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MEETING REPORT: ADVANCED FOSSIL FUELS SECTOR GROUP Cincinnati, 31 March 1976

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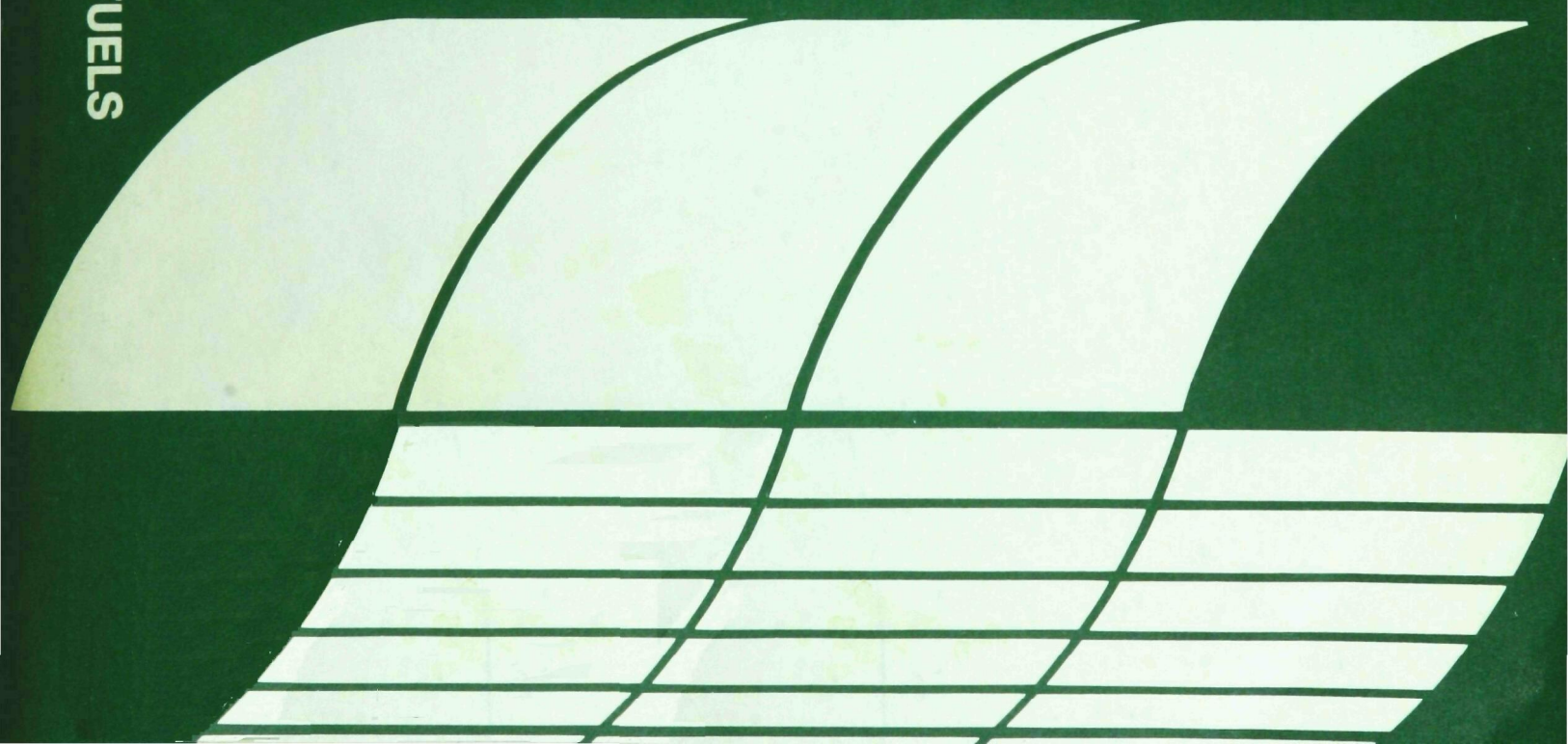
Program Report



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EPA-600/7-76-001
June 1976

# MEETING REPORT

# ADVANCED FOSSIL FUELS SECTOR GROUP (AFFSG)

# CINCINNATI

31 March 1976

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Task 004

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# ADVANCED FOSSIL FUELS SECTOR GROUP MEETING

CINCINNATI, OHIO

31 MARCH 1976

## SESSION I: PREVIOUSLY DEFINED ISSUES, OPTIONS AND PROGRAM IMPACT

Dr. Gary Foley, Chairman of the Sector Group, introduced Dr. David Stephan, Director of EPA's Industrial Environmental Research Laboratory in Cincinnati (IERL-CINC) who gave the welcoming remarks. Dr. Stephan noted the importance of enhancing communication among the various groups involved in the advanced fossil fuels area and of avoiding a "catch up" environmental situation in regard to energy development. He indicated that IERL-CINC is evaluating the environmental aspects in various energy fields.

Dr. Foley reviewed the content of the November meeting of the Advanced Fossil Fuels Sector Group (AFFSG) and gave a summary and analysis of the more pertinent issues raised.*

Dr. Foley stated that, based on concerns expressed at that meeting, it was recommended to Dr. Gage, Deputy Assistant Administrator for EPA's Office of Energy, Minerals and Industry (OEMI), that:

- OEMI carefully review the regulatory approach of the Air Standards office for gasification plants
- R&D assume a role in promoting the integration of air and water standards.

He also indicated that the Synthetic Fuels Environmental Assessment Program is moving along. OEMI is conducting tests (primarily measurement of sulfur and nitrogen compounds and particulates) on the Lurgi process at a plant in Yugoslavia. Other groups were invited to participate in this program.

In addressing the concern for greater EPA/ERDA cooperation, he said that a joint program is now being developed to take environmental measurements at HYGAS and solvent refined coal (SRC) facilities.

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*See EPA Report No. 600/9-76-006; Meeting Report: AFFSG, Research Triangle Park, 13 November 1975; February 1976.

Dr. Foley asked the Sector Group to consider whether it would be useful to establish a "wise-man" panel as the basis for achieving commonality in the various programs in the area of establishing pollutant priorities.

Opinions and recommendations were solicited from the Sector Group, particularly in respect to actions proposed or taken which resulted from the November meeting.

Discussion--Session I

The discussion following Session I addressed these major points:

- EPA Program at Yugoslav Plant. Considerable interest was expressed in the plans for the Yugoslav plant. Various group members inquired regarding the extent to which studies would be conducted, samples obtained, etc.

- Standard Setting. A recommendation was made that R&D efforts should concentrate on determining what emissions result after the best control technology is applied. There were mixed opinions on the integration of air and water standards; however, it was thought that it might be possible to integrate sequences or timing of approaches.

- EPA/ERDA Cooperation. This was felt to be very important, especially in the environmental measurement activities; it was recommended that OEMI establish early communication with developers, so that modification of process rather than application of add-on technology could be utilized to the maximum degree possible.

- "Wise-Man" Panel. The group appeared to be unanimous in support of the "wise-man" panel concept. It was suggested that such a panel include someone who is thoroughly acquainted with the legislative and political framework. The importance of providing the panel experts with information on the effluent volume released to the environment and the toxic properties to aid them in defining pollutant priorities was pointed out.

## SESSION II: ENVIRONMENTAL RESEARCH AND DEVELOPMENT FOR OIL SHALE PROCESSING

Mr. William McCarthy of EPA/OEMI and chairman of Session II, introduced Dr. Foley who opened the session by indicating that OEMI desires input from the Sector Group in order to determine what emphasis should be put on the environmental R&D oil shale program.

Mr. Eugene Harris of IERL-CINC presented a summary of the work being carried out by the Oil Shale Working Group (a subcommittee of the Western Energy Resources Development Sector Group*) and explained that most of the effort so far has been in the area of resource handling and extraction. The extraction program is presently addressing the following areas: stream surveys, down-the-road health and ecological effects, establishment of groundwater monitoring protocol, revegetation of spent shale, and development of a model for prediction of runoff and leachate effects on receiving streams. He indicated that an interface with the Energy Research and Development Administration (ERDA) is being worked out and encouraged anyone interested in obtaining specific information regarding ongoing projects to contact him.

In the discussion which followed, he stated that his group hopes to have access to processing information on the Oil Shale Corporation (TOSCO) process and Occidental's in-situ process. He said that the short operating lifetime of oil shale facilities has made it difficult to carry out meaningful measurement and monitoring.

### A. Health Effects and Environmental Assessment

Dr. David Coffin, senior scientific advisor for health effects at EPA's Health Effects Research Laboratory in Research Triangle Park (HERL-RTP), spoke on the subject of the EPA Health Effects and Related

*Clint Hall of OEMI is the Chairman of the Western Energy Resources Development Sector Group.

Environmental Assessment Programs. He indicated that a systems and interagency approach is being used in the health effects area, with greatest emphasis on carcinogenesis. He stated that HERL-RTP is establishing a central repository for products and effluents in conjunction with the National Cancer Institute. A number of shale oil samples have been provided by the Navy Department. He indicated that there is a need for input from other agencies concerning what to test and what priorities should be applied. He recommended that an interagency committee be established to review the data so that toxicological input can be fed back into the technologies and to consider processes from the standpoint of commercialization. He indicated that there are difficulties in obtaining sufficient specimens to conduct definitive biological standard testing of whole animal systems.

Dr. Richard Pelroy of ERDA's Pacific Northwest Laboratories (PNL) (Battelle) described the major project areas under study at PNL stating that the greatest progress has been made in studying the mutagenicity and carcinogenicity of compounds derived from oil shale. He stated that through using the salmonella testor strains, it has been demonstrated that raw shale oil, tar and retort waters are potentially carcinogenic and that the shale oil produced is very likely carcinogenic. He also indicated that a great deal of effort should be spent in studying the effluent waters. He did not feel that the selection of a process for sampling was important, but that effort should be made to determine sample variability over time. He mentioned that waste stream samples are badly needed for testing and recommended that a great deal of effort should be spent in studying the effluent waters from the processes. In the discussion which followed, several points of contact for sample procurement were mentioned--companies may be contacted directly for samples and the Bureau of Land Management and Pete Rutledge (Area Oil Shale Supervisor, U.S.G.S., at Grand Junction, Colorado) may be contacted for publications pertaining to companies' work in carcinogenesis.

LCDR Leigh Doptis, of the Navy Department's Occupational and Preventive Medicine Division, summarized Navy concerns related to the health

effects of oil shale and synthetic fuels. He gave a brief history of Naval involvement in synthetic fuel development. As part of Project Independence, five fuels have been refined from shale oil crude with minimum modification to a commercial refinery for Navy studies. Crude shale oil (30,000 barrels) has been designated for processing through an improved refining procedure that may solve problems of wax, gum and particulate content and storage and thermal instability. He then stated that the Navy is particularly concerned about the health effects problems associated with the product fuels since there is a high probability of personnel exposure. He described the two-phase approach developed by the Navy Bureau of Medicine and Surgery which is designed to evaluate existing fuels as well as candidate fuels derived from oil shale in order to determine how these fuels compare from the standpoint of personnel exposure risk. LCDR Doptis stated that the greatest present need is to further assess the chemical composition of synthetic fuels and their combustion products. He recommended that better procedures be considered for health effects assessment of combustion products.

Discussion--Session II(A)

The following major points were addressed during the discussion relating to oil shale:

- The lack of sufficient samples is of concern. Some possible sources were given and the proposed establishment of certain repositories was discussed.

- Industrial concern regarding release of samples was expressed--i.e., misinterpretation of test results can lead to premature public alarm. It was suggested that the agencies or groups requesting these samples take measures to prevent release of incomplete or erroneous information. It was also suggested that samples which are representative of commercial operations be taken during pilot plant operations and that a complete description of process operation and measurement technique accompany the sample.

B. Environmental Measurements and Technology

Mr. Thomas Powers of EPA's Fuel Technology Branch, IERL-CINC, reviewed the EPA program being carried out under contract with TRW-Denver Research Institute (DRI) which will obtain data on air, water, and solid waste streams from oil shale processing operations. He briefly mentioned the environmental testing which has recently been performed at the Paraho facility and that testing is planned for in-situ and other retort processing activities when those operations get underway.

Mr. Powers stated that EPA's strategy for environmental control R&D for oil shale extraction and processing places strong emphasis on characteristics of air, water, and solid waste discharges, assessment of available control technology and the development, demonstration and/or evaluation of appropriate control methodologies.

Mr. Rober Kerr of ERDA's Laramie Energy Research Center (LERC), explained that the ERDA/LERC desires to carry out environmental research concurrent with process research in the areas of oil shale, coal gasification and tar sands extraction. He described an environmental characterization approach which the LERC will be using in addressing these areas.

Mr. Balfour Wallace of the David Taylor Naval Ship Research and Development Center spoke on the subject of DoD/Navy environmental measurments and associated technology in relation to the qualification of synthetic fuels for use in naval propulsion systems. He stated that two areas of interest are the impact of pollutants in populated areas and exposure of personnel who work in close proximity to the fuel. He listed the pollutants of interest and gave the general approach to qualifying fuels for Navy use.

Mr. Wallace described the Navy efforts to date and presented some of the data collected from stack emission studies conducted on a marine propulsion system burning synthetic shale oil from the Paraho process. He stated that the fuel burned well and that only the oxides of nitrogen exceeded the EPA limits.

He indicated that the main problem encountered was that of determining the best method of collecting and analyzing the samples from the shipboard environment which were to be taken in conjunction with a compartment survey to be conducted by his group and the Naval Environmental Health Center on a FF 1052 class destroyer in April of this year.

Discussion--Session II(B)

In the discussion, industry representatives indicated that the oxides of nitrogen are a major problem, both economic and environmental, and expressed the need for the development of markets for nonhydrotreated shale oil.

C. Industrial Considerations

Dr. Charles Prien of Denver Research Institute commented on approaches outlined in earlier presentations from an industrial point of view. He pointed out that it is not economical to produce shale oil at the present time and that opinions are diverse within industry as to its future. In response to previous discussion, he explained that developers are not reluctant to supply samples but that researchers must recognize their need to guard against misinterpretation of test results. Commenting that the problem is one of communication, he suggested that the formation of EPA/ERDA/industry panels for carcinogen studies would be a step toward establishing a closer working relationship between the three groups.

Dr. Prien stated that, in his opinion, control technology will have to be developed in coordination with the process development itself. Care must be taken not to overregulate an industry which doesn't exist and communication between EPA and developers is required.

He cited several environmental factors which should be taken into account in oil shale R&D. He also indicated that the problems of in-situ processing can be as troublesome as those of aboveground retorting, and cited the ERDA program at the Laramie Energy Research Center and

the Occidental Petroleum program as good opportunities to examine what those problems might be.

## GENERAL DISCUSSION

Dr. Foley observed that it appeared from comments made earlier in the sessions that there will be ample opportunity to obtain environmental data and samples and that coordination and standardization to assure all pertinent information is recorded and transmitted with the samples could be accomplished.

He asked whether passage of the Synthetic Fuels Commercialization Bill could possibly turn the economic picture around and result in putting one or several plants into operation in the next five years. Mr. Grossman (Shell Oil) replied that TOSCO feels confident that they could borrow money on the market based on loan guarantees, but that it remains to be seen whether investors would be willing to take the risk even then.

The meeting was adjourned.

# HIGHLIGHTS
# ADVANCED FOSSIL FUELS SECTOR GROUP MEETING

CINCINNATI, OHIO

31 March 1976

The following issues were raised at the meeting and are being considered by the Executive Committee and/or staff members of OEMI in terms of possible recommendations and/or actions which might be taken as a consequence.

EPA/Industry Interaction

Concern was expressed regarding improving EPA/industry communication in the following areas:

- Sector Group members indicated that there is a need for EPA (and ERDA) to communicate with the industrial developer early in a project to permit process modification and thereby reduce the probability of the need for add-on techniques.

  This is being considered in terms of who within EPA and/or ERDA could best assure that such communication channels are provided, and by what means.

- It was suggested that available gasification process and environmental control technology designs be reviewed to identify possible improvements (e.g., Mr. Schora, IGT, indicated that there may be more efficient means of treating hydrocarbon emissions than by incineration).*

  The Executive Committee is considering this as a possibility for the future as a review such as this would entail significant effort.

- Concern was expressed by industry representatives that indiscriminate release of information generated by sample testing could be misleading and result in premature public alarm.

  Dr. Coffin (EPA/HERL-RTP) suggested that a coordinating committee be formed to review test results at an early stage to reduce the likelihood of premature release of findings to the press.**

- There was concern that government agencies may not be aware of work being done by industry in evaluation

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*See page 28

**See page 38

of the carcinogenicity of the oil shale, processing effluents and products.

The Executive Committee recommended that a list of such studies be compiled.

- Concern was expressed that realistic process conditions be established prior to sampling and that there be enough known about process conditions so that reliabile sampling repeatability is possible.

- Sector Group members suggested that EPA consider industry development timetables as a basis for establishing research program priorities and schedules. Subsequent to the meeting, it has also been suggested that increased attendance by industry representatives would be of value for this purpose and others.

Although industrial representatives currently attend Sector Group meetings on a contract associated basis, obtaining Advisory Committee status is being pursued as a possible means through which industry could be represented on an invitational basis.

Pollution Ranking Method

It appeared to be the consensus of the Sector Group that the establishment of a panel of experts (i.e., "wise-man" panel) to develop methodology by which pollutant priorities could be determined would be useful. This would aid EPA in developing effective programs to assess effects of pollutants, appropriate control technologies, and appropriate new source performance standards (NSPS).

The Executive Committee is preparing a recommendation to this effect to be sent to Dr. Stephen Gage. Deputy Assistant Administrator of EPA's Office of Energy, Minerals and Industry.

Yugoslav Lurgi Plant Program

Considerable interest was shown in EPA/OEMI arrangements to conduct tests at a Yugoslav coal gasification plant (Lurgi process). There was considerable discussion regarding how best to maximize the benefits of such an opportunity.

Other groups are encouraged to participate in defining what types of studies might be conducted and to consider direct participation should it prove possible to further expand the present program.

# MINUTES OF
# ADVANCED FOSSIL FUELS SECTOR GROUP MEETING

CINCINNATI, OHIO

31 MARCH 1976

## SESSION I: PREVIOUSLY DEFINED ISSUES, OPTIONS AND PROGRAM IMPACT

### Summary and Analysis of Issues Raised at Previous Sector Group Meetings

The Director of EPA's Industrial Environmental Research Laboratory in Cincinnati (IERL-CINC), Dr. David Stephan, was introduced by Dr. Gary Foley, Chairman of the Advanced Fossil Fuels Sector Group (AFFSG). Dr. Stephan noted the breadth of representation within the Sector Group of those groups involved in energy development and the importance of the efforts being made to enhance communication among the various sectors. He noted that the task of attempting to develop priorities with regard to environmental R&D needs associated with advanced fossil fuels development is a difficult one and that it is important to avoid playing a "catch up" environmental game in regard to energy development. He indicated that IERL-CINC is evaluating environmental aspects in various energy fields: coal mining, oil and gas extraction, oil spills, industrial pollution control, the practices of energy conservation in industry, waste as fuel, development of non-coal-based synthetic fuels, advanced energy systems, energy conversion processes, and oil shale extraction processing.

The chairman of the meeting, Dr. Gary Foley of EPA's Office of Energy, Minerals and Industry (OEMI), reviewed his previous comments concerning the sector group concept.* OEMI was formed in 1975 to better implement interagency coordination in the area of energy environmental R&D. The AFFSG serves as a forum for the exchange of ideas and information between the various agencies and private interests and acts in an advisory capacity to OEMI and the Energy Processes Division in planning for environmental control technology and processes and effects programs. He also reiterated that there are two additional sector groups within

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*Presented in greater detail in EPA Report No. 600/9-76-006; Meeting Report: AFFSG, Research Triangle Park, 13 November 1975; February, 1976.

the office: the Electric Utilities Working Sector Group, chaired by Frank Princiotta, Director of the Energy Processes Division; and the Western Energy Resources Development Sector Group, chaired by Clint Hall, Director of the Energy Coordination Staff.

Dr. Foley gave a summary and analysis of the more pertinent issues raised at the AFFSG November meeting. In the area of R&D strategies for control technology the following key points were discussed:

- In relation to the role of R&D in meeting best available technology (BAT) guidelines for water effluents (see Figure 1), it was pointed out that the task of developing the basis for the BAT guidelines for first generation synthetic fuel processes is of immediate concern if one is to meet the July 1983 deadline.

Figure 1

ROLE OF R&D IN MEETING BAT GUIDELINES
FOR WATER EFFLUENTS

- Effluent standards are technology based.
- BPT by July 1977
- BAT by July 1983
- Ten industrial developers have paid a great deal of attention to first generation plant design.
- Review of these designs may define BPT for Lurgi gasification.
- EPA R&D has an objective of developing a best practices manual for water pollutant control in the coming year.
- EPA R&D plans to develop needed water pollution control technology (BAT) over the next several years.

- The critical timing involved in the water standards area was addressed and recommendations were solicited as to where the emphasis should be placed in the water R&D program (see Figure 2).

Figure 2

CRITICAL TIMING
(Water Standards)

- A short time frame is associated with BAT standards and regulations (five-seven years).
- Long time frames are normally associated with R&D.
- To maximize the likelihood of developing the best available control technology in this short time frame, how should emphasis be placed in the synthetic fuel water pollution technology R&D program?
  - new ideas and concept development
  - optimization and combination of existing control technologies
  - dependence on ERDA demonstration plants to develop BAT
  - transfer of knowledge available from other industries

- Key points were discussed relating to the role of R&D in the development of new source performance standards (NSPS) for air pollutants (see Figure 3). Dr. Foley noted that since the November meeting an agreement has been signed with Yugoslavia and work is being initiated there through the special foreign currency program.

Figure 3

ROLE OF R&D IN DEVELOPMENT OF NEW SOURCE
PERFORMANCE STANDARDS FOR AIR POLLUTANTS

- The EPA preliminary approach to standards for sulfur emissions from coal gasification plants is to be publically reviewed this year.
- The importance of setting standards early in the development process was noted.
- An industry representative suggested that they should be involved in the standards setting process early because of the long lead times required for control technology development.

Figure 3 (Continued)

ROLE OF R&D IN DEVELOPMENT OF NEW SOURCE PERFORMANCE STANDARDS FOR AIR POLLUTANTS

- Another industry representative suggested that standards should not be set for second generation plants until demonstration plants have been tested and found commercially viable.

- An agreement has been made with Yugoslavia to test emissions on the Lurgi process.

- Based upon the concerns expressed at the November meeting as to appropriateness of standards for coal gasification plants at this time, several recommendations were made to Dr. Stephen Gage, Deputy Assistant Administrator of OEMI (see Figure 4). Comments were solicited regarding these recommendations. Other groups were invited to participate in the program relating to the Yugoslav plant.

Figure 4

CONSIDERATIONS AND RECOMMENDATIONS
(Standard Setting)

- A recommendation was made to Dr. Gage that a very careful look be taken at the preliminary approach to standards.

- A recommendation was also made to Dr. Gage that R&D take a role in promoting the integration of air and water standards, possibly through publication of a multi-media background document for the synthetic fuel industry.

- Ways of taking maximum advantage of availability of the Yugoslav plant were selected:

  - air standards
  - water standards
  - health effects
  - ERDA interests

- Steps to further EPA/ERDA interaction, particularly with regard to control technology for synthetic fuel plants, are being taken (see Figure 5). Meeting participants were asked whether EPA should encourage ERDA to utilize pilot and demonstration plants to aid in the development of environmental control technology R&D, rather than emphasizing process technology and considering environmental control only as necessary to satisfy local and Federal regulations.

Figure 5

EPA/ERDA INTERACTION
(Control Technology for Synthetic Fuel Plants)

- Consultants representing industrial points of view encouraged EPA/ERDA cooperation and coordination.
- ERDA and EPA each have several groups with a strong interest in environmental aspects of synthetic fuel development.
- In January, representatives from ERDA and EPA groups made a joint visit to the Synthane, Solvent Refined Coal and HYGAS process facilities.
- As a result of the joint visit, a coordinated program* is being developed to take environmental measurements at two of these facilities.

- Additional recommendations and considerations brought out at the November meeting are summarized in Figure 6.**

Figure 6

ADDITIONAL RECOMMENDATIONS/CONSIDERATIONS

- Ten industrial developers have paid a great deal of attention to environmental control and it was stated that it would be difficult if not impossible for EPA R&D to make significant additional contributions.

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*Kelly Janes of EPA/IERL-RTP is the project officer.

**Pertaining to Figure 6, Gerald Rausa of EPA/OEMI, is the coordinator of an ongoing EPA/NIOSH program.

Figure 6 (Continued)

ADDITIONAL RECOMMENDATIONS/CONSIDERATIONS

- Should EPA be spending R&D money in studying the control technology in the designs of the 10 gasification processes which are ready for full-scale commercial development?

- With regard to in-plant fugitive emission, a NIOSH representative recommended:

  - that occupational chemical and physical agent exposure standards recommended by NIOSH and promulgated of OSHA need to be directly factored into the design of advanced fossil fuel plants
  - that there should be an EPA/NIOSH cooperative R&D effort.

Dr. Foley reviewed approaches toward establishing pollutant priorities which were presented during the afternoon session of the November meeting:

- Extrapolation of effects from known emission streams in order to draw analogies

- Determination of the pollutants of concern, the sources of these, and the level to which the pollutants must be controlled to provide safety for the general public

- Addressing emissions on a broader basis than as pure compounds (with the exception of those known to be hazardous).

- Averaging of emissions over operating periods and making provision for emissions during start-up in order to reduce industry's burden

- Utilization of a group of knowledgeable researchers to determine the best strategy for toxicity research (i.e., the "wise-man" approach)

- Development of a scheme, such as the one used by EPA's Health Effects Research Laboratory at RTP, which is general enough to apply to pollutants from several different sources and routes of exposure.

Problems associated with establishing priorities which were noted were that:

- Not enough data are currently available.
- Thousands of chemical compounds are potentially toxic and it is too costly to treat each separately and with equal weight.
- Little correlation exists among priority lists.
- It is difficult to weight the relative importance of different classes of criteria.

Presentations relating to research on pollutant hazards (see Figure 7) were summarized and comments regarding the possibility of establishing "wise-man" panels as the basis for achieving commonality in the various programs were solicited (see Figure 8). For example, should one central panel be established, or are several needed? If several, should they be based on the conversion processes to be evaluated, or on health effects versus control technology concerns?

Figure 7

RESEARCH ON POLLUTANT HAZARDS

- Population-at-risk
  - immediate: industrial workers
  - long term: general population
- Basic results needed
  - concentrations which produce health hazards
  - biological effects produced by pollutant concentrations
- Compounds of interest (mainly polycyclic aromatic hydrocarbons)
- Key elements of research
  - rapid screening to select dangerous pollutants
  - rapid bioassay techniques

Figure 7 (Continued)

RESEARCH ON POLLUTANT HAZARDS

- quantification of risk element
- development of models

- The ERDA stepwise research plan described is actually a series (set) of continuous interrelations

Figure 8

"WISE-MAN" APPROACH

- Purpose of panel(s)
  - determine which pollutants (present in feedstock and/or formed in process) should have priority
  - determine from health measurements which are short-term concerns (i.e., industrial) and long-term (i.e., general public)
  - determine those pollutants for which to test at each emission source, to develop control technology and to determine health effects
- How many panel(s) should there be?
- Should the panel(s) operate from within EPA's R&D program?
  - one from each lab?
  - central one for EPA and ERDA?
- Who would serve on the panel(s)?

Discussion--Session I

The following points were raised:

- As a result of a query relative to use of American coal, Dr. Foley indicated that initially the testing at the plant in Yugoslavia will be carried out using native coals rather than American coals. The initial thrust will be to measure sulfur and nitrogen compounds and particulate matter. Program resources

do not allow for looking at ash burial at the present time; however, it is hoped that the program will be expanded. The suggestion was made by James R. Jones, (Peabody Coal) that it would be useful to bring back quantities of ash for study in this country particularly for leaching studies. It was also suggested by David Coffin of EPA's Health Effects Research Laboratory at RTP (EPA/HERL-RTP) that health and ecological impact studies be done at the plant site. Dr. Coffin also cited another problem--the lack of chemical backup data--biologists need more input from chemical engineers who are involved in the petroleum industries, etc. He commented that although the Yugoslav plant uses different coal than is used in most processes in the U.S., it provides a starting point for gathering samples and acquiring the needed chemical backup data. In answer to another query, Dr. Foley replied that no health effects research from an air pollution standpoint is planned at the present time. Kelly Janes (EPA/IERL-RTP) was identified as the project officer.

- J. F. Stara (EPA/HERL-CINC) commented that standards are needed for hazardous pollutants for which no control technology yet exists, and the necessary control technology should be developed.

- James Durham of EPA's Office of Air Quality Planning and Standards (OAQPS) replied to a query regarding existing standards that the only standards which have been set at this time for coal gasification plants are New Mexico standards.

- J. F. Stara (EPA/HERL-CINC) commented that cooperation of EPA/ERDA in measurement activities is important.

- Jack Johnston (DoI-U.S. Geological Survey) informed the Sector Group that a Coal Working Group under the International Energy Agency plans to establish a coal data bank which will receive, arrange and store information available from any nation on the characteristics and amount of coal. He commented that as pilot plants are developed, it will be important to assess the chemical quality of the resource before large amounts of money are put into the operational systems.

- Frank Schora (Institute of Gas Technology) emphasized that EPA/ERDA coordination and early communication with the developer was important so that modification of process rather than add-on techniques could be utilized. He indicated that EPA/ERDA should work to improve existing control technology where it is not adequate and

believes that developers are also in favor of this and would support such a position.

- Mr. Schora also pointed out that review of the coal gasification designs which already exist may still be useful since it is possible to effectively treat hydrocarbon emissions by other than incineration--a method which decreases process efficiency.

- Dr. Foley (EPA/OEMI) indicated that the joint EPA/ERDA measurements program will take place at the HYGAS and Solvent Refined Coal facilities and that ERDA has not yet determined when the program will begin.

- Steve Brown (SRI-Menlo Park) commented that the support of an acknowledged expert community lends credibility to R&D efforts and that it is important to develop a body of information, including volume of effluents and toxic properties, to be used by the experts in their efforts in defining pollutant priorities.

- For the shorter term priority setting efforts, James Durham (EPA/OAQPS) suggested that work should be concentrated on finding out what the emission would be after control processes have been applied.

- Arne Gubrud (American Petroleum Institute) recommended that at least one member of the "wise-man" panel be thoroughly acquainted with the legislative and political framework which will affect to what extent any good idea can be implemented in the real world. The pending amendment to the Clean Air Act concerning nondeterioration was cited as an example of legislation which should be considered.

- From the control system design point of view, it was indicated by Jack Cotter (TRW) that it is essential to obtain samples of the actual effluents produced in synfuel processes.

- One view (James Durham, EPA/OAQPS) was that the integration of air and water standards would require a major restructuring of EPA. However, Alden Christensen (EPA/IERL-CINC) suggested that it may be possible to integrate the sequences or timing of approaches without restructuring the organization in a different manner.

- Gerald Rausa (EPA/OEMI) noted that EPA's R&D office has an integrated presentation of the data. The STAR reports (Scientific and Technical Assessment Reports) are supposed to use a comprehensive approach in presenting the information regarding individual pollutants. However, it was indicated that program offices may or may not wish to use the STAR documents since standard setting is their responsibility.

## SESSION II: ENVIRONMENTAL RESEARCH AND DEVELOPMENT FOR OIL SHALE PROCESSING

The chairman of the second session, William McCarthy of OEMI, stated that the Sector Group concept is still evolving and that feedback from the participants regarding the content and structure of the 31 March meeting would be helpful to the Executive Committee in planning for the next meeting. He recommended that meetings of the three Sector Groups be held on consecutive days in the future. He called on Dr. Foley to give the introduction for the environmental research and development for oil shale processing portion of the meeting.

Introduction--Dr. Gary J. Foley. Dr. Foley explained that oil shale R&D has been preempted, for the most part within EPA, by coal liquefaction/gasification and electric utilities work. While meetings have been held on oil shale commercialization and technologies, little has been done to get people tegether who are concerned with the environmental aspects. From the OEMI point of view, the future of oil shale versus other synthetic fuel technologies is not clear and thus it is not certain what emphasis should be placed on the program. Therefore, input from the Sector Group in the area would be helpful.

Background: Information Available from Oil Shale Working Groups of the Western Energy Resources Development Sector Group--Eugene T. Harris. The first speaker, Eugene Harris of EPA's Industrial Environmental Research Laboratory in Cincinnati (IERL-CINC), presented a summary of the work being done by the Oil Shale Working Group (a subcommittee of the Western Energy Resources Development Sector Group).

The Oil Shale Working Group is composed of EPA representatives working in the following areas:

- Stream survey (Duluth)
- Down-the-road health and ecological effects (Corvallis)
- Establishment of a protocol in the area of groundwater monitoring (Utah and Las Vegas)

- Revegetation of spent oil shale and development of a model for prediction of runoff and leachate effects on receiving streams from disposal of spoil materials and spent shale (IERL-CINC)

- Processing methods and other developments as they occur (IERL-CINC contract with TRW).

Region VIII (Denver) projects include those associated with work going on at meteorological stations and keeping up-to-date on industrial, state, regulatory and academic study or research efforts. He stated that new representatives in the group will most likely include those involved in a coal and oil shale groundwater project (Ada, OK) and a carcinogenic survey-type study (Athens, GA).

Mr. Harris explained that, although the group's membership was originally intended to include only EPA personnel, there is a need to communicate with industry and other government agencies. Therefore, an interface with ERDA is being worked out and a representative from the U.S. Bureau of Mines attended the last meeting.

He encouraged anyone interested in obtaining specific information as to ongoing projects and associated personnel to call him at (513) 684-4417.

The following points were made during the discussion period:

- Mr. Harris stated that his group hopes to have access to Union Oil's TOSCO (The Oil Shale Corporation) processing of Utah coal shales and Occidental's in-situ processing. He also indicated that it has been difficult to do meaningful measurement and monitoring due to the short operating lifetime of oil shale facilities.

- He indicated that most of the effort, so far, has been in the area of resource handling and extraction, and that the more recent effort is related to the processing aspects.

A. Health Effects and Environmental Assessment

1. The EPA Health Effects and Related Environmental Assessment Program--David Coffin.

Mr. McCarthy introduced the next speaker, Dr. David Coffin, who is senior scientific advisor for health effects at EPA's Health Effects Research Laboratory in Research Triangle Park (HERL-RTP).

Dr. Coffin indicated that a systems and interagency approach is being used by HERL-RTP in the health effects area, with greatest emphasis on carcinogenesis. Efforts include presumptive tests (in vitro models, etc.) and work on animal lung exposure to air effluents and definitive skin carcinogenesis. A broad approach has been taken in order to measure the possible interactions of materials. In the future more refined cuts will be examined. The Gulf Breeze models are being developed to determine the effect on animals of possible spills into the marine environment and the impact of such occurrences on man through the food chain. HERL is establishing a central repository for products and effluents, thus assuring that scientists are working on the same materials. The repository affords an opportunity to do chemical analyses where backup work in certain areas is needed. Fractionation can also be carried out. The repository will be shared with the National Cancer Institute. The Navy Department has provided shale oil samples.

Dr. Coffin stated that there is need for input from other agencies concerning what to test and the priorities which should be applied to the effluent. He asked if a committee should be developed to look at processes in terms of their commercialization possibilities in order to avoid putting effort and money into processes which may not prove to be commercially viable. He recommended that an interagency committee be established to review the data so that toxicological input could be fed back into the technologies.

He noted the difficulty in obtaining sufficient specimens to conduct definitive biological standard testing of whole animal systems and suggested that arrangements with Yugoslavia might somewhat alleviate this problem.

There was no discussion at this point.

2. The ERDA Health Effects and Related Environmental Assessment Program--Richard Pelroy.

Subsequent to Dr. Coffin's presentation, Mr. McCarthy reiterated that communication among Sector Group members can serve to avoid duplication of effort and determine areas where efforts are lacking, thus making it possible to plan more cost-effective programs. He then introduced the next speaker, Dr. Richard Pelroy of ERDA's Pacific Northwest Laboratories (PNL) (Battelle).

Dr. Pelroy described the major project areas now under study at PNL--acute toxicity and associated range of effects of consequence, carcinogenesis and mutagenesis (under his direction), teratogenesis, or embryotoxicity (just getting underway) and a delayed health effects program which deals mainly with particulates and inhalation of spent shale particles.

The greatest progress has been made in studying the mutagenicity and carcinogenicity of compounds derived from oil shale. In the system employed by Battelle, at PNL, mutagenesis is being investigated as a presumptive measure of carcinogenicity. Ninety percent of the known carcinogens are frameshift mutagens; however, the converse is not necessarily true. The basis for the testing program is to discover whether a material which is a frameshift mutagen is also a carcinogen. Using the salmonella testor strains it has been demonstrated that raw shale oil, tar and retort waters clearly contain frameshift mutagens and thus are potentially carcinogenic. Polar fractions--acidic,basic and tar--exhibited very strong killing of the testor strain which suggests direct attack on cellular DNA (deoxyribunucleic acid). He indicated that it is also clear that the oil shale product is very likely carcinogenic. Tests conducted on eight chemicals known to be present in spent shale have resulted in the identification of two chemicals, not previously known to be dangerous, as mutagenic and potentially carcinogenic--anthanthrene and benzo(ghi)perylene.

Dr. Pelroy indicated that shale oil which is kept contained or used for combustion can be more easily controlled, however, little is known about the effluent water, therefore a great deal of effort should be spent in that area.

Dr. Pelroy pointed out that in the area of environmental assessment and measurement the following considerations are pertinent:

- Election of a particular process from which to take representative samples may not be important since testing can be conducted on samples from any number of procedures with little increase in funding or effort.

- Data must be time correlated in order to determine sample variability and attempt correlation of what is observed with pyrolytic temperatures, oxygen concentration and other physical factors such as pressure which are likely to affect shale oil composition.

- Samples from government agencies and industry are desperately needed.

Discussion. During the discussion following Dr. Pelroy's presentation the following most pertinent point was made:

- Allan Grossman (Shell Oil Company) indicated that a great deal of work in carcinogenesis has been done by the companies involved in oil shale R&D. Contacts for publications are the Bureau of Land Management and Pete Rutledge, (Federal) Area Oil Shale Supervisor at Grand Junction, Colorado. He suggested contacting companies directly for samples.

3. Navy Concerns Related to the Health Effects of Oil Shale and Synthetic Fuels--LCDR Leigh Doptis.

Mr. McCarthy next introduced the third speaker, LCDR Leigh Doptis of the Navy Department's Occupational and Preventive Medicine Division.

After concurring with Dr. Coffin's recommendations regarding interagency cooperation, LCDR Doptis gave a brief history of Naval involvement in synthetic fuel development. As part of Project Seacoal (November 1973), the Navy and the Office of Coal Research investigated the feasibility of using coal-derived fuel with the USS Johnston as the demonstration platform. Naval laboratories have studied fuels derived from Canadian tar sands and found them to have the necessary physical and chemical requirements for marine diesel and jet fuels. As part of

Project Independence, five fuels have been refined from shale oil crude. This effort resulted in producing 5,765 barrels of various military operational fuels this past Spring from the 10,000 barrels of crude shale oil produced by the Paraho process using shale mined from the Naval Oil Shale Reserve located in Colorado. The various fuels did not meet all military and Federal specification requirements. Storage and thermal instability problems were encountered and a great deal of wax, gum and particulate matter was found in them. It is expected that military specification fuels could be obtained from industrial refining facilities with minimum modification. Crude shale oil (30,000 barrels) has been designated for processing through an improved refining procedure which may successfully solve these problems.

LCDR Doptis indicated that the Navy is particularly concerned about the health effects problems associated with the product fuels since there is high probability of personnel coming into contact with the fuels. Little is known about chronic and long-term effects of exposure, even to existing fuels. Literature searches have indicated that carcinogenic properties are associated with shale oil fuels, and that increased boiling points of the fuels are associated with an increase in carcinogenic potential. He stated that the health effects of these fuels would most appropriately be ascertained by examination of the entire fuel product, as opposed to studying only fuel fractions such as might be desirable for developing process controls.

He pointed out that the constituents of oil shale vary with geographic location and that effects of exposure to U.S. sources may not correlate with exposure to oil shale from other countries.

He described a two-phase approach which has been developed by the Navy Bureau of Medicine and Surgery.

- Phase I: Designed to answer the question, "How bad is what we have?" Efforts have involved defining toxicity of existing naval fuels, examining health experience of personnel, and evaluating exposure conditions that presently exist aboard ships.

- Phase II: Designed to answer the question, "How bad is what we will have in comparison to what we have now?" Due to limited resources, this answer will depend on interagency cooperation. Efforts include:

- BuMines/Navy report on the separation of polynuclear aromatics and compositional analysis of the various candidate fuels derived from oil shale.

- Gulf Breeze and RTP studies on effects on marine life (shale oil fuel samples provided by the Navy).

- The National Cancer Institute has been encouraged to consider representative fuels from shale oil which meet military specifications for their bioassay program. Acute and chronic inhalation effects studies, sponsored by the Navy, focusing on handling and logistics problems.

LCDR Doptis stated that the greatest need, at present, is to further assess the chemical composition of synthetic fuels and their combustion products. He also recommended that better procedures be considered for assessment of health effects related to combustion products.

Discussion--Session II(A)

The general discussion in the area of oil shale associated health effects and environmental assessment encompassed the following points:

- The lack of sufficient samples appears to be a major obstacle. A concentrated effort must be made by all concerned. (David Coffin, EPA/HERL-RTP)

- The National Bureau of Standards' Standard Reference Materials Group is running a series of workshops looking into the possible need for setting up a repository there; therefore, the need for establishing another repository was questioned. Another source for samples of crude oil is the Bureau of Mines repository at the Bartlesville Energy Research Center. (William Mott, ERDA/Environment and Safety Research).

- Dr. Mott made a plea that when dealing with emissions, effluents and feedstock from oil shale operations, there be reference to the process under consideration. He also suggested that very careful controls be used in the gathering, storage, and handling of samples.

It is important to recognize that shale oil samples will vary greatly according to process conditions, feedstock and storage and handling procedures.

- Dr. Coffin commented that presumptive tests of the type being conducted at PNL-Batelle (see presentation by Richard Pelroy, p. 34), though they serve a valuable function in providing a basis for further study, do not provide the definitive answers needed at this point; therefore, more definitive tests are also required to determine if presumptive test results are, in fact, valid.

- Dr. Pelroy pointed out that the advantage of microbial testing is that it is exquisitely sensitive (will detect mutagenic agents presumed to be carcinogenic down to sub-gram levels) and as a consequence only a small sample is needed and the testing can be accomplished in a fairly short time.

- Dr. John Garner (EPA/HERL-CINC) agreed that communication is important among those involved in energy development and research, but stated that efforts should also be made to communicate with groups who are working with very similar problems in non-energy-related contexts.

- A definition of terms was given by LCDR Doptis: shale oil connotes a product or a derived crude, whereas oil shale is the basic mineral.

- Jack Cotter (TRW) and Al Grossman (Shell Oil) noted that developers are cautious regarding release of samples as misinterpretation of test results can lead to undue public alarm. Public releases should be made only after careful screening. Mr. Grossman also indicated that economic effects must be taken into consideration--in-plant controls could result in higher cost to consumers for the product and in some cases the consumers (e.g., naval ships) could apply the controls themselves at lower cost.

- Dr. Coffin agreed that caution must be used regarding public releases--e.g., the presence of carcinogens does not necessarily imply a health hazard. He suggested that a coordinating committee be formed to determine what the data mean at an early stage rather than everyone going in his own direction and releasing findings to the press. A committee could also oversee sample collection and handling to assure controlled analyses and results. Several members of the

Sector Group indicated interest in and support for Dr. Coffin's suggestion.

- A member of the Sector Group suggested that the selection of samples should be based on relevant pilot plant operations, and possibly include side stream material, waste products, final products, and products produced from the combustion of the fuel.

- Arne Gubrud stated that the American Petroleum Institute has a modest budget for a health effects program in oil shale and coal gasification under Dr. Neill Weaver. He suggested that the members of this group and Dr. Weaver consider a combined effort to establish a repository of representative material from shale technology. Mr. Rausa (EPA/OEMI) stated that initial contacts have been made with Dr. Weaver's group.

B. Environmental Measurements and Technology

1. EPA Environmental Measurements and Control Technology--Thomas Powers.

Mr. Thomas Powers of EPA's Fuel Technology Branch, IERL-CINC gave the first presentation in the area of environmental measurements and technology associated with oil shale development.

Mr. Powers opened his remarks with the comment that activity in oil shale is highly dependent upon the synthetic fuels commercialization program and more specifically the aspects of loan guarantees, fuel costs, and shale oil processing costs. Oil shale processing may be carried out either underground (in-situ) or on the surface. Several key in-situ and surface processing developments, as well as EPA, ERDA and other government agency programs, have been projected through 1981 (Figure 9). Surface processing of oil shale (retorting) involves three basic methods. In each of the methods the shale is heated to 900°-1000°F and the oil vapors cooled to produce crude shale oil. Surface processing may include the recovery of by-products.

He reviewed the TRW-Denver Research Institute (DRI) contract which is providing EPA with a preliminary assessment of environmental impacts of oil shale processing and a pollutant characterization based on the results of field testing. An outline of the tasks involved is shown in Figure 10.

Figure 9 SHALE OIL DEVELOPMENT PROGRAM

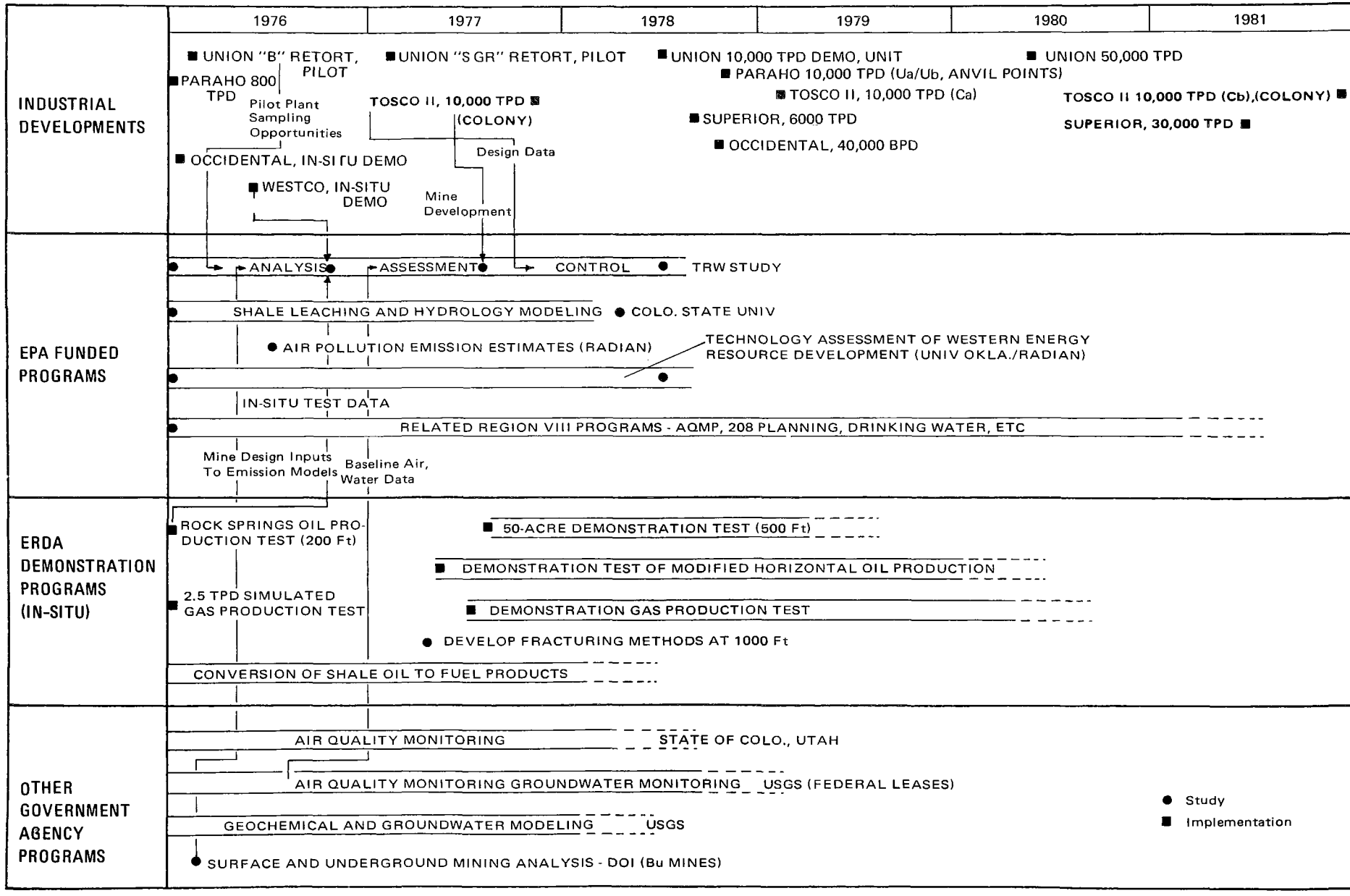

Figure 10

TRW/DRI TASK BREAKDOWN

- Project Management
- Oil Shale and Recovery Process Characterization
  - Characterize Oil Shale Resources
  - Characterize Mining Technology
  - Characterize Surface Processes
  - Characterize In-situ Processes
  - Develop Data Management
- Engineering Analysis and Problem Definition
  - Mining and Feed Preparation Analysis
  - Process Analysis
- Field Testing and Laboratory Analysis
  - Planning and Execution of Field Testing Requirements
  - Analytical Laboratory Analysis of Site Samples
- Environmental Evaluation
  - Oil Shale Development Scenarios
  - Air and Water Impact Analysis
  - Spent Shale Disposal
- Existing Environmental Control Technology Evaluation
  - Investigation of Existing Control Technology
  - Determination of BPT/BAT for the Shale Industry

TRW has conducted process emission and effluent testing at the Paraho oil shale demonstration plant at Anvil Points, Colorado. The personnel on site were from the TRW Environmental Engineering Division in Redondo Beach, California, and the principal subcontractor, Denver Research Institute in Denver, Colorado. The testing program is being done in close cooperation with both Paraho and the Laramie Energy Research Center/ERDA. The data will be used to estimate the qualitative characteristics of air, water, and solid waste streams from shale recovery operations of the Paraho type for control technology R&D needs. Additional field testing is planned for in-situ and retort processing evaluations when those operations get underway.

The characteristics of emissions, effluents, and solid waste residues depend upon the oil shale processes employed in developing the resource. Specific processes depend on such factors as geology, economics, and governmental regulations. Environmental control technology will vary depending on specific processes. Prior to retorting, preparation of the oil shale involves primary and secondary crushers. The fines from secondary crushing can be utilized directly in the TOSCO process but not in the Paraho process.

Processing of oil shale involves retorting and refining to recover the hydrocarbons present in the shale. The oil shale retorting stage is the part of the process where the major technological choices are being made. Shale oil refining operations will involve a number of processing and product options somewhat similar to those in petroleum refining.

Shale oil is formed by the pyrolysis or distillation of the organic matter (kerogen) found in shalelike rock. This material has limited solubility in ordinary solvents and cannot be easily recovered. At high temperatures, the organic material decomposes into gas and condensible liquids. Residual carbonaceous material remains on the spent shale.

Retorting of oil shale may be classified in four categories: gas combustion, solid heat transfer, in-situ and miscellaneous processes. Efforts to provide economically attractive processes have resulted in

proposals for literally hundreds of retorting processes over the years, each of which offers a somewhat different choice of operating conditions. Leading retorting operation developers include: Paraho, Union "B", TOSCO II, Occidental (in-situ), WESCO (in-situ) and Superior.

Information essential to environmental control technology planning includes geology, location, process selection, and pollutant identification. "Add-on" pollutant control requirements must be compared to the pollution abatement possibilities inherent in process modifications.

The major emissions, effluents and solid wastes depend on the processes employed to develop the resource. The current testing at the Paraho Oil Shale Demonstration area was to obtain quantitative data related to emissions from the crushing, retorting and disposal of oil shale. Emission data were collected from the recycle gas, thermal oxidizer exhaust, and crusher area exhaust. Water samples were collected from process effluents. Leachate studies will be carried out with samples of spent and raw shale from the material handling belts. The test team registered plant operating conditions in effect during effluent sampling. Factors which were evaluated included the raw shale feed rate, feed size range, gas recycle rate, air rate and average retorting temperature.

The factors relating to environmental versus process control could not be addressed in this study.

As shown in Figure 11, a preliminary evaluation of the possible environmental impacts of oil shale processing is currently underway and will result in an interim report scheduled for completion in June 1976. A TRW concurrent effort is being carried out to provide an updated assessment to include pollutant characterization and the results of field testing by July 1977. A manual of the best available control technology practices is to be prepared by November 1978. A report on pilot-scale testing of possible control devices and methods should be available by early 1979, to be followed by an updated assessment based on new concepts as well as state-of-the-art. This is to provide the

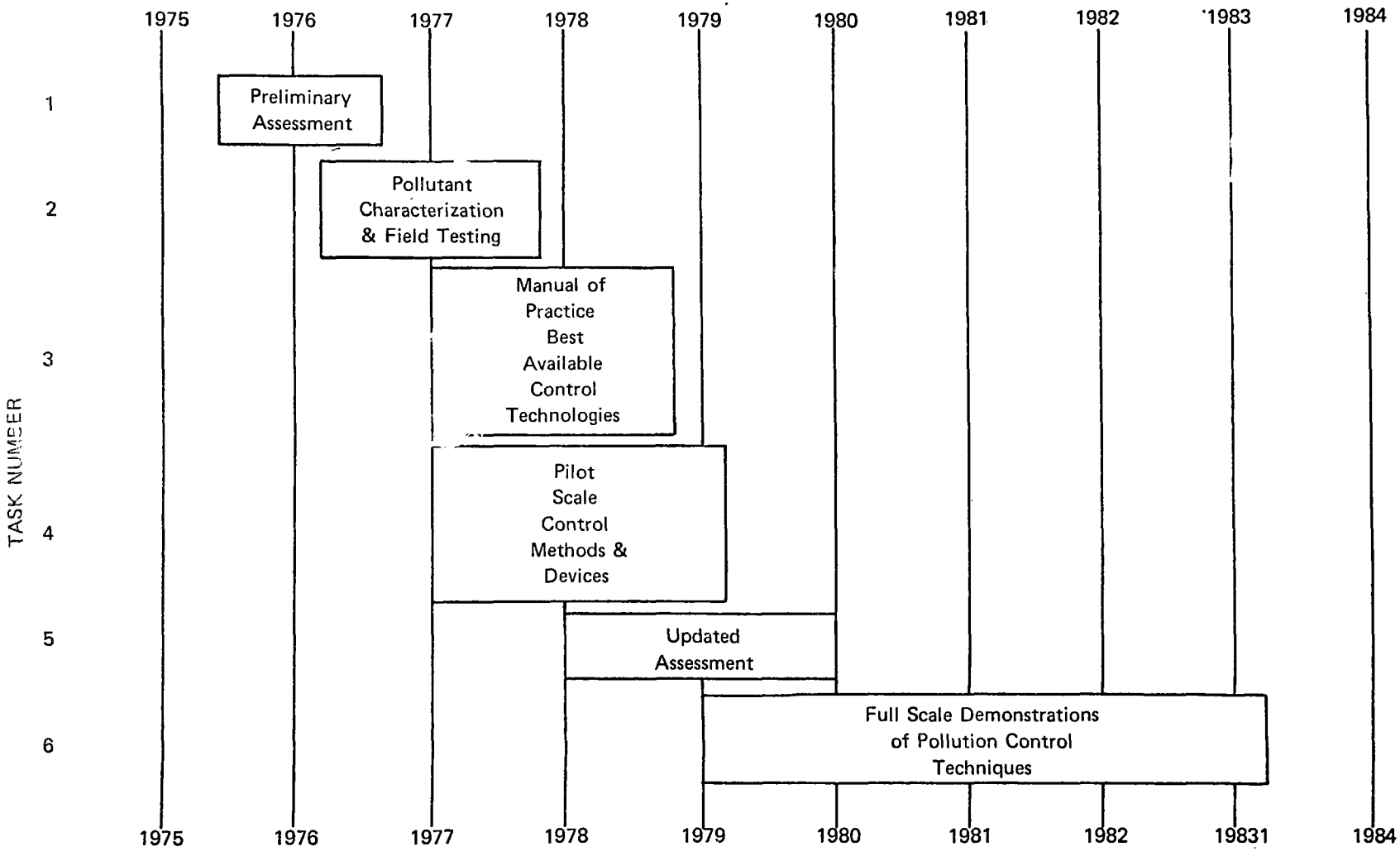


Figure 11: OIL SHALE ENVIRONMENTAL CONTROL TECHNOLOGY

basis for demonstration of advanced pollution control techniques required under Federal and state regulations which is to be completed in 1980. The final effort is that of demonstrating advanced pollution control techniques which are adequate for environmental protection during the evolution of the shale oil industry in the United States.

In conclusion, Mr. Powers indicated that the oil shale process development program has been underway since the early 1950's and will continue into the 1980's. EPA's strategy for environmental control R&D for oil shale extraction and processing places strong emphasis on characterization of air, water, and solid waste discharges, assessment of available control technologies and the development, demonstration, and/or evaluation of appropriate control methodologies. The environmental control methods to be emphasized by EPA will be associated with the leading process technologies expected to be employed for shale oil development.

There was no discussion at this point.

2. ERDA Environmental Measurements and Associated Technology--Robert Kerr.

Mr. Robert Kerr of ERDA's Laramie Research Laboratory discussed the strategy presently employed at the Laramie Energy Research Center for carrying out environmental research concurrent with process research in the areas of in-situ and surface retorting of oil shale, coal gasification and tar sands extraction.

The ERDA approach is to tie the process research, technology, environmental research and economic factors together. The environmental program progresses from guidelines to strategy and then to implementation of the strategy.

The first part of the effort is to design a system which will serve as an environmental characterization research mode to take samples, analyze them and complete an evaluation of the data at each opportunity during the process development.

The following types of samples are to be taken:

- Combustion products in the process lines
- Gaseous products that are going to be directed toward a stack or incinerator
- Samples that will reflect what is exiting the stack
- Samples of effluent water, particulates and residues (Liquid streams, such as water, are not considered products).

This stage of research is to provide needed data on the process products so that decisions can then be made on recovery and control systems. This also provides a basis for planning more process research (i.e., experiments can be carried out based on what is found--the effects of changes in temperatures, etc.--as compared to variations in results.

The next phase of interest is the transport and deposition of the products of combustion and processing. Aqueous products would be evaluated for treatment and reuse. The particulates exiting from the stack would be modeled for dispersion and disposition. The retorted shale would be cored and tested for residuals. Long range research efforts are initiated for handling of products and the overall health effects of the processing of products. Cooperative efforts with Eugene Harris regarding revegetation of retorted shale are ongoing.

Mr. Kerr stated that, at this juncture in the strategy, long range research associated with the handling of the products, as well as inhalation and ingestion, must be initiated. Consideration must be given to coordinating the right effort at the right time with the right process.

The ERDA program for environmental measurements associated with the process research can best be summarized, according to Mr. Kerr, as a coordinated effort which would keep the oil shale efforts moving forward while looking critically at environmental concerns. An environmental plan is normally presented to the process group. This plan is incorporated into their process plan in order to develop an

overall working plan for research at the site. This results in an assessment based on data which is to be made available to anyone who has use for it.

Mr. Kerr then addressed some of the major points raised at the morning session as follows:

- ERDA groups (Fossil Energy Division and the Division of Biomedical and Environmental Research (DBER) and Control Technology (CT) groups of the Environmental and Safety Division) are using the field research projects to take environmental measurements.

- Other research groups such as EPA are being contacted as quickly as possible in order to determine whether they want to work in conjunction with ERDA experiments. ERDA must, however, work with these groups on a one-to-one basis. There is a funding problem and ERDA is interested in pooling the money in cooperative efforts.

- ERDA relies heavily on industry expertise to provide the answers regarding what happens to the shale oil after it becomes available for use.

- Although cause and effect, long term, carcinogenic and mutagenic studies, etc., will be incorporated, LERC's primary efforts now are to develop the process and technology. Companies who have had to present plans for commercialization have had to proceed further in delineating possible long-term effects.

There was no discussion at this point.

3. DoD/Navy Environmental Measurements and Associated Technology--Balfour Wallace.

The next speaker, Mr. Balfour Wallace of the David Taylor Naval Ship Research and Development Center, spoke on the subject of DoD/Navy environmental measurements and associated technology in relation to the qualification of synthetic fuels for use in naval propulsion. Mr. Wallace stated that the objective of the Navy R&D Synthetic Fuels Program (in the area of toxicology) is to determine toxic volatiles and other constituents released into the atmosphere from the use of synthetic fuels aboard Navy ships. Two areas of interest are environmental

pollutants in populated areas such as shipyards and exposure of personnel who work in close proximity to the fuel. Pollutants of interest in these areas are listed in Figure 12.

Figure 12

POLLUTANTS OF INTEREST

I. Exhaust Emissions

- Smoke
- Particulate matter
- Carbon monoxide
- Sulfur oxides
- Nitrogen oxides
- Total hydrocarbons

II. Personnel Exposure

- Liquid fuel from use, storage, and handling
- Vapors from thermal degradation during pre-combustion stages
- Possible polynuclear aromatics
- Suspended particulate matter
- Exhaust emissions

He gave the general approach to qualifying fuels for Navy use. First, the shale oil goes through a prescreening test in which the physical properties are evaluated and compared to the properties of an existing fuel of the same category. If MILSPECS are met, the next step is a chemical identification and evaluation of liquids and vapors (leached in water such as that found in the bilges of ships and during combustion) simultaneously with the Bureau of Medicine and Surgery evaluations (long and short term anmial tests). The results of the two investigations are then compared and if go-ahead is indicated, the human toxicology and engine testing programs are initiated. Assuming the fuel favorably passes the tests, standards are issued, the fuel is recommended for use, and regulations are issued. This is depicted in greater detail in Figure 13.

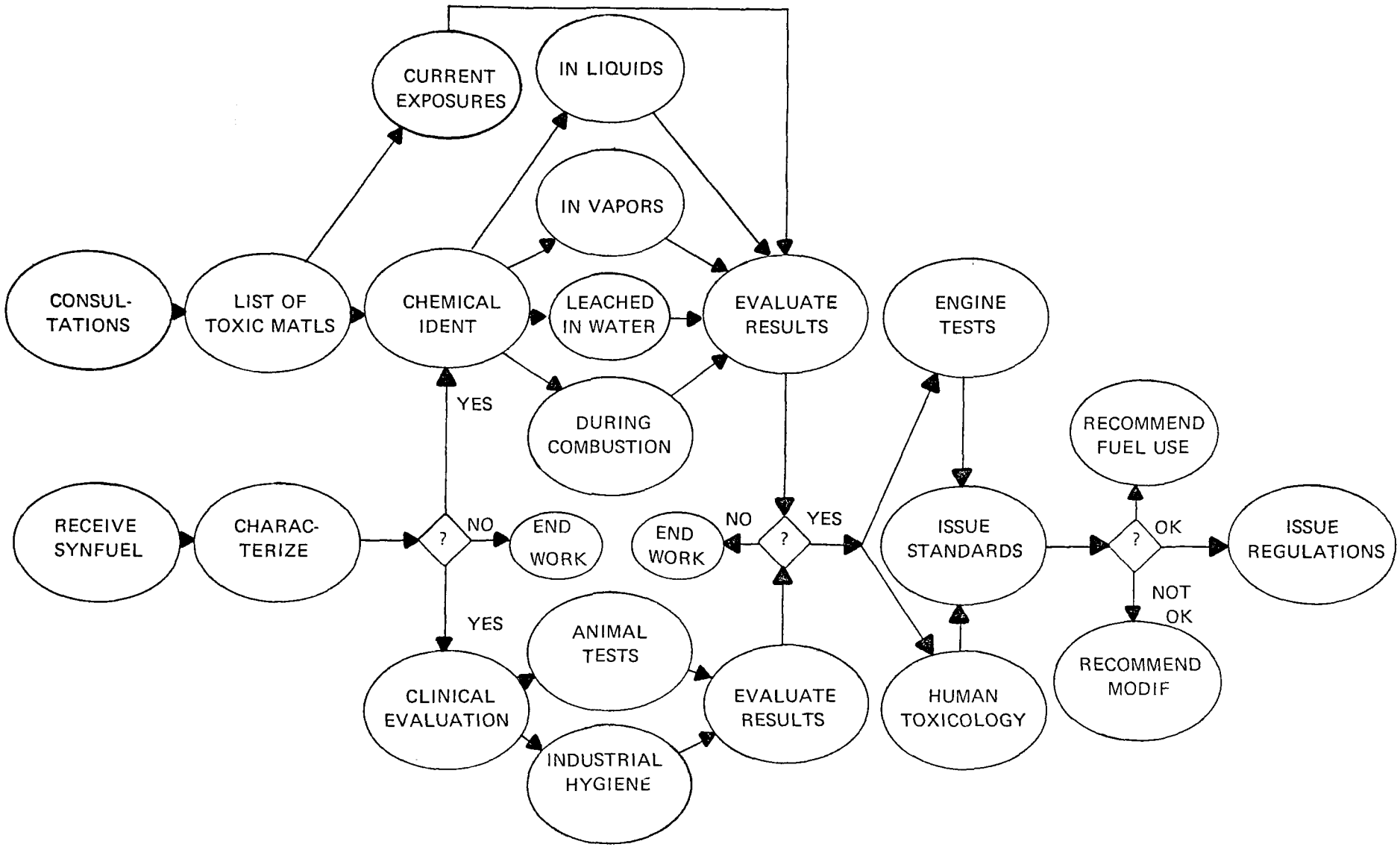


Figure 13: NAVY R&D PROGRAM TOXICOLOGY OF SYNTHETIC FUELS

Mr. Wallace listed the Synthetic Fuel Program efforts to date (see Figure 14 below).

Figure 14

EFFORTS TO DATE

I. Established a fully equipped source emission test (set) team for monitoring pollutants from shipboard propulsion exhaust systems

II. Developed laboratory capabilities for analyzing synthetic fuels physical and chemical properties

III. Developed procedures or adopted existing ones to determine trace quantities of hydrocarbons and other hazardous constituents that may be present in shipboard atmospheres

IV. In progress, development of chromatographic procedures for separation and identification of PNAs

V. Completed first stack emission study on a marine propulsion system burning synthetic shale oil (steamer Edward B. Greene)

He presented some of the data collected from stack emission studies conducted on a marine propulsion system burning synthetic shale oil from the Paraho process (i.e., the steamer, Edward B. Greene). (See Tables 1 and 2.) It was found that the fuel contained 25 percent water, the source of which is undetermined; however, once the water problem was dealt with, the fuel burned well, and smoke was very negligible. In relation to gaseous data taken, the sulfur dioxide content was found to be very low; however, the oxides of nitrogen exceeded the EPA limits as was to be expected considering the nitrogen content (1.4 percent of the fuel). Compartment surveys were also conducted using the charcoal tube method, carbon disulfide (desorbers) and analysis based on gas chromotograph procedures. The results are shown in Table 3 and tests are now being carried out to determine possible carcinogen presence. Tests run on conventional fuel yielded almost identical aromatic content in parts per million (expressed as benzene). (See Table 4.)

Table 1

PARTICULATE DATA
Edward B. Greene
Shale Oil (Synthetic Fuel)

| Run No. | Power Condition | No. of Burners | Percent Isokinectic | Particulates grains/SCF[1] | Particulates gr/SCF @12% $CO_2$ | lb/hr | $lb/ft^3$ -6 x 10 |
|---|---|---|---|---|---|---|---|
| 1 | F.P.[2] | 2 | 105 | .0217 | .0230 | 2.15 | 3.113 |
| 2 | F.P. | 2 | 103 | .0128 | .0147 | 1.30 | 1.826 |
| 3 | F.P. | 2 | 103 | .0135 | .0155 | 1.34 | 1.934 |
| 4 | F.P. | 2 | 106 | .0367 | .0421 | 3.49 | 5.25 |
| 5 | F.P. | 2 | 107 | .0274 | .0311 | 2.65 | 3.921 |
| 6 | F.P. | 2 | 102 | .0310 | .0352 | 2.93 | 4.44 |
| 7 | Hoteling | 1 | 93 | .0256 | .0256 | 0.595 | 3.66 |
| 8 | Hoteling | 1 | 100 | .0236 | .0236 | 0.512 | 3.38 |

PARTICULATE DATA[3]

| | | | | Particulates (#/MBtu)[4] |
|---|---|---|---|---|
| 1 | F.P. | 2 | 105 | .050 |
| 2 | F.P. | 2 | 103 | .030 |
| 3 | F.P. | 2 | 103 | .031 |
| 4 | F.P. | 2 | 106 | .082 |
| 5 | F.P. | 2 | 107 | .062 |
| 6 | F.P. | 2 | 102 | .069 |
| 7 | Hoteling | 1 | 93 | .073 |
| 8 | Hoteling | 1 | 100 | .063 |

[1] Grains per standard cubic foot.

[2] Full power.

[3] Based on API Gravity of 13.8 which is equivalent to 8.11 lbs/gal.

[4] Lbs per million Btu.

Table 2

GASEOUS EMISSION DATA
Edward B. Greene
Oil Shale Fuel

| Power Condition | Number of Burners | Excess Air (Percent) | Smoke Ringleman Number | Sulfur Dioxide (ppm) | Sulfur Dioxide (#/MBtu)* | Oxides of Nitrogen (ppm) | Oxides of Nitrogen (#/MBtu) |
|---|---|---|---|---|---|---|---|
| | | | 5/21/75 | | | | |
| F.P. | 2 | 25 | 0.22 | 233 | 0.45 | 421 | 0.59 |
| | | | 5/23/75 | | | | |
| F.P. | 2 | 36 | 0.23 | 200 | 0.43 | 245 | 0.37 |
| | | | 5/24/75 | | | | |
| F.P. | 2 | 37 | 0.21 | 149 | 0.32 | 260 | 0.40 |
| | | | AVERAGE | 194 | 0.40 | 309 | 0.44 |

Source: EPA's Standards of Performance of New Stationary Sources, Federal Register, Vol. 36, No. 247, Part II of 23, December 1971.

| | |
|---|---|
| Particulates. . . . | 0.1 lbs/MBtu |
| Smoke . . . . . | 1.0 Ringleman Number |
| Sulfur. . . . . | 0.8 lbs/MBtu |
| Oxides of $N_2$ and $NO_2$ . . | 0.3 lbs/MBtu |

FUEL ANALYSIS
(Percent)

C = 85.8
H = 11.3
N = 1.4
S = 0.5
HHV = 18,330
API = 13.8 or 8.11 lb/gal

* Lbs. per million Btu.

Table 3

COMPARTMENT SURVEY TEST RESULTS
(Synthetic Fuels)

| | 1A* | 2A* | 3A* | 4A* | 5A* |
|---|---|---|---|---|---|
| Liters per minute of air sampled | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Total volume of air sampled (liters) | 180 | 180 | 180 | 121 | 120 |
| Micrograms of total hydrocarbons in air sampled** | 78.3 | 310 | 700 | 145 | 146 |
| Parts per million (Expressed as benzene) | .14 | .54 | 1.20 | 0.37 | 0.38 |

---

* 1A-Sampled between two boilers and fire room level.
2A-Sampled left of port boiler.
3A-Sampled one level below fire room next to day tank pump.
4A-Sampled at bilge right at shale oil leak.
5A-Sampled between two boilers and fire room but two decks up.

**Based on detector response calibrated for benzene.

Table 4

TEST RESULTS
(Conventional Fuel)

| | 1A* | 2A* | 3A* | 4A* |
|---|---|---|---|---|
| Liters per minute of air sampled | 1.6 | 1.8 | 1.8 | 1.8 |
| Total volume of air sampled (liters) | 56 | 155 | 131 | 671 |
| Micrograms of total hydrocarbons in air sampled** | 28.7 | 92 | 112 | 7070 |
| Parts per million (expressed as Benzene) | 0.16 | 0.19 | 0.27 | 3.3 |

* 1A-Sampled between two boilers and fire room level.
2A-Sampled left of port boiler.
3A-Sampled one level below fire room next to day tank pump.
4A-Sampled at bilge right at shale oil leak.

** Based on detector response calibrated for benzene.

Mr. Wallace indicated plans to conduct compartment (fire rooms, engine and auxilliary diesel compartments) surveys on a FF 1052* class destroyer in April of this year. He indicated the main problem was in trying to determine the best method of collecting and analyzing the samples. This is to be a joint effort with the Naval Environmental Health Center.

Mr. Wallace also included Table 5 in a handout prepared for distribution, which depicts yields from various synthetic fuel plants.

Discussion--Session II(B)

The discussion following the oil shale environmental measurements and technology portion of the meeting addressed the following major points:

- To illustrate the importance of careful sample selection, Allan Grossman (Shell Oil) referred to the Paraho (process) produced shale oil used in the naval tests which was processed by the Gary Western Refinery near Fruita, Colorado. He explained that the Gary Refinery does not have hydrotreaters of the quality to take out nitrogen, whereas Colony (a consortium) and the Federal lease tract, designated as Cb**, plants would have the capability of reducing nitrogen to very low levels and saturating some of the aromatics. He stated that existing Navy fuels present no environmental problems and that the fuels from hydrotreated shale oil should exhibit no problems either (with 98 percent assurance). He further stated that there is interest in developing markets for the nonhydrotreated shale oil since adequate hydrotreating costs approximately $4.00 a barrel. This is the cost of removing the high amount of bound nitrogen from the fuel by hydrotreating methods. At this point the shale projects are not economically viable and industry is not likely to go ahead commercially given the high project cost, product price controls, present lack of a clear Federal policy encouraging synthetic fuels, and other uncertainties.

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* 1200 psi steam generator propulsion system.

** Cb is one of a number of lease sites in Colorado.

Table 5

SYNTHETIC LIQUID FUELS CURRENTLY PRODUCED
OR PRODUCTION EXPECTED IN FY 1975

| RAW MATERIAL | PROCESS/COMPANY | LOCATION | OPERATION DATE | CAPACITY (Bbl/day) |
|---|---|---|---|---|
| Tar Sands | Great Canadian Oil Sands, Ltd. | Alberta, Canada | On Stream | 45,000 |
| Oil Shale | Tosco | Denver, Colorado | On Stream | 15 |
| | Paraho Devel. Corp. | Anvil Pts. Colorado | On Stream | 22 |
| | Paraho Devel. Corp. | Anvil Pts. Colorado | 1974 (Sept-Oct) | 250 |
| | Laramie Energy Res. Center (In-Situ) | Laramie, Wyoming | 1974 (Sept) | 800 (Total) |
| | Laramie Energy Res. Center (Aboveground) | Laramie, Wyoming | 1974 | 500 (Total) |
| | Petrobras | Brazil | On Stream | 1,000 |
| Coal | COED (FMC) | Princeton, New Jersey | 1974 (Sept) | 30 |
| | SRC (GULF) | Tacoma, Washington | 1974 (Sept)<br>1975 (Jan) | 53<br>150 |
| | Synthoil (BuMines) | Bruceton, Pa. | On Stream | 1.5 |
| | H-Coal (HRI) | Trenton, N.J. | 1974 (Nov) | 7 |
| | SRC (Southern Services) | Wilsonville, Alabama | On Stream | 3* |
| | SASOL | S. Africa | On Stream | 6,600** |

* Tons of solid produced per day

** Tons of coal processed per day

- To a question regarding whether plans are being made to develop air standards for oil shale processing, Mr. James Durham (EPA/OAQPS) answered that work will proceed in this area when it appears that oil shale development is breaking out of its present holding pattern.

- Mr. Robert Kerr's (ERDA/LERC) response to a question of calculating process efficiency for in-situ oil shale processing, was that one would have to go back and take core samples over the whole area and compute a recovery percentage on that basis to determine how much of the resource may have been burned.

- A question addressed to Mr. Kerr concerning the cost of environmental measurements elicited the following response:

  - A coal burn monitoring and measurement effort to characterize gases produced and particulates ahead of the stack and also downstream of the stack is estimated at $100,000 for the required work and that an all out effort, i.e., looking at water, offgases, characterizing core and residue samples, analyzing dust, modeling on dispersion, is estimated at $200,000 to $300,000 for assessment alone--an amount of funding which is not available for each experiment. He further indicated that one should have $125,000 available every time field measurements are to be carried out.

  - Studies for characterizatin of in-situ processing and the relationship to groundwater studies for an in-situ experiment could involve $600,000 over a period of three to four years.

- Mr. Kerr further commented that there is a retort located in Laramie which can handle up to 150 tons, that has been set up to simulate conditions which one might expect under in-situ conditions. ERDA/LERC has on-site engineers who observe the surface retorting processing at the Anvil Point facility (Paraho process) but cannot release the data. The Anvil Point facility may go to zero effort which will be a blow to surface retorting research. The facility may be turned back to ERDA, and ERDA will have to look for a way to fund the effort.

- John Talty of NIOSH asked Mr. Kerr whether the measurements program considers the potential worker exposure involved in the process. Mr. Kerr replied that it is

realized that dust could be generated and be of concern; therfore ERDA is attempting to develop a program to address the question and would welcome technical input and funding from NIOSH.*

C. Industrial Considerations

The industrial considerations portion of the meeting consisted of a presentation by Dr. Charles Prien of Denver Research Institute (DRI), who gave an industrial point of view and comment on approaches outlined in earlier presentations. Dr. Prien reiterated that it is not economical to produce shale oil at the present time, and stated that there are diverse opinions within industry as to the future of shale oil. Dr. Prien explained that the University of Denver's Research Institute could act as spokesman for industry because the majority of DRI's work in oil shale over the years has been for these industries. The first 10 years of research on the TOSCO was carried out at DRI; this was prior to the formation of the Oil Shale Corporation's own research group.

He addressed the comments made earlier in the session concerning the difficulty of obtaining samples of shale oil and the reluctance of some developers to furnish it, by stating that DRI would not have been willing to say that oil produced by the TOSCO process (even near the end of the 10-year effort) would be typical of that produced by a full-scale plant. Developers are not reluctant to supply samples--DRI has spent shale samples from every developer--but researchers need to be persistent in their requests, realizing the causes for concern and therefore the need for proper negotiations. There is a communication problem, rather than an attempt by anyone to hide anything. A close working relationship between EPA, ERDA and industry should be developed. He suggested that the formation of ERDA/EPA/industry panels as Dr. Coffin suggested for carcinogen studies would be an excellent step in this regard. For example, the TOSCO group alonehas spent over $400,000

* Dr. Foley has since made the NIOSH Energy Coordinating Committee aware of this and such work is being considered in current NIOSH discussions with ERDA.

carcinogen research and the results should be a part of the efforts now going on; and, DRI has also, independent of the TRW-EPA contract, been engaged in examining polycyclic organic materials for about four years. The possibilities of misinterpretation of data are of concern.

Most of the processes which are becoming viable have evolved over long periods of time. The Bureau of Mines research in the gas combustion process began in the early 1940s--this is the process which Paraho is now utilizing but with specific modifications developed by Paraho to the inlet and outlet systems of that process. The TOSCO process work began in 1956. The Union Retort A process was at a 1,200-ton level in 1958. Their Retort B process (using indirect mode of heating) has been under investigation for at least seven to eight years. Many of the ERDA activities did not consider environmental impacts because it did not seem to these developers that there was much point in talking about environmental impacts until there was a process. Once there is a process, then it can be refined and the necessary control technologies imposed. Dr. Prien's opinion is that this will have to be the history of development of oil shale processes--control technologies developed in cooperation with the process development itself. Again, the more communication between EPA and the developer as the developments occur (at least through the first generation stage), the more closely they are going to be able to assess what control technologies are available for the first generation plants, and also to look at what might be the possible future control technologies for second generation plants. Care must be taken not to over-regulate an industry that does not exist. While industrial developers might not be invironmentalists per se, they are not going to pollute the atmosphere knowingly, especially in this day of enlightened attitude toward the fragility of the environment.

Dr. Prien indicated that care must be taken when considering the question of nondeterioration of pristine air quality due to the fact that extreme air problems already exist at some locations. A great deal of data on ambient background information are being obtained on tracts Ca, Cb, Ua, and Ub (sometimes designated as C-a, C-b, U-a, U-b), which are available from the Federal Area Oil Shale Supervisor's office,

U.S.G.S., Grand Junction, Colorado providing it can be correlated as it should be. (See Figures 15 and 16.)*

Dr. Prien referred to Dr. Coffin's mention of the possibility of synergistic effects with respect to carcinogens, which occur when two compounds A and B (neither of which when taken separately are carcinogenic) come together and become carcinogenic. He pointed out that this problem could be faced with respect to the particulates resulting from oil shale processing.

Dr. Prien stated that if effluent water is used to wet the shale pile, precautions must be taken to assure that materials do not migrate from the pile, and that this will require testing over a period of time in the context of a full-scale field program.

The variation in quantity and characteristics of aqueous effluents, solid waste and air emissions occurring as a result of the various processes was mentioned early in the session, and Dr. Prien emphasized this point by commenting that there were at least eight oil shale processes in varying degrees of development at the present time. TOSCO II is probably closest to scale up to commercial size. The Superior Oil process is still fairly small in scale as far as the retort itself is concerned. Other processes (Paraho--350 tons a day; Union, Retort A--1,000 tons a day; Union Retort B B--50 tons a day, to be scaled up) have a smaller capacity than TOSCO II, but larger than the Superior process. He added that there should be ample opportunity for industry, EPA and ERDA to cooperate on proper environmental control of the new industry, because most processes will go through a modular stage with a 10,000-ton prototype plant being built prior to reaching a full-scale operational stage.

Dr. Prien agreed that one must be very careful of the history of samples and the source materials due to their fugitive nature. Crude shale oil, store even under ideal conditions, undergoes significant changes over a period of time.

*Figures 15 and 16, showing the locations of prototype oil shale tracts are contributed by Roger A. Tucker, Area Oil Shale Supervisor's Office, U.S.G.S., Conservation Division, Grand Junction, Colorado.

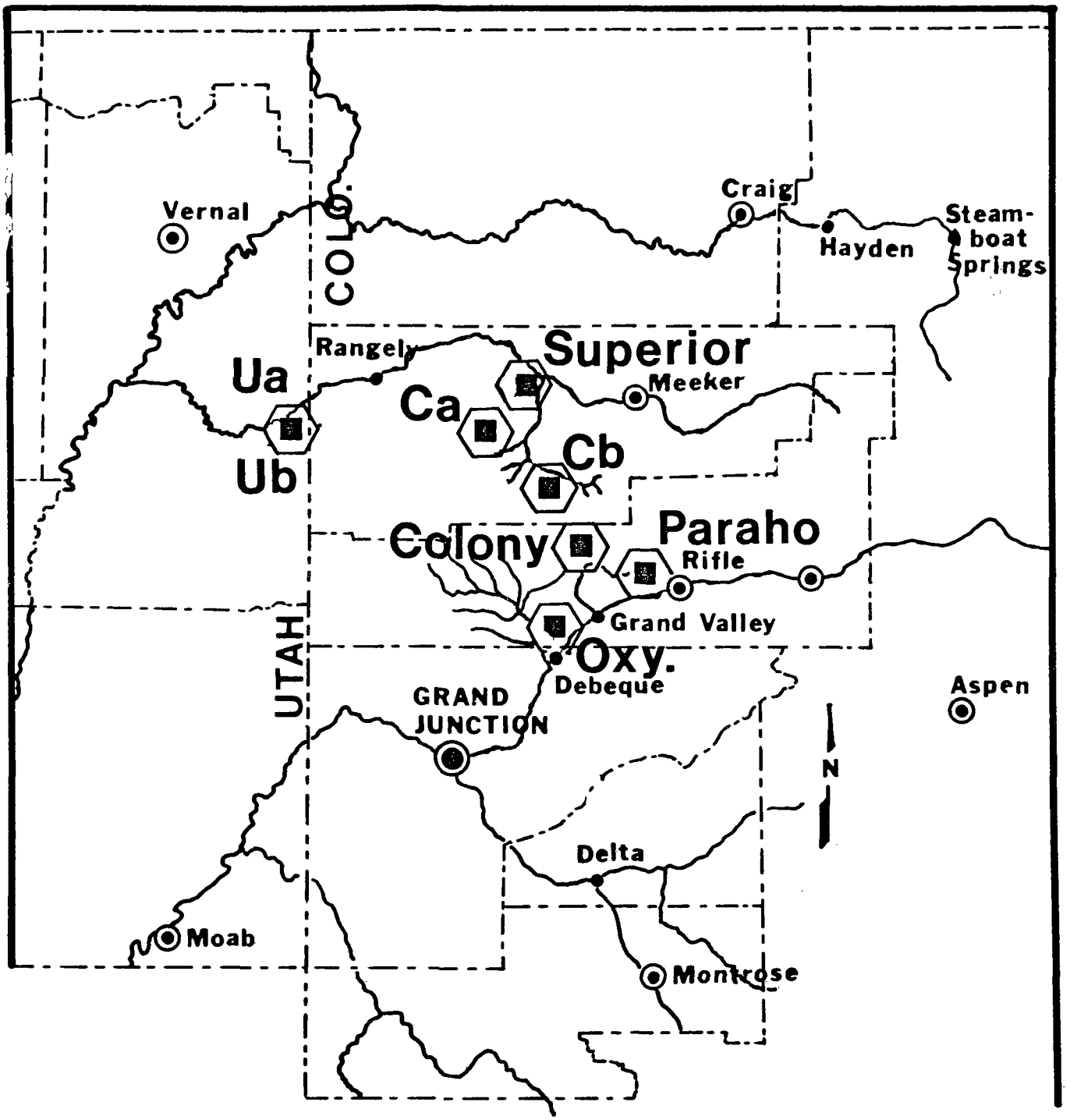


FIGURE 15

# OIL SHALE PROPERTIES

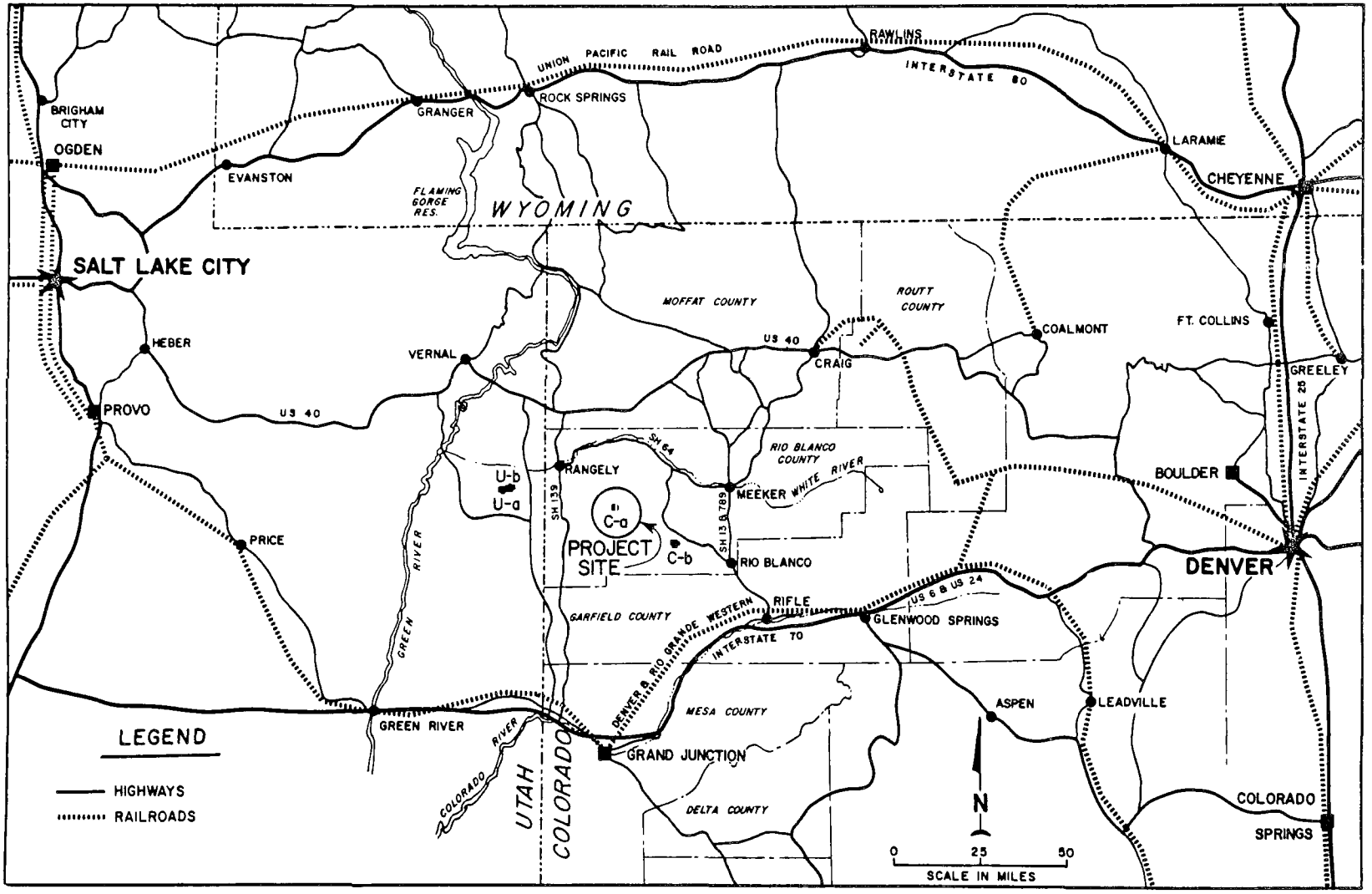


Figure 16

REGIONAL MAP SHOWING LOCATION OF TRACT C-a

Dr. Prien does not agree that in-situ processing provides an answer to environmental problems in the oil shale business. He stated that although in-situ is a way of handling certain of the oil shale strata, the problems of in-situ processing can be as troublesome as those of aboveground retorting. He stated that the opportunities to examine what those environmental problems will be, as provided by the ERDA program at LERC and the Occidental Petroleum program, are welcome ones since some of these problems are completely unknown at the present time.

Discussion--Session II(C)

Following his presentation a question was asked as to whether additional surface processes have been developed for the handling of special quality shale. Dr. Prien replied that in surface processing, one would normally like to use as rich a shale as possible because of the higher yields. However, certain of the retorting processes have problems with the very rich shales (40-45 gallons per ton of shale)--when such rich shale was used in a conventional gas combustion retort, bridging occurred. The Union Oil Company retort was developed specifically to break up such bridging. The TOSCO process has a very inherent advantage in its ability to handle fines. He further stated that in-situ processes would probably develop in much the same way--i.e., where 40-50 feet thick strata of shale exist, horizontal in-situ retorting may be applied, as opposed to the vertical methods used by Occidental, where a cavern is mined out, explosives are placed above, and rock broken down into the open space.

Just prior to the general discussion Mr. Kerr (ERDA/LERC) clarified earlier statements he had made:

- When a budget is developed to do a series of experiments within a fiscal year, that money is set aside from the ERDA budget for research relating to a specific process. An environmental plan is then associated with that process. If the process costs more than was estimated, the environmental monitoring effort may have to give up some of its funding. Sharing funds is then a means of obtaining auxilliary funding dedicated to a particular environmental measurement program which could not be diverted for use in other critical RD&D areas of concern.

## GENERAL DISCUSSION

Dr. Foley opened the general discussion period with the observance that previous presentations and discussions indicated that there will be ample opportunity to obtain the necessary environmental data and samples for health effects and that coordination and standardization will be needed to assure all pertinent information is recorded and transmitted along with the samples. He commented that whereas such a task will require a great deal of effort, it could be accomplished with relatively little difficulty.

He indicated that a question of concern appears to be whether environmentalists should be worried as yet, considering the uncertain future of the industry. He asked the Sector Group to respond to the following question: If the Synthetic Fuels Commercialization Bill (which would provide government loan guarantees and price guarantees in certain cases) is passed by Congress and signed by the President, will this completely turn around the economic picture for the oil shale industry and result in putting one or several plants into operation in the next five years? Sector Group response was as follows:

- Allan Grossman (Shell Oil) replied that some people in industry feel that congressional action would be a significant factor in getting one or two demonstration plants, or a module of each, started. It was his understanding that TOSCO feels confident that on the basis of loan guarantees, they could borrow money on the market to get something started. However, he remarked that it remains to be seen whether people who would be providing that money would be willing to take the risk, even with government loan guarantees.

There were no further comments or questions and the meeting was adjourned.

ATTACHMENT 1

AGENDA

ADVANCED FOSSIL FUELS SECTOR GROUP MEETING

31 March 1976
Industrial Environmental Research Laboratory
Cincinnati, Ohio

| | | |
|---|---|---|
| 8:30 | Welcoming Remarks | Dr. David G. Stephan<br>IERL, CINC |

Session I

PREVIOUSLY DEFINED ISSUES, OPTIONS AND PROGRAM IMPACT

| | | |
|---|---|---|
| 8:45 | Summary and Analysis of Issues Raised at Previous Sector Group Meeting | Dr. Gary J. Foley<br>OEMI |
| 9:30 | Program Modifications | Dr. Gary J. Foley |
| 10:00 | Coffee Break | |
| 10:15 | Discussion | |

Session II

ENVIRONMENTAL RESEARCH AND DEVELOPMENT FOR OIL SHALE PROCESSING

Chairman, Mr. William N. McCarthy, Jr., OEMI

| | | |
|---|---|---|
| 11:00 | Introduction | Dr. Gary J. Foley, OEMI |
| 11:15 | Background: Information Available from Oil Shale Working Group of the Western Energy Resource Development Sector Group | Mr. Eugene F. Harris<br>IERL, CINC |
| 11:30 | Lunch | |

A. HEALTH EFFECTS AND ENVIRONMENTAL ASSESSMENT

| | | |
|---|---|---|
| 12:45 | The EPA - Health Effects and Related Environmental Assessment Program | Dr. David Coffin<br>HERL, RTP |
| 1:00 | The ERDA - " | Dr. Richard Pelroy,<br>Pacific Northwest<br>Laboratory (Batelle) |

AGENDA (Continued)

| | | |
|---|---|---|
| 1:15 | DoD/Navy - Navy Concerns Related to the Health Effects of Oil Shale and Synthetic Fuels | LCRD Leigh E. Doptis<br>Occupational and Preventive Medicine Division, Navy Dept. |
| 1:30 | Discussion | |

B. ENVIRONMENTAL MEASUREMENTS AND TECHNOLOGY

| | | |
|---|---|---|
| 2:00 | EPA Environmental Measurements and Control Technology | Mr. Thomas Powers<br>IERL, CINC |
| 2:15 | ERDA Environmental Measurements and Associated Technology | Mr. Robert Kerr<br>Laramie Research Laboratory, ERDA |
| 2:30 | DoD/Navy Environmental Measurements and Associated Technology | Mr. Balfour Wallace<br>David Taylor Naval Ship Research and Development Center |
| 2:45 | Coffee/Soft Drink Break | |
| 3:00 | Discussion | Mr. William N. McCarthy, Jr.<br>OEMI |

C. INDUSTRIAL CONSIDERATIONS

| | | |
|---|---|---|
| 3:30 | Industrial Point of View and Comment on Approaches Outlined in Earlier Presentations | Dr. Charles Prien<br>Denver Research Institute (DRI) |
| 4:00 | General Discussion | Dr. Gary J. Foley<br>OEMI |
| 4:30 | Adjournment | |

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TRW
Jack Cotter
L. G. Neal

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16. ABSTRACT

The minutes of the third Advanced Fossil Fuels Sector Group Meeting cover the content of the presentations which were made and the discussion which followed. The general areas of concern were:

(1) A review of the content of the second Sector Group Meeting with indications of action taken

(2) The development of oil shale processing in which the following areas were addressed

(a) Health effects and environmental assessment programs at EPA, ERDA, and DoD

(b) Environmental measurements and technology programs at EPA, ERDA, and DoD

(c) Industrial point of view

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| Oil shale development<br>Coal gasification and liquefaction<br>Environmental control technology<br>Pollutant prioritization<br>Pollutant characterization<br>Water standards<br>Air standards | Environmental standards<br>Control technology<br>Pollutants<br>Synthetic fuels | |

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