considers the comments

of the EPA before advising the President and Congress on the recommended course of action.

The EPA has established an Office of Federal Activities in Washington, DC, for assistance and review of all environmental impact statements which do not fall within the control of the regional offices. If the impact statement pertains primarily to policy, regulation, or procedures which do not have a geographical focus, if the regional office lacks technical expertise, or if a high degree of national controversy is involved, then the Office of Federal Activities is called to review and assist. The procedures of assistance, review of the draft EIS, and if objections are noted, the review of the final EIS, are all detailed in a manual issued by the Office of Federal Activities entitled "Review of Federal Actions Impacting the Environment," (Draft, July 6, 1972).

### B. 3 The Environmental Impact Statement and the Department of Defense

The Department of Defense (DoD) had been engaged in pollution abatement activities for several years prior to the formulation of the environmental legislation. Many directives and instructions from the Departments of the Army, Navy, and Air Force were concerned with environmental preservation. (Examples are the DoD Directive 5500.5 [May 24, 1965], "Natural Resources - Conservation and Management" and NAVFACINST 6240.1 [August 29, 1966], "Environmental Pollution Control Program," which was the Navy's action to improve air quality and water quality through pollution abatement at Naval facilities.)

The sequence of orders which led to the environmental impact statement in proposed DoD actions include the initial legislation, "The National Environmental Policy Act," (P. L. 91-109, January 1, 1970); the presidential directive, Executive Order 11514 (March 5, 1970); and the DoD Directive 5100.50 (June 23, 1970) entitled "Protection and Enhancement of Environmental Quality." This Directive assigns responsibilities and establishes procedures for an effective and coordinated program of pollution abatement and environmental enhancement. It is important in that it became the authority for later Army, Navy, and Air Force directives and instructions. The emphasis at this time (1970 and early 1971) was still on pollution abatement rather than the broader scope of environmental enhancement. Consequently, the impact

statement was a document of reportage rather than the present form which is a complete and authoritative scientific, technical, and ecological presentation of a proposed action and its alternatives. The principal legislation which became the content and formula of the earlier EIS were the air and water pollution acts through the 1960s. These statutes were the evidence of "a national policy for the environment which provides for the enhancement of environmental quality" as noted in the "Environmental Quality Improvement Act of 1970" (Title ii of P. L. 91-224).

The DoD Directive 5100.50 established an Environmental Pollution Control Committee to act in an advisory capacity to the Assistant Secretary of Defense (Health and Environment). The Committee presently serves the new Deputy ASD(H&E) for Environmental Quality. This office is the one which receives the EIS from the individual military services, review them, and presents them to the CEQ.

Following the issuance of "Guidelines" by the CEQ in April, 1971, the ASD(H&E) issued DoD Directive 6050.1 on August 9, 1971, which served a similar purpose. It established DoD policy, assigned responsibilities, and provided guidance for the preparation of an EIS. However, one new and important concept developed--that of the environmental assessment statement (EAS). The EAS was the first step in the evaluation of adverse environmental effects, the possible environmental enhancement, and the compliance with local, state, and Federal pollution

statutes in connection with a proposed action. The Directive 6050.1 directed the individual departments to establish procedures for the preparation and processing of an EAS within their departments, establish procedures for assessing the environmental consequences and, if significant, comply with the requirements to formulate an EIS and forward it to ASD(H&E).

The importance of the EAS, from a practical standpoint, is great. It eliminates the cost and the effort associated with an EIS when that level of documentation is not really called for. It expedites actions with minor environmental effects within the departments (Army, Navy, Air Force). It also complies with a later CEQ request (February 29, 1979) to consolidate the number of EIS into fewer, broader, and more meaningful reviews. If the proposed action is of a classified nature, the EAS can be processed easily within the department. A classified EIS must have its classified portion as an annex, if feasible, so that the unclassified portion can be made available to the public.

The environmental assessment procedure begins with the proposed action at the geographical location of that action. The initiating activity holds informal discussions with the local and state organizations having a responsibility for that type of action and with the regional office of the EPA.

The EAS is a less comprehensive document than the EIS, being used for proposed actions of no significant environmental impact, and

intended for internal use within the military departments. However, some states have enacted laws similar to the National Environmental Policy Act, and have established state organizations similar to the EPA. They require disclosure of proposed actions to the public at the state and local level, a disclosure which in the absence of an EIS would be an EAS. Local environmental impact can be based on different standards than are used in an EIS for the CEQ. For example, political or sociological motivation may make military housing in a residential zone unacceptable--although no unreasonable or significant impact is made on the environment. The result is that the EAS may become as comprehensive as the EIS, in which case it is the draft stage of the EIS and no distinction or advantage remains to the EAS. As the environmental groups within the military departments issue more detailed and better formulated guidelines, the EIS will become easier to prepare. The EAS then will have ended its service.

## Appendix C

### Tabulation of Issued Environmental Impact Statements

The environmental impact statements that have been issued by the Department of Defense, released to the public by the CEQ, and received at our facility are tabulated below. The documents are arranged in alphabetical and numerical order and all pertinent data, such as draft (D) or final (F) statement, title of the action, date of issue, and issuing agency, are given.

	<u>Page</u>
1. EIS-FL-72-5015-F	8-6
Land Outlease for Wastewater Treatment Facilities, Tyndall AFB, Florida. Department of the Air Force, July 1972	
2. EIS-MD-72-4449-F	8-8
Relocation of Harry Diamond Laboratories, White Oak, Maryland Department of the Army, May 1972	
3. EIS-SC-72-4568-D	8-12
500 Units of Military Family Housing, Shaw AFB Department of the Air Force	
4. Land Acquisition, Naval Security Group Activity Homestead Florida Department of the Navy, August 1971	8-16
5. Range Operations Air Force Blair Lakes Department of the Air Force, August 1972	8-18

	<u>Page</u>
6. PB 198 690-F	8-21
Land Acquisition, Naval Submarine Base New London, Connecticut Department of the Navy	
7. PB 198 764-F	8-23
1550th Air Training and Test Wing (MAC) Hill AFB, Utah Department of the Air Force, November 1971	
8. PB 198 900-F	8-26
Anti-Personnel Biological Agents and Weapons at Pine Bluff Arsenal, Arkansas Department of the Army, April 1971	
9. PB 199 018-F	8-30
Land Acquisition, Sewage Disposal Facility Naval Air Station, Lemoore, California Department of the Navy, February 1972	
10. PB 199 312-F	8-34
Western Medical Institute of Research, Phase II Presidio of San Francisco, California Department of the Army, U. S. Army Medical Research and Development Command, March 1972	
11. PB 199 314-F	8-39
New Walter Reed General Hospital Walter Reed Army Medical Center Department of the Army	
12. PE 199 732-F-1	8-45
Sanguine System for Research, Development, Test and Evaluation Department of the Navy, April 1972	

	<u>Page</u>
13. PB 199 732-F-2	8-45
Sanguine System for Validation and Full-Scale Development Department of the Navy, April 1972	
14. PB 199 851-F	8-51
F-14 Fighter Aircraft Department of the Navy, September 1971	
15. PB 200 540-F	8-55
Project EAGLE - Phase 1 Disposal of Chemical Agent Mustard at Rocky Mountain Arsenal, Colorado Department of the Army, June 1971	
16. PB 201 259-F	8-59
Disposal of Anti-Crop Biological Agent Beale AFB, California and Rocky Mountain Arsenal, Colorado Department of the Army	
17. PB 201 710-F	8-62
The Development of the F-15 Aircraft Department of the Air Force, September 1971	
18. PB 201 711-F	8-65
B-1 Aircraft Department of the Air Force, September 1971	
19. PB 201 855-F	8-68
Land Acquisition, Naval Station Norfolk, Virginia Department of the Navy, March 1972	

	<u>Page</u>
20. PB 202 308-D	8-72
<p style="margin-left: 40px;">Transportable Disposal System  Tooele Army Depot, Tooele County, Utah  Department of the Army, Edgewood Arsenal  July 1971</p>	
21. PB 202 335-F	8-78
<p style="margin-left: 40px;">Use of Target Ship Hulls in Exercises at Sea  Department of the Navy, August 1971</p>	
22. PB 202 796-F	8-80
<p style="margin-left: 40px;">Minimum Facilities for Air Cavalry Combat  Brigade Test at Fort Hood, Texas  Directorate for Facilities Engineering (Army)  Fort Hood, Texas, December 1971</p>	
23. PB 203 238-F	8-84
<p style="margin-left: 40px;">National Guard Use of Arnold Engineering  Development Center  Department of the Air Force, April 1972</p>	
24. PB 203 321-F	8-87
<p style="margin-left: 40px;">Safeguard Ballistic Missile Defense System,  North Dakota and Montana Deployment Areas  Department of the Army  U. S. Army Safeguard System Office  Arlington, Virginia, October 1971</p>	
25. PB 203 509-D	8-90
<p style="margin-left: 40px;">Demilitarization of Toxic Munitions at  U. S. Army Materiel Command Installations  Department of the Army, Edgewood Arsenal  July 1971</p>	

	<u>Page</u>
26. PB 203 876-F	8-93
<p style="margin-left: 40px;">Concerning the Military Use of the Kahoolawe Island Target Complex in the Hawaiian Archipelago Department of the Navy, February 1972</p>	
27. PB 204 162-D	8-96
<p style="margin-left: 40px;">Safeguard Ballistic Missile Defense System Missouri and Wyoming Deployment Areas with the NCA Option Department of the Army, U. S. Army Safeguard System Office, Arlington, Virginia, November 1971</p>	
28. PB 204 919-D	not included
<p style="margin-left: 40px;">Task Force Eagle - Plan for the Demilitarization and Disposal of the M 34 GB Cluster at Rocky Mountain Arsenal Department of the Army, October 1971</p>	
29. PB 205 226	not included
<p style="margin-left: 40px;">Deactivation of Anti-Crop Biological Agent at Ft. Detrick, Maryland Department of the Army, December 1971</p>	
30. PB 206 051-F	8-99
<p style="margin-left: 40px;">Relocation of Target Facilities from Aqua Cay to Cross Cay, Atlantic Fleet Weapons Range, Puerto Rico Department of the Navy, January 1972</p>	
31. PB 206 061-D	8-102
<p style="margin-left: 40px;">Disposition of Orange Herbicide by Incineration Department of the Air Force, January 1972</p>	

	<u>Page</u>
32. PB 206 761-F	8-105
<p style="margin-left: 40px;">Airfield Complex, 3 Phases, Campbell Army Airfield, Fort Campbell, Kentucky Department of the Army, January 1972</p>	
33. PB 207 467-D	8-110
<p style="margin-left: 40px;">Sonic Booms (Supersonic Flight Producing Sonic Booms) Department of the Air Force, January 1972</p>	
34. PB 207 572-D	8-112
<p style="margin-left: 40px;">Over-the-Horizon (OTH) Radar System Continental United States Department of the Air Force, March 1972</p>	
35. PB 207 577-D	8-116
<p style="margin-left: 40px;">Advanced Ballistic Re-entry Systems (ABRES) Radioactive Sensors Department of the Air Force</p>	
36. PB 207 726-D	8-119
<p style="margin-left: 40px;">Military Ocean Terminal, Sunny Point, North Carolina Department of the Army, March 1972</p>	
37. PB 207 741-F	8-124
<p style="margin-left: 40px;">EXOTIC DANCER V, A JCS Directed Joint Exercise Conducted by the Atlantic Command Scheduled to take place in May 1972 Commander-in-Chief Atlantic (DoD), Norfolk, Virginia, May 1972</p>	

	<u>Page</u>
38. PB 207 911-D	8-126
<p style="margin-left: 40px;">Land Acquisition, Naval Ammunition Depot Oahu, Hawaii Department of the Navy, January 1972</p>	
39. PB 207 922-F	8-129
<p style="margin-left: 40px;">Outlease of Land to Gulf Power Company at Eglin AFB, Florida Department of the Air Force, August 1972</p>	
40. PB 208 198-D	not included
<p style="margin-left: 40px;">Runway Extension, Keesler AFB, Mississippi Department of the Air Force, March 1972</p>	
41. PB 208 369-D	8-133
<p style="margin-left: 40px;">Pacific Cratering Experiments (PACE) Department of the Air Force, April 1972</p>	

In addition to the above tabulation, the following environmental impact statements of the Tri-Services have been identified but have not been received at our facility.

1. "Operation CHASE" (Ocean disposal of concrete vaults containing chemical munitions)  
Department of the Army, July 1970
  
2. "Operation RED HAT" (transportation of chemical munitions from Okinawa to Johnston Island)  
Department of the Army, November 1970  
[Portions of this statement are classified.]

3. EIS-CA-72-4692-D

Construction of Navy Family Housing and Lower  
Reservation Consolidations, Fort MacArthur,  
Los Angeles, California  
Department of the Navy

4. EIS-FL-72-4737-D

Continued Military Use of the Pinecastle  
Electronic Warfare Range Complex  
Department of the Navy, June 1972

5. PB 207 472-D

DIAMOND ORE, Phase II, High Explosive  
Cratering Experiment  
Department of the Army

6. PB 207 908-D

The Air Force Academy Airmanship Program  
Department of the Air Force

7. PB 208 175-D

Dredge River Channel, Naval Submarine Base  
New London, Connecticut  
Department of the Navy

8. PB 208 959-D

Dock Basin, Naval Station  
Newport, Rhode Island  
Department of the Navy