THE UNIVERSITY OF WYOMING

MINUTES OF THE TRUSTEES

July 30, 1982

For the confidential information

of the Board of Trustee

THE UNIVERSITY OF WYOMING

Minutes of the Trustees
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A regular meeting of the Trustees of The University of Wyoming was called to order by President Quealy at 8:30 a.m. on July 30, 1982, in the Board Room of Old Main.

ROLL CALL The following Trustees were in attendance: Chapin, Coulter, Gillaspie, McCue, Mickelson, Miracle, Nolan, Quealy, Sawyer, Smith, Thorpe, and ex officio members Veal, Simons, and Eisenhauer. Trustee Brodrick and ex officio member Herschler were absent. Also in attendance were Allan Spitz, Vice President for Academic Affairs; Robert Jenkins, Acting Vice President for Research and Graduate Studies; Durward Long, Acting Vice President for Finance; William G. Solomon, Special Assistant to the President; Vern Shelton, Assistant to the President for Information; and Joyce Scott, Associate Vice President for Academic Affairs. Patricia Linenberger, Chairperson of the Faculty Senate, and Dennis Dreher, Vice President of the Staff Council, were also present.

APPROVAL OF MINUTES President Quealy asked if there were any corrections or additions to the minutes of May 14, 1982. There were no corrections or additions, and Mr. Quealy declared the minutes approved as circulated.

1982-83 COMMITTEES OF THE TRUSTEES

President Quealy announced the following Trustee Committee appointments for the 1982-83 year:

Executive Committee

Patrick J. Quealy, Chairman
James R. Nolan
Virgil L. Thorpe
W. R. Gillaspie

W. R. Coe Trust Fund Committee

Carlin Smith, Chairman
Gordon M. Mickelson
Thomas A. Sawyer

Budget Committee

Donald E. Chapin, Chairman
Gordon M. Mickelson
Brian Miracle
James R. Nolan
W. R. Gillaspie

Development Committee

Gordon M. Mickelson, Chairman
W. R. Gillaspie
Leo P. McCue, Jr.
Thomas A. Sawyer

Physical Plant and Equipment Committee

James R. Nolan, Chairman
Gordon H. Brodrick
Darrell Coulter
Carlin Smith
Virgil L. Thorpe
Thomas A. Sawyer
W. R. Gillaspie

Campus Planning Committee

Leo P. McCue, Jr.

Athletic Committee

Carlin Smith, Chairman
Gordon H. Brodrick
Darrell Coulter
Gordon M. Mickelson
Virgil L. Thorpe
Brian Miracle
James R. Nolan

Personnel Committee

Brian Miracle, Chairman
W. R. Gillaspie
Virgil L. Thorpe
Thomas A. Sawyer
Carlin Smith

Honorary Degree Committee

Donald L. Veal, Chairman
Darrell Coulter
Brian Miracle
Virgil L. Thorpe

Committee on Community College Relations

Leo P. McCue, Jr., Chairman
Donald E. Chapin
Thomas A. Sawyer
Brian Miracle

Academic Issues Committee[1/]

Donald E. Chapin, Chairman
Brian Miracle
Virgil L. Thorpe
Leo P. McCue, Jr.
Thomas A. Sawyer
Gordon H. Brodrick
Lynn Simons

1/ The Medical Education Committee was combined with the Academic Issues Committee pursuant to the Bylaws of the Trustees on October 2, 1981.

SCHEDULE OF MEETINGS OF THE TRUSTEES

President Quealy read the minutes of the Committee of the Whole. The Committee recommended to the Trustees that the following schedule of Trustees' meetings be adopted on a trial basis.

September	16 -	Committee Meetings (all day)
	17 -	Visitation (Inaugural Symposium and Elizabethan Fair)
	18 -	Business Session (followed by Wyoming/Long Beach State football game)
November	11 -	Visitation (beginning with luncheon)
	12 -	Committee Meetings
	13 -	Business Session (followed by Wyoming/Wichita State football game)
December	16 -	Committee Meetings
	17 -	Business Session
January	20 -	Visitation (beginning with luncheon and followed by Wyoming/ Utah basketball game)
	21 -	Committee Meetings
	22 -	Business Session (followed by Wyoming/BYU basketball game)
March	17 -	Visitation (beginning with luncheon)
	18 -	Committee Meetings
	19 -	Business Session
May	13 -	Committee Meetings
	14 -	Business Session
	15 -	Commencement

Mr. McCue moved that the recommended schedule of meetings be adopted on a trial basis. The motion was seconded by Mr. Gillaspie, and it carried.

ACADEMIC ISSUES COMMITTEE — President Quealy called on Mr. Sawyer for a report of the Academic Issues Committee meeting held on July 29, 1982. Committee members Miracle, Thorpe, McCue, Sawyer, Simons, Quealy, and Veal attended the committee meeting, along with other Trustees and University staff. Committee members Chapin and Brodrick were absent. Based on the Academic Issues Committee's report and recommendations, the following actions were taken in the regular meeting.

APPROVAL OF DEGREES — Mr. Coulter moved approval of awarding of degrees for those individuals recommended by the faculty and deans for the 1982 summer session, with a record of such degree awards to be maintained in the Registrar's office after authentication by the President of the University. Mr. Gillaspie seconded the motion, and it carried.

TERMINATION OF AGRICULTURAL MECHANIZATION CURRICULUM — At the request of the College of Agriculture and with the concurrence of the University Academic Planning Committee, the Academic Issues Committee considered terminating the agricultural mechanization curriculum. Mr. Mickelson moved that the agricultural mechanization curriculum be terminated,

effective 1982 Fall, with the concomitant condition that the curriculum remain a part of the academic structure until the graduation of the remaining students enrolled therein (normal progress towards graduation May, 1983). The motion was seconded by Dr. Thorpe, and it carried.

LARAMIE ENERGY TECHNOLOGY CENTER

Dr. Jenkins reported to the Committee on the progress and developments of the negotiations with the Department of Energy to date. Mr. Smith moved that the University administration be authorized to proceed with negotiations with the Department of Energy, and to develop an arms-length organization and details of implementation for a cooperative agreement, with the results to be reported to the Trustees at the September meeting; and further, that the Preliminary Draft Proposal for the UW Sponsored Operation of LETC, which is attached as Enclosure 1, be approved with the following three changes:

On page 9, (2), line 2, remove the word "irrevocably", so that (2) will read:

> The facilities and all real property associated with WERTC shall be owned by the University of Wyoming and leased to the corporation for as long as it operates the fossil energy programs described in this proposal.

On page 10, (b) remove "upon recommendation of the President of the University", so that (b) will read:

> The Board shall be appointed by the Trustees of the University of Wyoming.

On page 13, line 9, delete the following sentence:

> There is comparability between the Professional categories and certain University ranks.

The motion was seconded by Mr. McCue, and it carried.

SATELLITE AND MICROWAVE CARRIER SYSTEMS

As a matter of information only, Dr. Scott reported to the Committee on the advantages of satellite transmission for television and radio programming. A summary assessment of the two systems is provided in Enclosure 2, which is titled COMPARISON OF SATELLITE AND MICROWAVE CARRIER SYSTEMS. A review team felt that initial efforts to expand the University's radio and television outreach activities should be tested through microwave systems already in existence.

This concluded the items of business considered by the Academic Issues Committee.

BUDGET COMMITTEE

President Quealy called on Mr. Mickelson for a report from the Budget Committee, which met on July 29, 1982. Committee members Mickelson, Miracle, Nolan, Gillapsie, Quealy, and Veal attended the committee meeting along with other Trustees and University staff. Committee member Chapin was absent. Based on the Budget Committee's report and recommendations, the following actions were taken in the regular meeting.

CONTRACTS, GRANTS, GIFTS, AND SCHOLARSHIPS

Mr. Mickelson moved acceptance of contracts, grants, gifts, and scholarships, in the total amount of $3,662,464.10 as follows: (1) Contracts and grants for the period April 27, 1982 through June 30, 1982, $3,410,372.00; and (2) Gifts and scholarships for the period April 19, 1982 through June 30, 1982, $252,092.10. The motion was seconded by Mr. Nolan, and it carried.

APPROVAL OF REVISED FEE SCHEDULE FOR SUMMER SCHOOL

Following the Trustees' action on October 2, 1981, to set new academic year registration fees for the 1983-84 biennium, Summer School fees were reviewed for consistency. Mr. Mickelson moved that Summer School fees for resident students be maintained at $28.00 per credit hour up to the maximum of $308.00 for 12 credit hours or above, and that registration fees for nonresident students be increased to $90.00 per credit hour up to the maximum of $1,038.00 for

12 credit hours effective January 1, 1983, to assure equitable treatment of full-time enrolled nonresident students in the academic year and the summer session. Mr. Gillaspie seconded the motion, and it carried.

APPROVAL OF FEE FOR PHYSICAL EXAMINATIONS FOR NURSING STUDENTS

At the request of outside agencies and in the interest of students' well-being and public safety, the School of Nursing recommended that students enrolled in its curriculum should have a yearly physical examination including lab work and that students should be responsible for obtaining their own examinations and paying the required fees. For those students wishing to take advantage of the service, the Student Health Service at the University has agreed to perform these examinations for an $8.00 fee to cover lab work. Based on the Budget Committee's recommendation, Mr. Mickelson moved approval of an $8.00 fee for nursing students who choose to have the Student Health Service perform the physical examinations. The motion was seconded by Mr. Nolan, and it carried.

DEPOSITORY FOR OPERATING ACCOUNTS FOR UNIVERSITY FUNDS

Mr. Mickelson moved that the Citizens Bank of Laramie, Wyoming be designated as a depository for University funds. The motion was seconded by Mr. Gillaspie, and it carried.

INAUGURAL SYMPOSIUM

In accordance with the Budget Committee's recommendation, Mr. Mickelson moved that $5,000.00 be expended from Trustee

Reserve funds for the Inaugural Symposium in September. The motion was seconded by Mr. Smith, and it carried.

BUDGET INDEX AND SUMMARY FOR FISCAL YEAR 1983

As a matter of information only, the Budget Index and Summary for fiscal year 1983 and the results of implementation of the fiscal year 1983 salary improvements policy were presented to the Budget Committee.

This concluded the report and recommendations of the Budget Committee.

REPORT OF PERSONNEL COMMITTEE

Mr. Miracle reported on the Personnel Committee meeting held on July 29, 1982. Committee members Miracle, Gillaspie, Sawyer, Smith, Thorpe, Quealy and Veal attended the committee meeting along with other Trustees and University staff.

Mr. Miracle read the recommendations from the Personnel Committee concerning appointments, clinical appointments, honorific appointments, administrative appointments, reappointments, promotion, recall, leave of absence, change in sabbatical leave, retirements, rescission of appointment, part-time appointments, and resignations. Based upon discussion and recommendations from the Personnel Committee, Mr. Miracle moved approval or acknowledgment of the following personnel actions. The motion was seconded by Mr. Gillaspie, and it carried.

APPOINTMENTS In accordance with the Personnel Committee's recommendations, the following appointments were approved.

In the College of Agriculture

1. Jeff Powell as Professor of Range Management for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

2. Robert R. Dahlgren as Associate Professor of Microbiology and Veterinary Medicine and Associate Director of the Wyoming State Veterinary Laboratory for the 1982-83 fiscal year and for the period June 1, 1982 through June 30, 1982, at an annual (11-month) salary rate.

3. Elizabeth S. Williams as Assistant Professor of Microbiology and Veterinary Medicine for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

In the College of Arts and Sciences

4. Charles Evan Davis as Associate Professor of Political Science for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

5. Mary John Smith as Associate Professor of Communication for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

6. Joe Dickerson Hagan as Assistant Professor of Political Science for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

7. Kip Vernon Hodges as Assistant Professor of Geology for the 1982-83 academic year and the period July 1, 1982 through August 25, 1982, at an annual (9-month) salary rate.

8. Eli Leon Isaacson as Assistant Professor of Mathematics for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

9. Duane Rhoades as Assistant Professor of Modern and Classical Languages for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

10. Sherry Lynn Smith as Supply Instructor in History for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

11. Susan E. Declercq as Lecturer in English for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

12. M. Elizabeth Grubgeld as Lecturer in English for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

13. Christina Haas as Lecturer in English for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

14. Margaret G. Krumm as Lecturer in English for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

In the College of Commerce and Industry

15. Peter Lorenzi as Visiting Assistant Professor of Business Administration for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

16. Charles F. Mason as Instructor in Economics for the 1982-83 academic year, effective August 26, 1982, and for the period May 17, 1982 through June 30, 1982, at an annual (9-month) salary rate. (Appointment is made with the contingency that if the requirements for the Ph.D., the required terminal degree, are met prior to August 26, 1982 or January 10, 1983, the rank will be that of Assistant Professor, effective at the beginning of the semester following the completion date.)

17. Francis L. Stevenson as Instructor in Accounting for the 1982-83 academic year and for the period May 24, 1982 through June 30, 1982, at an annual (9-month) salary rate. (Appointment is made with the contingency that if the requirements for the Ph.D., the required terminal degree, are met prior to August 26, 1982 or January 10, 1983, the rank will be that of Assistant Professor effective at the beginning of the semester following the completion date.)

18. Stephanie C. Bluher as Lecturer in Business Administration for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

19. Elizabeth Fornstrom as Lecturer in Accounting for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

In the College of Education

20. Joseph A. Braun, Jr. as Assistant Professor of Curriculum and Instruction in the Cheyenne Field Office, for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

21. Robert Timothy Rush as Assistant Professor of Curriculum and Instruction for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

22. Stephen Bradley Kucer as Instructor in Curriculum and Instruction for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate. (Appointment is made with the contingency that if the requirements for the Ph.D., the required terminal degree, are met prior to August 26, 1982 or Janaury 10, 1983, the rank will be that of Assistant Professor effective at the beginning of the semester following the completion date.)

23. Cynthia A. Mills as Lecturer in the University School for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

24. Joannie L. Thelen as Lecturer in the University School for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

In the College of Engineering

25. Bruce R. Dewey as Professor of Mechnical Engineering for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

26. Henry W. Haynes as Professor of Chemical Engineering for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

27. Jocelyn F.B. Shaw as Associate Professor of Civil Engineering (Construction) for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

28. James O. Rose as Assistant Professor of Civil Engineering for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

In the College of Human Medicine

29. Jay Andrew Swedberg as Assistant Professor of Family Practice/Casper for the 1982-83 fiscal year and the period May 3, 1982 through June 30, 1982, at an annual (11-month) salary rate.

30. Dennis Paul Zoller as Assistant Professor of Family Practice/Cheyenne for the 1982-83 fiscal year and for the period from June 7, 1982 through June 30, 1982, at an annual (11-month) salary rate.

In the Division of Intercollegiate Athletics

31. Danny A. Richards as Assistant Women's Basketball Coach and Lecturer in Intercollegiate Athletics for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

32. Jay E. Schaake as Assistant Football Coach and Lecturer in Intercollegiate Athletics for the period July 1, 1982 through January 31, 1983, at an annual (11-month) salary rate.

In the University Library

33. Ruth Boettcher as Assistant Professor in the Library and Technical Services Librarian for the period May 17, 1982 through March 31, 1983, at an annual (11-month) salary rate.

34. Barbara Lou Wagner as Assistant Professor in the Library for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

35. James Michael Walsh as Assistant Professor in the Library and Maps and Documents Librarian for the 1982-83 fiscal year, effective August 9, 1982, at an annual (11-month) salary rate.

36. Judith Ann Bateman as Temporary Assistant Professor in the Library and Collection Development Librarian for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

In the School of Extended Studies

37. Gary Lee Benson as Assistant Professor of Business Administration/Casper and Coordinator of Business/Casper for the 1982-83 fiscal year, effective July 1, 1982, at an annual (11-month) salary rate.

CLINICAL FACULTY APPOINTMENTS-- College of Human Medicine — The following appointments in support of Student Programs were approved for the 1982-83 fiscal year in the College of Human Medicine.

1. David M. Anderson, M.D., Clinical Assistant Professor of Family Practice (Obstetrics/Gynecology/Laramie).

2. James W. Barber, M.D., Clinical Professor of Family Practice (Radiology/Cheyenne).

3. Gary G. Becker, M.D., Clinical Assistant Professor of Family Practice (Family Practice/Gillette).

4. Lyman R. Brothers, M.D., Clinical Associate Professor of Family Practice (Urology/Laramie).

5. John C. Budge, M.D., Clinical Assistant Professor of Family Practice (Radiology/Laramie).

6. William R. Caldwell, M.D., Clinical Assistant Professor of Family Practice (Obstetrics/Gynecology/Cheyenne).

7. Robert J. Curnow, M.D., Clinical Assistant Professor of Family Practice (Orthopedic Surgery/Laramie).

8. Gerald B. Demarest, M.D., Clinical Assistant Professor of Family Practice (General Surgery/Jackson).

9. Gary S. Ellibee, M.D., Clinical Instructor in Family Practice (Obstetrics/Gynecology/Cheyenne).

10. Thomas E. Hettinger, M.D., Clinical Associate Professor of Family Practice (Radiology/Cheyenne).

11. Michael W. Hiller, M.D., Clinical Assistant Professor of Family Practice (Internal Medicine/ Sheridan).

12. Donald G. Iverson, M.D., Clinical Associate Professor of Family Practice (Ophthalmology/Cheyenne).

13. John G. Knepper, M.D., Clinical Assistant Professor of Family Practice (Pediatrics/Sheridan).

14. Robert M. Knight, M.D., Clinical Assistant Professor of Family Practice (Diagnostic Radiology/Laramie).

15. Kathryn D.K. Kohler, M.D., Clinical Assistant Professor of Family Practice (Obstetrics/Gynecology/Laramie).

16. Donald A. Kougl, M.D., Clinical Assistant Professor of Family Practice (Internal Medicine/Cheyenne).

17. Kenneth B. Kurica, M.D., Clinical Instructor of Family Practice (Emergency Medicine/Cheyenne).

18. Donald J. Lawler, M.D., Clinical Associate Professor of Family Practice (Ophthalmology/Cheyenne).

19. Robert A. McNutt, M.D., Clinical Assistant Professor of Family Practice (Internal Medicine/Sheridan).

20. Michael F. Morosky, M.D., Clinical Instructor in Family Practice (Obstetrics/Gynecology/Cheyenne).

21. Douglas M. Peterson, M.D., Clinical Assistant Professor of Family Practice (Internal Medicine/Cody).

22. Richard B. Southwell, M.D., Clinical Assistant Professor of Family Practice (Orthopedic Surgery/Laramie).

23. Galyn M. Stahl, M.D., Clinical Associate Professor of Family Practice (Pathology/Laramie).

24. William R. Wahl, M.D., Clinical Instructor in Family Practice (Family Practice/Cheyenne).

HONORIFIC APPOINTMENTS The following honorific appointments were approved. These honorific appointments carry no tenure rights and no salaries are provided.

In the College of Arts and Sciences

1. Norman Bleistein as Adjunct Professor of Mathematics for the period from May 15, 1982 through June 30, 1985.

In the College of Health Sciences

2. Harold L. Frost as Adjunct Professor of Medical Technology for the period July 1, 1982 through June 30, 1985.

3. Rose Virginia Brown as Adjunct Assistant Professor of Medical Technology for the period July 1, 1982 through June 30, 1985.

4. Bonnie A. Fingerhut as Adjunct Assistant Professor of Medical Technology for the period July 1, 1982 through June 30, 1985.

5. Pam I. Kieffer as Adjunct Lecturer in Medical Technology for the period July 1, 1982 through June 30, 1985.

In the Department of Military Science

6. Joseph F. Thomas as Adjunct Assistant Professor of Military Science for the period August 15, 1982 through August 18, 1985.

APPOINTMENT OF DEPARTMENT HEADS

In accordance with the Personnel Committee's recommendations, the following department heads were appointed.

In the College of Arts and Sciences

1. Hilliard E. Chesteen, Jr., Temporary Professor of Social Work, as Head of the Department of Social Work and Professor of Social Work for the period August 1, 1982 through June 30, 1984.

2. Nancy L. Stanton, Associate Professor of Zoology and Physiology, as Head of the Department of Zoology and Physiology for the period May 18, 1982 through June 30, 1984.

In the College of Commerce and Industry

3. John T. Tschirhart, Associate Professor of Economics, as Head of the Department of Economics for the period July 1, 1982 through June 30, 1985.

In the College of Education

4. Ward K. Gates as Associate Professor of Physical Education with tenure and Head of the Department of Physical Education for the 1982-83 academic year, effective August 26, 1982, at an annual (9-month) salary rate.

In the College of Engineering

5. Gabor Vali, Professor of Atmospheric Science, as Head of the Department of Atmospheric Science for the period August 15, 1982 through June 30, 1985.

ACTING DIRECTOR--University School

Mina Bayne, Assistant Professor in the University School, was reappointed as Acting Director of the University School for the 1982-83 fiscal year, effective July 1, 1982.

ACTING DEPARTMENT HEADS

In accordance with the Personnel Committee's recommendations, the following acting department heads were appointed.

1. Dennis H. Knight, Professor of Botany, as Acting Head of the Department of Botany in the College of Arts and Sciences for the 1982-83 year, effective August 1, 1982.

2. William Lindberg, Associate Professor of Mechanical Engineering, as Acting Head of the Department of Mechanical Engineering in the College of Engineering for the period August 1, 1982 through December 31, 1982.

CHANGES IN ASSIGNMENT In accordance with the Personnel Committee's recommendations, the following changes in assignment were approved.

In the College of Agriculture

1. Richard M. Adams, Associate Professor of Agricultural Economics, currently assigned to the Corvallis EPA Lab, be assigned again to the Corvallis EPA Lab for the 1982-83 fiscal year, effective July 1, 1982.

In the College of Commerce and Industry

2. John H. Mutti, Professor of Economics and Chairman of the Department of Economics, be reassigned as Professor of Economics only, effective July 1, 1982.

In the Division of Intercollegiate Athletics

3. Charles Edgar Bell, Assistant Basketball Coach and Lecturer in Intercollegiate Athletics, be reassigned as Assistant Director of Athletics and Lecturer in Intercollegiate Athletics, effective June 1, 1982.

In the College of Law

4. George A. Gould, Associate Professor of Law and Associate Dean of the College of Law, be reassigned as Associate Professor of Law, effective August 25, 1982.

CHANGE OF TITLE--
College of Arts and Sciences

The Trustees approved a change of title for Stanley Anderson from Adjunct Professor of Zoology and Physiology to Professor of Zoology and Physiology, effective March 1, 1982. This change in title is tied to Dr. Anderson's federal appointment and carries no salary or tenure rights.

REAPPOINTMENTS

The following faculty members were recommended for reappointment by the Personnel Committee. Reappointments were approved for the 1982-83 academic year unless otherwise noted.

Name	Department	Academic Rank
In the College of Agriculture		
Franklin, Douglas R. (1982-83 fiscal year)	Agricultural Economics	Supply Instructor
In the College of Arts and Sciences		
Albertini, Diane L.	English	Lecturer
Boling, Bruce	Anthropology	Adjunct Assistant Professor
Eggers, Sue H.	English	Lecturer
Forslund, Antoinette	Modern and Classical Languages	Lecturer
Gringel, Wolfgang	Physics and Astronomy	Supply Assistant Professor

Name	Department	Academic Rank
Jensen, Christine	English	Lecturer
Johnson, Abigail R.	English	Lecturer
McKay-Sim, Alan	Zoology/Physiology	Visiting Assistant Professor
Mooney, William B.	Social Work	Temporary Associate Professor
Sharpe, Susan I.	Communication	Assistant Professor
Urion, Celia A.	English	Lecturer

In the College of Commerce and Industry

Armitage, Jack L.	Accounting	Lecturer
Eckles, Robert W. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Professor
Fischer, Albert J. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Instructor
Griggs, Frank T.	Business Administration	Temporary Instructor
Jacobs, Lester W. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Associate Professor
Jones, Robert E. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Assistant Professor
Johnson, Patricia A. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Instructor
Martin, Louisa Ann	Accounting	Lecturer
Novotny, Timothy J. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Assistant Professor
Robinson, James S.	Accounting	Lecturer
Seward, Samuel (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Associate Professor
VonRiesen, Richard D. (1982-83 fiscal year)	AFIT/Cheyenne	Temporary Professor

Name	Department	Academic Rank
	In the College of Education	
Davis, James D. (1982-83 fiscal year)	Vocational Education	Temporary Instructor
Welch, Kenneth V.	Curriculum and Instruction	Temporary Instructor
Westlund, Dennis (1982-83 fiscal year)	Vocational Education	Lecturer
	In the College of Engineering	
Adesanya, Babefemi A.	Chemical	Visiting Assistant Professor
Barton, Keith J.	Mechanical	Associate Professor
Cerni, Todd Andrew (1982-83 fiscal year)	Atmospheric Science	Temporary Assistant Professor
*Edgar, Thomas	Civil	Instructor
Hash, J. Bender	Petroleum	Supply Associate Professor
Matthew, Harry L.	Civil	Lecturer
*Miller, Ronald Lee	Chemical	Lecturer
Polson, Donald E.	Civil	Lecturer
Rodi, Alfred R. (1982-83 fiscal year)	Atmospheric Science	Temporary Assistant Professor
Rogers, David C. (1982-83 fiscal year)	Atmospheric Science	Lecturer
Sand, Wayne R. (1982-83 fiscal year)	Atmospheric Science	Temporary Assistant Professor
	In the College of Health Sciences	
Beaver, Susan	Nursing/Sheridan	Temporary Assistant Professor
Hornibrook, Phyllis	Nursing/Casper	Temporary Assistant Professor

*With contingency that if requirements for the Ph.D. are met by August 26, 1982 or January 10, 1983, the rank will be Assistant Professor.

Name	Department	Academic Rank
Rucker, Maricarolyn	Nursing	Temporary Assistant Professor
Topping, Gary (1982-83 fiscal year)	Speech Pathology/ Audiology	Lecturer

In the University Library

Davidson, Barbara J. (7/1/82 - 3/14/83)	Library/LETC	Temporary Assistant Professor

In the School of Extended Studies

Greiner, Patricia Ann	English/Casper	Supply Assistant Professor
Williams, Jack	Business/Casper	Lecturer

PROMOTION — Bryce R. Frost, Assistant Professor of Geology in the College of Arts and Sciences, was promoted to Associate Professor of Geology, effective July 1, 1982.

RECALL--In the College of Arts and Sciences — Donald L. Blackstone, Jr., Professor Emeritus of Geology, was recalled on a part-time basis for the 1982 Fall semester, effective August 26, 1982, at a salary rate for the semester.

LEAVE OF ABSENCE — Wayne R. Sand, Temporary Assistant Professor of Atmospheric Science and Flight Facility Manager, was granted a leave of absence without pay for the period September 1, 1982 through June 1, 1983.

CHANGE IN SABBATICAL LEAVE-- In the College of Arts and Sciences

At the December 7, 1981 Trustee's meeting, Walter F. Eggers, Professor of English, was granted a sabbatical leave for the 1982 Fall semester. Subsequently, Dr. Eggers requested that his sabbatical leave be postponed until the 1983 Fall semester. The Trustees changed Dr. Eggers' sabbatical leave to 1983 Fall semester.

RETIREMENTS

The individuals listed below have requested retirement and retirement was granted for these individuals on the dates and under the conditions cited.

Name	Position	Effective Date of Retirement
Davis, Dana	Director, Service and Auxiliary Enterprises	9/30/82 with designation Retired
Haddenhorst, Georgina	Assistant Professor, Education	6/30/82 with designation Emeritus
Hill, Wallace C.	Carpenter, Division of Physical Plant	7/30/82 with designation Retired
Nielsen, Marinus C.	Quarryer and Heavy Equipment Operator	6/30/82 with designation Retired
Stull, Elmer F.	Superintendant, Custodial Department, Division of Physical Plant	5/31/82 with designation Retired

RESCISSION OF APPOINTMENT At the May 13-14, 1982 meeting of the Trustees, the appointment of Jack A. Siggins as Professor in the University Library, with tenure, and Director of the University Libraries was approved. Mr. Siggins was unable to accept the appointment because of personal reasons. Therefore, the Trustees rescinded the appointment of Jack A. Siggins.

PART-TIME APPOINTMENTS As a matter of information only, the part-time appointments were reported to the Trustees.

INFORMATION ON RESIGNATIONS The following resignations, effective on the dates indicated, were acknowledged.

1. Kendall L. Baker, Professor of Political Science and Head of the Department of Political Science, August 1, 1982.

2. Journey L. Beard, Assistant Women's Basketball Coach and Lecturer in Intercollegiate Athletics, June 30, 1982.

3. Michael Charles DeLuca, Instructor in Physical Education and Assistant Intramural Director, May 16, 1982.

4. Gerald C. Goodnight, Assistant Professor in the University School, May 16, 1982.

5. Janell Hanson, Supply Instructor in the Library, June 4, 1982.

6. Wesley W. Hiser, Associate Professor of Family Practice, June 30, 1982.

7. James E. Lindsay, Jr., Professor of Electrical Engineering, August 25, 1982.

8. Phyllis L. Messer, Assistant Professor of Education Foundations, July 14, 1982.

9. Guy E. Montgomery, Jr., Clinical Professor of Family Practice, June 30, 1982.

10. Jayne Furness Moore, Assistant Professor of Nursing, May 18, 1983.

11. Thomas S. Moore, Jr., Associate Professor of Botany and Head of the Department of Botany, August 1, 1982.

12. David D. Roberts, Assistant Professor of English, August 25, 1982.

13. Karen E. Todd, Lecturer in Speech Pathology/ Audiology and Clinic Supervisor, May 16, 1982.

14. Richard M. Whalen, Part-time Assistant Professor of Family Practice, June 30, 1982.

This concluded the report from the Personnel Committee.

ATHLETIC COMMITTEE — President Quealy called on Mr. Smith for a report on the Athletic Committee meeting held July 29, 1982. Committee members Smith, Coulter, Mickelson, Thorpe, Miracle, Nolan, Quealy, and Veal attended the committee meeting, along with other Trustees and University staff. Committee member Brodrick was absent. Based on the Athletic Committee's report and recommendations, the following actions were taken in the regular meeting.

DENVER NUGGETS/DALLAS MAVERICKS EXHIBITION GAME

Charles Bell, Assistant Athletic Director, reported to the Athletic Committee on the forthcoming Denver Nuggets/ Dallas Maverick Exhibition Game, scheduled for October 15, 1982, at 8:00 p.m. in the Arena-Auditorium. The Denver Nuggets have been guaranteed $15,000.00 for the event, which will occur on the weekend of the regularly scheduled Wyoming/Cal-State, Fullerton football game. It is yet to be determined whether or not the Denver team will utilize their rights to broadcast the game, and Athletic Department personnel were urged by the Athletic Committee to explore this issue with Nuggets officials.

A notice of the availability of tickets for the exhibition game will be included in the mailing of the regular basketball season ticket package, which is to be sent no later than September 1, 1982.

UPDATE OF COLLEGE FOOTBALL ASSOCIATION INSTITUTIONAL MEMBERSHIP

Dr. Veal reported to the Athletic Committee on recent discussions among the chief executives of the nine Western Athletic Conference schools, regarding institutional membership in the College Football Association. At its meeting May 14, 1982, the Trustees had directed the administration to act in concert with the other Conference schools in withdrawing from the CFA. Recently, however, the presidents of these institutions have been informed that the CFA is likely to be dissolved in mid-1983. In

light of this development, the WAC Council of Presidents was inclined to remain as members of the CFA for one additional year.

Mr. Smith moved that the University of Wyoming retain its membership in the CFA for another year, in accord with the action of a majority of other WAC institutions. Mr. Mickelson seconded the motion, and it carried.

UPDATE ON WESTERN ATHLETIC CONFERENCE POST-SEASON BASKETBALL

Dr. Veal reported further on the WAC Council of Presidents review of a proposed post-season basketball tournament. The conference chief executives have directed the athletic directors of the various institutions to give further study to the concept, with special attention being given to concerns relating to the location of such a tournament, the financial implications of the proposal, and the amount of additional time away from classes which such a tournament would entail for the participating student athletes. Pending receipt of this study, the Conference post-season tournament has been deferred for the 1982-83 season, and will be considered by the presidents for the following year.

ARENA-AUDITORIUM TICKET POLICY

Assistant Athletic Director Mary Ellen Cloninger reported to the Athletic Committee on a proposal relating to the allocation of seats for the forthcoming basketball season in the Arena-Auditorium. The Athletic Department is proposing that the number of half-price tickets (faculty/staff rate) available to University faculty

and staff be limited to two tickets in the lower level of the Arena, and two tickets in the facility's upper level, or four tickets in the facility's upper level. Faculty and staff would be allowed to purchase additional tickets at the regular price.

Ms. Cloninger noted that a recent survey of colleges and universities within the Big-8, PAC-10, and Western Athletic Conferences revealed that all of these schools limited the number of tickets offered to faculty and staff at a discount rate, and that no such institution offered a discount greater than the 50% reduction in price currently established at UW.

Upon the motion of Mr. Smith, seconded by Mr. Nolan, the above-described limitation on the number of discounted tickets available to UW personnel was approved as a pilot program for the forthcoming 1982-83 basketball season in the Arena-Auditorium.

MISCELLANEOUS ITEMS REPORTED TO THE ATHLETIC COMMITTEE

Mr. Bell reported further on a number of miscellaneous items, including 1) a new ticket marketing partnership involving the University of Wyoming, Colorado State University, and the Air Force Academy; 2) an update on a recently reported controversy in the area of basketball recruiting; and 3) arrangements for the Denver-based radio broadcast of all regularly scheduled UW football games during the 1982-83 season.

This concluded items of business considered by the Athletic Committee.

PHYSICAL PLANT AND EQUIPMENT COMMITTEE

President Quealy called on Mr. Nolan for a report of the Physical Plant and Equipment Committee meeting held July 29, 1982. Committee members Nolan, Coulter, Smith, Thorpe, Sawyer, Gillaspie, Quealy, and Veal attended the committee meeting, along with other Trustees and University staff. Mayor Larry Mickelson of the City of Laramie was also present. Committee member Brodrick was absent. Based on the Physical Plant and Equipment Committee's report and recommendations, the following actions were taken in the regular meeting.

1. Proposal and Study by the City of Laramie.

Dr. Long reported on a study the City of Laramie is doing in regard to expanding recreational facilities. Mayor Mickelson presented one of the City's proposals that would involve the possible long-term lease of certain University lands for the purpose of constructing new recreational facilities on the north side of campus, which would be used jointly by the University and the City. Based on the Physical Plant and Equipment Committee's recommendation, Mr. Nolan moved that the Trustees recommend to the City that they proceed with the development of a proposal which upon presentation will be considered by the Physical Plant and Equipment Committee. This Committee will then make a recommendation to the Trustees for action at the September meeting. The motion was seconded by Mr. McCue, and it carried.

2. Oil and Gas Lease, Goshen County. In January 1979, Mrs. Lura O. Wirick of Cheyenne bequeathed to the University one half of her partial interest in certain mineral rights on an 80-acre tract of land in Goshen County. Meany and Johnson Energy Corporation, Denver, Colorado, has proposed to lease this mineral interest from the University for a period of five (5) years, with an option to renew for a like successive period, for the sum of $10.00 per net acre, plus $1.00 per net acre annual rental and a 1/8th landowner's royalty. Mr. Nolan moved that the Trustees reject the proposal. The motion was seconded by Mr. McCue, and it carried.

3. Ratification of Executive Committee Action, Coe Library Renovation and Air Handling Project. Bids for the Coe Library Renovation and Air Handling Revision projects were opened on July 7, 1982, as follows:

Comin Construction, Laramie	$324,611
Spiegelberg, Laramie	329,822
Groathouse Construction, Laramie	335,525

The Executive Committee of the Trustees awarded the contract to Comin Construction Company for $324,611. Mr. Nolan moved that the action of the Executive Committee be ratified. The motion was seconded by Mr. Smith, and it carried.

4. Purchase of Cooper and Guthrie Properties. In 1980, the University of Wyoming Foundation acquired the Cooper and Guthrie properties adjacent to the University campus, with a view toward the ultimate transfer of those properties to the University upon receipt of legislative funding for that

purpose. Since 1980, the University has held both properties under leases with options to purchase from the Foundation. During its 1982 session, the Wyoming Legislature appropriated $850,000 for acquisition by the University of both the Cooper and Guthrie tracts. Under terms of the agreement with the Foundation relating to the Cooper property, the University may exercise its option to purchase the property no earlier than January 10, 1983. Mr. Nolan moved that the Trustees authorize the exercise of the option for the purchase of the Guthrie property, with a date of closing to be set during the month of August 1982, at a purchase price of approximately $143,000.00 (the exact figure to be determined when a precise date of closing is set), and that they authorize the exercise of the option for the purchase of the Cooper property, with a date of closing to be set during the month of January 1983, at a purchase price of approximately $631,000.00 (the exact figure to be determined when a precise date of closing is set). The motion was seconded by Mr. Gillaspie, and it carried.

5. City of Laramie/University Drainage Study. Mr. Jones reported to the Committee that the City Council had approved the budget for the City's share of the East Campus Drainage Study and that University staff will meet with the City the week of August 2 to make plans for getting the study underway.

This concluded items of business considered by the Physical Plant and Equipment Committee.

DEVELOPMENT COMMITTEE President Quealy called on Mr. Mickelson for a report of the Development Committee meeting held July 29, 1982. Committee members Mickelson, Gillaspie, McCue, Sawyer, Quealy, and Veal attended the committee meeting, along with other Trustees and University staff. Also in attendance were Jack P. Ellbogen, Bruce P. Badley, and George J. Millett, representing the University of Wyoming Foundation Board of Directors.

Mr. Ellbogen reported to the Trustees on the proceedings of the University of Wyoming Foundation annual meeting on June 29, 1982, at which the recommendations of the Ad Hoc Committee which is considering the relationship between the University and the Foundation were reviewed. Mr. Ellbogen and Mr. Badley presented the Foundation Board's reactions to these recommendations, and detailed discussion followed with respect to organizational models, methods of coordination between the two entities, and the initial budgetary requirements of the Foundation.

At the conclusion of this discussion, Mr. Quealy assured the Foundation directors that the Trustees would give careful consideration to the recommendations of the Ad Hoc Committee and the Foundation's concerns, and would report the results of that study to the Foundation Board in the near future.

INAUGURAL/SYMPOSIUM

Mr. Chapin reported that a symposium examining the direction of higher education in the United States, rather than the traditional inaugural ceremony, is planned to inaugurate Donald L. Veal as 20th President of the University of Wyoming. Mr. Chapin said that the program on September 17 features a panel discussion by seven prominent educators on "What Is the University?" and a major address on American higher education by Barbara S. Uehling, Chancellor of the University of Missouri-Columbia. Members of the panel are Donald L. Veal; Barbara S. Uehling; Lawrence W. Wood, Executive Vice President of the Mobil Oil Corporation, New York; Joan Smith-Sonneborn, UW Professor of Zoology and Physiology; State Representative Jack Sidi, Casper; Walter G. Langlois, UW Professor of French; and James G. Hook, Associate Dean of the College of Education, panel chairman and moderator. All events are scheduled in the UW Fine Arts Center and are open to the public.

The complete symposium schedule is:

2 - 4 p.m.	Panel, "What Is the University?" -- Concert Hall
5:30-6:45 p.m.	Buffet Dinner -- Art Museum
7:00 p.m.	Address by Chancellor Uehling -- Concert Hall
8:30 p.m.	Elizabethan Fair Concert -- Concert Hall

RESOLUTION RE LARRY A. JANSEN

Dr. Veal moved, Mr. McCue seconded, and it carried to adopt the following resolution honoring Larry A. Jansen:

> WHEREAS, Larry A. Jansen has been an effective voice for University of Wyoming staff employees throughout his term as chairman of the UW Staff Council; and
>
> WHEREAS, Trustees of the University of Wyoming have been pleased to receive the insights offered by Larry A. Jansen on behalf of his co-workers; and
>
> WHEREAS, Larry Jansen's participation in Trustees meetings and subsequent reports at Staff Council sessions have expanded channels of communication across the campus;
>
> NOW, THEREFORE, BE IT RESOLVED:
>
> That the Trustees of the University of Wyoming commend Larry A. Jansen for his leadership, commitment, and cooperation.

ORIENTATION

Lynn Simons said that she had received very favorable comments on the orientation programs held on campus for students. She feels that this two-day program is of great benefit to both students and parents.

ADJOURNMENT AND DATE OF NEXT MEETING

There being no further business to come before the Trustees, President Quealy declared the meeting adjourned. Following adjournment, a short executive session was held, but no business was conducted. The next meeting of the Trustees is scheduled for September 16-18, 1982.

Respectfully submitted,

Karleen B. Anderson

Karleen B. Anderson
Deputy Secretary

PRELIMINARY DRAFT PROPOSAL

FOR

UNIVERSITY OF WYOMING SPONSORED OPERATION OF THE LARAMIE ENERGY TECHNOLOGY CENTER

JULY 6, 1982

* ORGANIZATIONAL OUTLINE
* LETC BACKGROUND
* PROGRAM
* BUDGET

DRAFT

I. INTRODUCTION

This proposal has been generated as a result of discussions with Jan Mares, Assistant Secretary for Fossil Energy of the U.S. Department of Energy. These discussions revealed that while the oil shale, underground coal conversion, and tar sands programs of the Laramie Energy Technology Center (LETC) are considered to be important and valuable, the proposed D.O.E. Fossil Energy FY1983 budget would reduce their funding. Moreover, of greater significance is the fact that the number of positions for Federal Employees in Fossil Energy is being drastically cut for FY1983. Therefore, the LETC operation is in serious jeopardy when the current federal fiscal year ends (30 September 1982). Since LETC occupies space contiguous with the main campus of the University of Wyoming, and since there have developed many programmatic relationships between University of Wyoming faculty and LETC staff, University officials began preliminary exploration of a UW-LETC affiliation. This action lead to adoption of the following resolution by the University of Trustees on 19 February 1982.

WHEREAS the continued operation of the Laramie Energy Technology Center by agencies of the federal government is highly improbable; and

WHEREAS the Laramie Energy Technology Center is located contiguous with the campus of the University of Wyoming; and

WHEREAS there presently exists a highly productive collaboration between researchers at the University and the Laramie Energy Technology Center; and

WHEREAS these collaborative research programs are critical to the development and management of the great energy resource of the State of Wyoming; and

WHEREAS the continued and essential research mission of the Laramie Energy Technology Center could best be discharged and the needs of the State simultaneously met if the Laramie Energy Technology Center were to be administered as a program of the University of Wyoming;

NOW, THEREFORE, BE IT RESOLVED:

That the Trustees of the University of Wyoming hereby direct the University administration to commence immediately a thorough investigation of possible alternatives relating to the acquisition and operation of the Laramie Energy Technology Center by the University of Wyoming, to explore the feasibility of said alternatives with the appropriate state and federal lawmakers and administrators, and to initiate open discussion of this matter within the faculty community on campus.

Armed with this mandate formal efforts have been underway to develop a plan whereby LETC's important fossil energy programs could be sustained in a new structure which would place the Center under the purview of the University. This proposal is the result of such efforts. It has been generated on the basic premise that a successful outcome would be highly beneficial to the nation, region, and state and therefore to UW and LETC.

The University has maintained from the outset of discussions that three criteria were paramount and must be satisfied if the University is to assume responsibility for the Center and its programs: (1) There must be a clear benefit to the academic programs of the University without compromise in either financial or personnel resources of current programs, (2) operation of the Center must not require the immediate infusion of State funds nor should the State assume any implied financial responsibility without proper University planning and State government agreement, and (3) operation of the Center must provide a research and technology program which develops the fossil energy resources of both the State and the region while maintaining a sensible flexibility to allow for maximum university interaction.

Brief historical background information is as follows:

The Laramie Energy Technology Center (LETC) was begun in Laramie, Wyoming in 1924 when two researchers established a "Petroleum Field Office"

under the Bureau of Mines, United States Department of the Interior, to aid in the development of petroleum resources. This office was located on the University of Wyoming campus as a result of a formal agreement between the University and the Department of Interior.

LETC has grown and flourished during the past 58 years. The Petroleum Field Office changed names and government agencies several times during this period with its research emphasis expanding from basic research only to include applied research and technology. The Center, now a part of the U.S. Department of Energy, has grown from its original staff of two into a nationally and internationally prominent technology center, with more than 150 employees. In 1978, LETC was designated as DOE's "Lead Center" for oil shale and non-oil shale in situ processes.

The LETC budget increased dramatically from 1977 to 1981 with its management of large field demonstration projects in oil shale. The FY81 budget was $50 million. With the close-out of the demonstration projects, LETC's budget for FY82 was $30 million.

The Center has a heavy concentration of scientists and engineers, 44 of whom are University of Wyoming graduates. In addition, LETC has graduates from 87 other colleges and universities.

The main LETC facility in Laramie occupies a 2.13-acre site on the northwest corner adjacent to the University of Wyoming campus. The main building is a four-story research laboratory, housing 41 laboratories, 55 offices, a technical library, computer, and maintenance facilities.

The center Annex has an additional 18 offices, a large conference room, general shop space, and storage areas. Other buildings on the site house hot oil storage, high-pressure refining equipment, oil shale crushing machinery, and geologic core storage laboratories.

LETC's location, adjacent to the UW campus, has proven mutually beneficial. University professors are available for consultation, cooperative seminars are sponsored, and some LETC personnel hold Adjunct Professorships at the University and other regional universities. Many students are employed as part-time technicians, and a summer fellowship program allows selected undergraduates, graduates, and professors to conduct research at LETC, sometimes as part of their requirements for advanced degrees from regional universities. LETC is also the largest supporter of the graduate student and faculty on site research programs of Associated Western Universities (AWU).

LETC's role in the fossil-energy-rich Rocky Mountain region has expanded geographically far beyond Laramie. Its field sites are located in Colorado, Utah, and elsewhere in Wyoming where oil shale, coal, and tar sand resources are abundant. The Laramie North Retort Site, located one mile north of the Center, houses a 10-ton and a 150-ton retort (oil shale furnances) designed to simulate below-ground conditions for in situ oil shale research. An experimental underground coal conversion site is located in Centralia, Washington. LETC also has a tar sand research site near Vernal, Utah, and monitors above-ground retorting of shale oil at the government-owned, contractor-operated Anvil Points Facility west of Rifle, Colorado.

During the past few years, the Center has also expanded its horizons internationally, answering requests for expertise and consultation from the United Nations and such countries as Morocco, Israel, Canada, Yugoslavia, the USSR, Brazil, the People's Republic of China, and France. LETC has also hosted many international visitors.

The University of Wyoming, founded in 1886, is the state's only baccalaureate level institution. It has an enrollment of 10,000 students in eight colleges (Agriculture, Arts and Sciences, Commerce and Industry, Education, Engineering, Health Sciences, Human Medicine, Law) and the Graduate School. Doctoral degrees are offered in some 40 fields, master in 100 fields and bacheolor degrees in 120. The University's operating budget for the biennium beginning 1 July 1982 will be $299,000,000 of which $99,000,000 is in support activities (e.g. dormitories, food service, external research support, etc.) The external research support is about $15,000,000 per annum. In addition to the direct operating budget the University has a capital budget of about $60,000,000 for buildings under construction and an additional $20,000,000 for buildings yet to be placed under contract.

The University of Wyoming has developed a strong and comprehensive program in the general area of energy research. This effort extends from
the broad area of the hydrometallurgy through hydrocarbon characterization to assessment of air and water toxicology associated with energy technologies. LETC is physically located adjacent to the University science and engineering activities thereby maximizing the integration of energy research programs of the Center and the University. Over the years this proximity and a

spirit of cooperation have fostered a productive, highly synergistic relationship between U.W. and the LETC. Because of research opportunities presented by the various LETC programs, University faculty and facilities have been developed to form a natural and valuable complementation to those of LETC. Currently, the University is engaged in approximately $2.1 million in LETC program research.

The eight intermountain states led by Wyoming constitute the nation's "energy basket." This widely variant land contains some of the most beautiful scenery and fragile ecology in the world. The region is vast, representing about 25 percent of the land area of the contiguous 48 states. Yet it is sparsely populated with only 5 percent of the nation's people. The federal government owns some 50 percent of the land, and state governments own a a considerable fraction of the remainder. Within the region lies 42 percent of the nation's coal, 8 percent of the crude oil and natural gas, 11 percent of the hydropower, 91 percent of the uranium, 95 percent of the tar sands, and 70 percent of the oil shale. In addition there are extensive timber, metallic mineral and other (than energy) nonmetallic mineral resources. When one adds the geothermal and solar potential there is no question that the intermountain region, which has at least 50 percent of the nation's energy reserves, is indeed the nation's "energy basket." In Wyoming alone the value of mineral production increased from less than $0.5 billion in 1970 to $2.5 billion in 1980. The State's coal production of 98 million tons in 1981 made it the third largest in the nation.

DRAFT

II. PURPOSE AND OBJECTIVES

The purpose of the proposal is to present to the Department of Energy a plan whereby the University of Wyoming will acquire LETC facilities and operate LETC fossil energy research and technology programs in oil shale, coal, and tar sand to the benefit of the state, region and the nation as well as to the University and LETC.

The objectives in meeting this purpose are:

(1) To establish a corporate structure which will permit the University to operate LETC while maintaining the center staff and facilities at a level commensurate with the fossil energy research and technology mission.

(2) To make the Center programs fully responsive to the needs of the government and industry while reflecting close interaction with University teaching and research programs.

(3) To continue the emphasis on quality and cogency in the conduct of the Center's work by instituting a system of technical peer review before, during, and after initiation of particular programs.

(4) To insure necessary initial funding levels by negotiating a five-year agreement with the DOE Office of Fossil Energy such that the total cost as shown in the Budget (Section VI) would

be funded for FY1983, FY 1984 and FY1985, and that 2/3 of the cost be funded for FY1986 and 1/3 for FY1987.

(5) To elicit support from state governments and from industry for the Center's programs.

(6) To maintain and expand a center of fossil energy excellence by the combined efforts of University and LETC personnel.

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III. ORGANIZATION OF THE UNIVERSITY OF WYOMING RESEARCH AND TECHNOLOGY CORPORATION

(1) The University Trustees will create Wyoming Energy Research and Technology Corporation (WERTC), a non-profit, arms-length corporation governed by appropriate Wyoming statutes.

(2) The facilities and all real property associated with WERTC shall be owned by the University of Wyoming and irrevocably leased to the corporation for as long as it operates the fossil energy programs described in this proposal.

(3) The Corporation shall have as its goal the operation of a fossil energy research and technology center which pursues state-of-the-art work in oil shale, coal and tar sands. Furthermore, this goal shall be coincident with State, regional and national objectives and shall be realized through maximum congruence with academic goals of the University.

(4) The Corporation shall be guided by a statement of By-Laws developed to further the objectives of this proposal. The Board of Directors will have authority to amend these By-Laws.

(5) The Corporation will have as its supervisory and governing body, a Board of Directors.

(a) The Board shall consist of eleven (11) directors, three (3) ex officio and eight (8) appointed, who will serve four (4) year terms; term of initial appointments to be staggered by lot.

(b) The Board shall be appointed by the Trustees of the University of Wyoming upon recommendation of the President of the University.

(c) The President of the University of Wyoming and the President of the Trustees (or his/her designee) shall be voting ex officio members; the Center Director shall be a monitoring ex officio member. Appointed members of the Board, with vote, are to be four (4) from members of the University of Wyoming faculty and staff and four (4) from appropriate private and/or public entities.

DRAFT

IV. PERSONNEL AND STAFFING PLAN

The internal organization of the Center staff, research programs and supporting activities must facilitate the following general goals:

The Center should retain a lead role and prominence in oil shale, underground coal conversion, and tar sand research.

The Center should provide technical expertise in response to national, regional, and state needs related to the development of oil shale, UCC and tar sand. The Center should interact with and be responsive to international fossil energy programs that are in the national interest. The Center should disseminate and exchange technical and scientific information through publication, symposia, workshops and short courses. The Center should remain an inter-disciplinary research approach which satisfies the requirements of governmental and industrial sponsors, and the basic and technological goals of the University.

In reviewing the program plan and the mission of the Center it has been determined that a staff of 102 persons together with the support provided by budgeted indirect costs will be necessary. The staffing structure will be in terms of Engineering, Physical Sciences, and Environmental Sciences; however, the mission will be in terms of Oil Shale, Underground Coal Conversion, and Tar Sand. Therefore, staffing and budgeting are in terms of full time equivalents rather than individuals as one person in Engineering, for example, may work on one or two or all three of the mission efforts.

Director of the Center

Responsibility for the operation of the Center shall rest with the Director. The Director shall be appointed by the Board of Directors and shall serve at the pleasure of the Board. The Director will effect operation of the Center in a manner coincident with the stated goals and objectives of the Center. Matters of staffing, budget and facilities management, and research development and reporting shall be major responsibilities of the Director. The Director will have administrative latitude to respond to research and technology opportunities in line with the mission of the Center and will have control of resources necessary to accomplish such responses.

Deputy Director of the Center

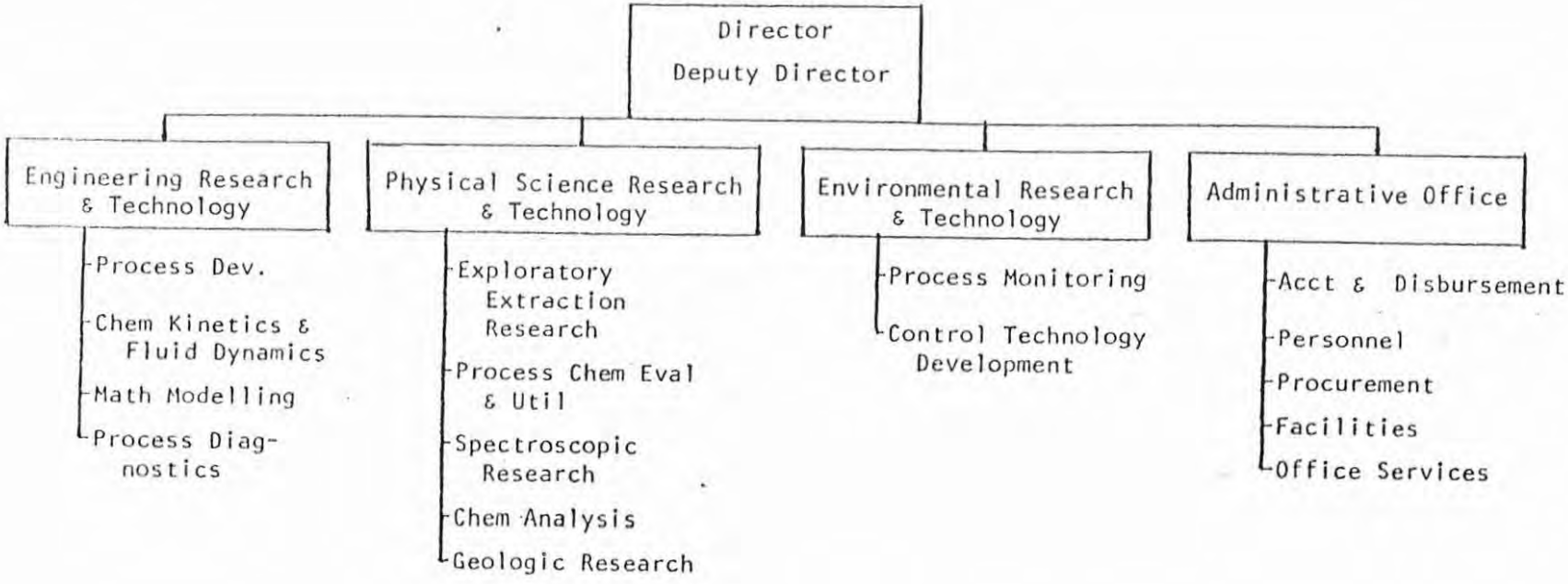
The development of program opportunities in the governmental and private sector shall be the responsibility of the Deputy Director. The Deputy will assist in the preparation of proposals by Center staff and will effect appropriate utilization of University faculty and graduate students in research programs of the Center. The Deputy Director will be the principal Center technical liaison with the University research community and the private sector, and will assume such other duties as the Director may assign.

The Center staff will be categorized as Professional, Technical Support, and General Support. Professionals will in general have at least a baccalaureate degree and will be in one of five classifications:

Senior Research Scientist (or Engineer), Research Scientist (or Engineer), Senior Research (name of discipline), Research (name of discipline), (Name of discipline). The first classification will be reserved for the small number of distinguished Scientists/Engineers on the staff and their pay level will be in the range of the top supervisory persons. The last classification will be for B.S. entry level persons. The classifications in between will be used to properly categorize and compensate employees as a function of degree level, experience, and job performance. There is comparability between the Professional categories and certain University ranks.

The Technical Support and General Support personnel categories will in general be modeled after the University system. This will insure equity between Center personnel and University personnel performing the same or similar duties.

A proposed staffing structure for the Center organized both in terms of D.O.E. fossil energy programs and in terms of the anticipated Center departmental arrangement is shown in the following table. Budget requirements (Section VI) reflect this staffing structure.


Director
Deputy Director
Engineering Research & Technology
Process Dev.
Chem Kinetics & Fluid Dynamics
Math Modelling
Process Diagnostics
Physical Science Research & Technology
Exploratory Extraction Research
Process Chem Eval & Util
Spectroscopic Research
Chem Analysis
Geologic Research
Environmental Research & Technology
Process Monitoring
Control Technology Development
Administrative Office
Acct & Disbursement
Personnel
Procurement
Facilities
Office Services

	PROFESSIONAL	TECHNICAL SUPPORT	GENERAL SUPPORT	TOTAL
Oil Shale	35	14	8	57
U.C.C.	12	4	6	22
Tar Sand	11	4	5	20
Director's Office	2		1	3
Totals	60	22	20	102

Engineering	22	17	7	46
Physical Sciences	24	4	8	36
Environmental Sciences	12	1	4	17
Director's Office	2		1	3
Totals	60	22	20	102

Federal Field Staff

The Center will house a field group of approximately ten (10) Federal employees who shall be the program managers for the oil shale, underground coal conversion, and tar sands programs of the U.S. Department of Energy. The Center will provide appropriate furnished office space in the Center building, secretarial/clerical assistance, drafting/photographic services and computer services as arranged on a reimbursable basis (approximately 3 person years/year). Parking shall be provided for two GSA vehicles.

Finally the University proposed to offer Center personnel the perquisites available to University personnel. Essentially all of these (e.g. parking, athletic tickets, use of facilities, tuition waivers for courses, etc.) are currently available to Center personnel. In general it is proposed that Center personnel will be treated as nearly as possible as their University peers; the chief (and only significant) difference being that Center personnel cannot acquire academic tenure unless they have specific academic appointments in the University and meet all other tenure requirements.

V. PROGRAM PROPOSAL

This section begins with a statement of significant accomplishments of the Laramie Energy Technology Center in the oil shale, underground coal conversion, and tar sands programs of the Department of Energy. Following this is a detailed research plan for oil shale, underground coal conversion, and tar sands. This section concludes with a detailed budget analysis for FY83 program support.

A strong technology theme underlies the lead mission assignments that have been placed at the Laramie Energy Technology Center. This technological focus is on the various thermal, in situ recovery processes applied to the recovery of energy from the U.S. oil shale, coal, and tar sand resources. This in situ technology development base represents several hundred man-years experience not only in the traditional engineering and scientific disciplines but also in specialized areas of petroleum engineering and geology which are particularly well suited to in situ recovery techniques. This expertise also encompasses the complete integration of the environmental mitigation and control aspects of the oil shale, coal and tar sand programs.

Past efforts of the LETC staff in oil shale, tar sands, and coal have resulted in a high credibility with state and local governments, industry, academia, and other Federal agencies. Because of funded research and development activities at universities, this has led to the development of university staff members that are knowledgeable consultants to their state governments and has provided training for students to take active roles in an emerging industry.

During the time span 1975 to present, many significant advances in research and development have taken place at the Laramie Energy Technology Center. The material that follows represent only a summary of these significant R&D accomplishments of the LETC staff from 1975 to present. These accomplishments have been documented in over 450 technical publications during this period of time.

ACCOMPLISHMENTS IN THE OIL SHALE R&D PROGRAM

Vertical Modified In Situ Retorting

Thick, deep deposits of good quality oil shale may be economically processed by the vertical modified in situ method. Previous LETC pilot plant simulation studies indicated that VMIS retorting would be possible; however, actual field research was required to determine if the concept would work. As a consequence, through a government/industry cooperative agreement managed by LETC five 1/3-scale and three full-scale VMIS retorts have been constructed and operated from which much has been learned regarding proper construction and operation of such retorts.

VMIS Oil Shale Retorting

Typical gas quality for vertical modified in situ retorting has been improved dramatically by using steam to dilute the combustion air. Previous tests with the LETC 10-ton and 150-ton retorts had demonstrated maximum oil recovery at oxygen concentrations of about 14% volume. With recycle gas as the diluent, gas heating value is only about 30 Btu/scf. The use of steam increases gas heating value to 50-80 Btu/scf. These improvements in gas quality greatly increase the value of by-product gas for electric power generation and other fuel uses associated with shale oil production and processing at the mine site. During the past 3 years, the 10-ton and 150-ton retorts have been operated to evaluate different levels of steam dilution. These data have provided guidance to industry in the design of field retorting tests.

The development of steam dilution data for VMIS retorting has included cooperative research with industry. At the request of Rio Blanco Oil Shale Company, a 150-ton retorting test was conducted with oil shale from the C-a Lease Tract. This test provided processing data for the design of surface facilities to operate and monitor 2 experimental VMIS retorts at the C-a Lease Tract. The 150-ton retorting test also provided samples of products to evaluate analytical methods for remote diagnosis of retorting conditions in the absence of direct instrumentation for the field retorts. Similar tests have been completed with Moroccan oil shale in the 10-ton retort. These tests have compared VMIS and T^3 processing conditions for different zones of the Timahdit deposit in Morocco.

Environmental control technology for VMIS retorts has also been tested as a part of the experiments with the 150-ton retort. In cooperation with the Environmental Protection Agency, the product gas recovery system has been modified to facilitate the installation of portable gas processing equipment. The EPA contractors have operated a venturi scrubber during the retorting tests, and LETC has contracted with Denver Research Institute to treat recycle water for the scrubber. The industrial field tests of VMIS retorting have not yet included this testing of cleanup technology for the overall process operation. These experiments in conjunction with the 150-ton retort operations are necessary to provide the design data for future industrial field tests.

Horizontal Modified In Situ Retorting

Thin seams of oil shale may be economically processed by horizontal modified in situ retorting methods. Shallow, thin seams of oil shale are suited to processing by explosive lifting of the overburden, fracturing of the shale and subsequent in situ retorting of the oil shale in a horizontal mode. Through a government/industry cooperative agreement managed by LETC, field experiments have been conducted starting with small-scale retorts and progressing to what are presently considered full-scale retorts. Methods for explosively lifting the overburden and fracturing the oil shale have been developed, as well as methods for operation of the retorts, advancing the technology to where realistic estimates of the commercial potential can be made.

Horizontal Oil Shale Retorting Studies at LETC

An experimental program has recently been completed by LETC to evaluate horizontal retorting of oil shale rubble. Both forward and reverse combustion tests have been conducted in a 10"-diameter by 12'-long adiabatic retort. These tests simulate a possible geometry for modified in situ retorting of relatively thin oil shale zones which are rich enough for mining. With reverse combustion, the oil yields are less than 30% of assay, but there is a high yield of 160 Btu/scf gas. Gasification of the shale predominates at these conditions. With forward combustion, retorting predominates, but the oil yield is principally dependent on the method of oil recovery. Oil yields are greater than 75% of assay, and gas quality is 30-40 Btu/scf when the oil can drain freely from the retort. If the oil cannot drain away in advance of the combustion zone, secondary cracking, coking and combustion reduces oil yield to 50% of assay, and the gas quality increases to only 60 Btu/scf.

Post burn coring of the Geokinetics' Retort 16 was initiated to evaluate the extent and nature of the retorted zone, to fully understand the long term stability and solid state chemistry of burned oil shale; and to produce insight into the trace elements and their importance to ground water contamination. Twenty core holes were drilled through Retort 16--lithologic cross sections and Fisher assay analyses have been completed and indicated that six distinct zones were created by the retorting. High temperature mineral surveys and trace element analyses will be completed this fiscal year.

The following oil shale R&D studies are being conducted at LETC.

Low Void Oil Shale Retorting

Much of the oil shale resource is too lean for economical mining. In situ retorting through fracture systems between wellbores is necessary to recover the shale oil from this lean resource. Field tests have previously been conducted to test this retorting geometry. However, laboratory methods have recently been developed by LETC to simulate the various geometries for true in situ retorting. In preliminary experiments, a 1-inch wide fracture has been simulated between the cut surfaces of 2 large shale blocks. Upon retorting in a large laboratory vessel,

the blocks swelled to close the simulated fracture. During this swelling, there was insufficient exfoliation of the blocks for forced convection. Combustion was sustained only along the free surface of the blocks, and the blocks were retorted only by heat conduction. Under these circumstances, most of the oil and gas products are burned to sustain combustion in the fracture. These laboratory results have explained the high pressure drops and low oil recoveries which have previously been observed in field tests with hydraulic and explosive fracture preparation.

A new low void retort has recently been fabricated at LETC to test different fracture geometries for in situ retorting. This retort operates with stacked beds of oil shale bricks. The bricks are cut with wire saws and can be stacked with open fractures, or the fractures can be filled with oil shale rubble. Preliminary experiments indicate that the rubble in the fractures is very beneficial for sustaining uniform combustion and improving product recovery. Oil yields as high as 70% of assay have been achieved at only 15% void volume. These data are necessary to design fracturing and explosive systems for development of lean oil shale deposits by in situ retorting technology.

The LETC low void retort has also been used to measure the types and amounts of sulfur compounds in the retort gas. At the request of Occidental Petroleum Company, high sulfur shale from the C-b Lease Tract has been retorted at VMIS processing conditions. Only about 90% of the gaseous sulfur is produced as H_2S. The remainder of the sulfur is produced as carbonyl sulfide and methyl mercaptans. These other sulfur compounds are more difficult to recover in gas cleanup processing and may affect total sulfur emissions in oil shale plants.

SO_3 Retorting of Oil Shale

LETC has recently submitted an invention disclosure for SO_3 retorting of oil shale. There have been previous industrial patents for the use of SO_3 in heavy oil recovery, but this technique has never been evaluated for application to oil shale. In preliminary experiments, the SO_3 has been shown to react with the water in oil shale, and there may also be appreciable sulfonation reactions. All of these reactions are extremely exothermic, and there is sufficient heat production to retort the shale. The current experiments are evaluating the reaction temperatures and extent of retorting for different levels of shale moisture content. These experiments in a quartz retort are necessary to design a larger stainless steel retort system for more detailed evaluation of material and energy balances.

Downhole TV Logging

Downhole TV logging technology has been developed to interrogate in situ fracturing, rubbling and subsidence conditions in the vicinity of wellbores. This technique has proven useful for evaluation of underground coal gasification as well as in situ retorts. In underground coal gasification, the standard fisheye camera lense for wellbore interrogation has been used to identify sources of water seepage and to locate casing failures. More importantly, the TV camera has successfully logged coreholes through subsidence regions above gasification

cavities to evaluate the extent of ground movement when there was no visible surface disturbance. Improvements in the lighting, focusing and viewing capabilities are under development to permit interrogation of the actual gasification cavities.

Oil shale rubble has previously been logged in experimental retorts at Occidental's Logan Wash Test Site. In this case, the TV camera was lowered in a borehole through a rubble bed to determine particle size and void distribution directly. More recently, there has been a cooperative research agreement with Rio Blanco to interrogate the wellbores and rubble surface after each blast in the detonation sequence for retort preparations at the C-a Lease Tract. For both of the 2 experimental retorts, rubble and ceiling levels have been determined after each blast to estimate the vertical distribution of void space in the rubble. These data were necessary for predictive modeling of retort performance by LLL under a separate cooperative research agreement with Rio Blanco.

The downhole TV surveillance at the C-a Lease Tract also included an assessment of wellbore damage after each blast. Measurements of wellbore expansion and ceiling levels provided the necessary information to design the explosive placement for each subsequent blast. With this information, the powder factors could be adjusted to level the retort ceiling for uniform void distribution and rubble size over the cross-section of the retort. The downhole TV pictures have also provided estimates of the particle size distribution for the oil shale rubble. Existing correlations between sieve analysis and a grid-by-number technique have been used to develop the particle size distributions. This experimental application demonstrated the practicality of the downhole TV system as an essential diagnostic tool for controlling the rubbling procedure.

Tracer Testing

LETC has developed and applied a variety of tracer testing systems to evaluate in situ permeability and porosity conditions. A radioactive Krypton-85 system is used for applications which involve multiple detection cells. This system has been used in most of the tar sand recovery experiments and underground coal gasification tests to identify directional permeability between wellbores. During tar sand recovery experiments and in situ oil shale retorting tests, this system is also used to detect any changes in flow communication in the well patterns. A helium tracer system is used to evaluate changes in porosity or cavity growth during underground coal gasification. An SF_6 tracer system is also used to evaluate oil shale rubble with a higher molecular weight tracer.

Mathematical Modeling

A variety of mathematical models have been developed to design and evaluate the performance of different in situ processing technologies. LETC has previously developed a one-dimensional model for modified in situ retorting. Improvements in the description of reaction kinetics have been achieved through experimental work by universities and LLL. LLL has also added gasification reactions for residual carbon in the retorted shale. All of these improvements have resulted in a very

comprehensive one-dimensional model that is used extensively by industry in the evaluation of experimental modified in situ retort operations.

More recently, LETC has worked with LASL and Sandia to develop and validate a two-dimensional retorting model. The code development is nearly complete and experiments are planned at LETC to test the model predictions in comparison with 10-ton and 150-ton retorting tests. These retorts enable the use of large rubble and wide size distributions to simulate the flow channeling and permeability distributions in field retorts.

There are also several different models for underground coal gasification. LETC has previously developed a model through a contract with the University of Wyoming. This model has been used in the design and evaluation of the Hanna coal gasification experiments. Laboratory tests have been conducted at LETC to determine the two-dimensional growth of the gasification cavity, and these results have been used to interpret the model predictions for evaluation of the field tests. LETC has recently modified the model to more accurately predict the temperature profiles at the wall of the gasification cavity. Other models which have been developed by LLL and university investigators are now being compared with the new LETC model to resolve any differences. All of these models will be tested against the field data to identify the best features for prediction of test results.

Kerogen Decomposition by NMR Analysis

A new NMR technique has been developed to distinguish between aliphatic and aromatic carbon in oil shale. In conjunction with Colorado State University, this technique is used to evaluate decomposition of oil shale kerogen. Recent experiments indicate that conventional thermal retorting methods do not recover the original aromatic carbon in oil shale. The retorted shales contain the same amount of aromatic carbon as the raw shale, but the aliphatic carbon is entirely removed by thermal retorting. This technique has proven reliable for oil shales from different world-wide resources. The technique is especially useful for characterizing oil shales from the eastern United States because these shales show more variation in the nature of the organic material than western shales in Colorado, Utah and Wyoming. The technique is also useful for evaluating hydroretorting or other processes which show potential for conversion of aromatic carbon to liquid products.

The new NMR technique is being used to evaluate kerogen decompostion kinetics in isothermal experiments. In addition to standard measurements of oil and gas, the NMR technique monitors the disappearance of aliphatic carbon. In these experiments, a catalytic or solution effect of natural bitumen has been discovered. At a relatively low temperature of 350°C, kerogen conversion is at least doubled by the presence of natural bitumen. This effect may be important in predicting oil production rates for in situ retorting. At in situ retorting conditions, heating rates are slow, and there is substantial shale oil production at low temperatures in advance of the combustion zone or in the interior of large rubble which is heated only by conduction.

Oil Upgrading

LETC has previously developed experimental equipment and procedures to test and compare the hydrotreating characteristics of shale oil. These tests have evaluated the hydrogen requirements to reduce shale oil nitrogen content for conventional refining. More recently, LETC has developed analytical techniques to evaluate the size distribution and metals content of shale oil particulates. These particulates tend to plug beds of hydrotreating catalysts and the metals are catalyst poisons. In recent experiments, about 30% of the shale oil particulates have been determined to be less than 20 μm in size. Conventional filter equipment will not remove these small particulates and prevent plugging of guard beds or hydrotreating catalysts.

The shale oil hydrotreating facilities have recently been modified to evaluate upgrading of tar sand oil. Previous university experiments have identified hydropyrolysis as a promising upgrading step for the tar sand oil. However, these tests were conducted in batch equipment. In the continuous tests at LETC, the residence time for hydropyrolysis has not been sufficient to reduce oil boiling range significantly. The tests are continuing to develop an effective system for hydropyrolysis of tar sand oil.

Optimization of Processes by Analysis of Products

An area of primary activity for the oil shale program concerns attempts to relate the chemical composition or physical properties of products (particularly shale oil) to the process parameters that produced the products. This effort is aimed toward predictive diagnostics mainly for in situ processes. Ideally, one could rapidly analyze some chemical or physical characteristic of a product oil and relate this characteristic to the process conditions that have been experienced by the oil. If the oil were not the optimum desired product, the process conditions might be altered by changing air injection rate, mode of injection, addition of water or steam, or some other means to attempt to optimize. The desired results might not necessarily be the highest conversion to oil but could include tailoring of product composition.

To this end, LETC personnel have two significant R&D studies that are nearing completion. A lab-scale retort was used for more than 80 experiments with varying heating rates, particle size of shale, retort atmosphere, grade of shale, etc. Results indicate that slower heating rates increased gas and coke production at the expense of oil; carbon dioxide production was proportional to oxygen content of inlet gas and more oil was held by the surface of particles but more secondary cracking of oils occurred within larger particles. About ten recent publications have documented these studies.

In the second study, 23 chemical and physical properties of shales were correlated with thermal histories of numerous shale oils, including Paraho, Oxy, LETC Site 9, 150-ton and 10-ton LETC retorts, and lab-produced shale oils. Some characteristics were shown to correlate very well with the thermal history either directly measured or inferred from other data. The best statistical correlation was shown with optical

activity of product oil. To complete this study, more than 90 oils were produced under carefully controlled conditions at the University of Utah. LETC personnel are now involved in analysis and correlation of the data to develop predictive diagnostics for in situ processes. Recent work has been documented by six publications.

Stability Studies of Raw and Upgraded Shale Oils and Distillates

Raw and partially upgraded shale oils have long been known to have problems with gum and sediment formation. These problems have been related to unsaturated or nitrogen-containing compounds in the oils. LETC has had an extensive involvement in such studies. Recent LETC results from a nitrogen compound study have shown that hydrotreatment at the commercial scale (Sohio) and bench scale (Sohio, Chevron, and LETC) yields oils in which some nitrogen compounds remain but the gum-formers are reduced significantly. Moreover, one can probably predict the type and percentage of nitrogen compounds that will result from hydrotreatment if an analysis of the crude is done. This can be done using a correlation developed during this study in an attempt to predict the minimal upgrading conditions needed to provide acceptable products from crude shale oil. Three recent publications have resulted from this work, and two more are in progress.

Use of CO/H_2O for Recovery of Oil from Oil Shale

LETC recently completed studies for recovery of oil from oil shale using carbon monoxide-water between 300 and 400?C. These studies were aimed at developing a new process for recovery at lower temperatures with higher oil yields than obtained by conventional thermal processing. Higher yields of liquids would allow upgrading of more material to provide liquid fuels as opposed to the gas or coke losses experienced by currently utilized thermal processes. Examples are about 30 percent yields of gas and coke from Green River oil shale and more than 60 percent yields of gas and coke using Eastern U.S. shales. Conversions of Green River oil shale at 300 to 375°C were less than those experienced by Fischer assay. However, processing at 400°C resulted in up to 80 percent oil yields. This value is greater than the Fischer assay yield at about 100°C lower temperature. Three publications have resulted from this work. This process is a candidate for additional, larger scale evaluation and for application to Eastern shales.

Supercritical Fluid Recovery of Oil from Oil Shale

Work is in progress to develop innovative processes for converting fossil fuel resources to usable fuel products. The benefits derived from new processes would be improved yields of fuel, improved efficiency and environmental acceptability, and recovery of the inorganic components that can be processed to recover valuable elements such as aluminum. Results to date have shown that use of a methanol/water solvent system at 400°C results in the recovery of more than 90 percent of the organic material as a heavy, liquid product which can be contrasted to 60 percent conversion of the original produced by conventional retorting of Western shale. This temperature is about 100°C lower than that used for conventional thermal recovery of oil from oil shale. The liquid product is rich in hydrogen and has very limited amounts of pyrolysis products. Analysis of the inorganic shale product indicates that very little coking occurs during the processing. Presentation of this work at scientific meetings resulted in numerous inquiries from industrial companies including Shell, Gulf, Mobil, and Exxon. Three publications are being prepared describing this research, and a patent has been applied for.

Effective Utilization of Fossil Fuel High-Boiling and Residual Fractions

Petroleum Asphalt Replacements from Shale and Tar Sand Oils

As we move toward the production and utilization of synfuels from shale oil and tar sands it is almost inevitable that residual products and byproducts, undesirable for fuel use because of their high nitrogen content, will be produced. These materials have potential as replacements for petroleum asphalts in paving applications. Over 500,000 barrels of petroleum asphalt, equivalent to over 3 percent of the U.S. crude oil to refineries, is presently diverted to this essential and vital nonfuel application. Many industry spokesmen predict future petroleum asphalt shortages because of the recent trends to upgrade or utilize asphalt residuals for fuels. Thus, evaluation of potential replacements from the fuel-undesirable components of shale and tar sand oils is desirable.

Laboratory quantities of paving asphalts have been prepared from residual materials derived from shale oil and tar sands. Preliminary evaluations show that asphalts acceptable for highway paving mixtures can be produced by conventional methods. The syncrude-derived products showed certain properties that were superior to their petroleum counterparts. For example, pavement mixtures prepared from shale oil or tar sand asphalts showed superior resistance to moisture damage. These findings are supported by the surprisingly good condition of a more than 25-year-old pavement produced from shale oil residue at the shale oil facility at Rifle, Colorado. In addition, highly desirable low-temperature flow properties and resistance to age hardening were also characteristic of the tar sand-derived asphalt. These findings have resulted in three LETC publications.

Use of Nitrogen Concentrates from Shale Oils

One major cause of premature failure of asphalt pavements is loss of the asphalt-aggregate adhesive bond from intrusion of water. As part of a long-term study at the LETC of the fundamental chemistry of the asphalt-aggregate bond, it was discovered that pyridine-type compounds were resistant to displacement from pavement aggregates by water; thus, treatment of the asphalt or aggregate with these materials produced asphalt-aggregate mixtures highly resistant to moisture damage.

Pyridine-type nitrogen compounds occur in shale oil as an undesirable component that must be removed prior to utilization as a fuel. We have demonstrated that pyridine-type compounds removed as a byproduct during the experimental refining of shale oil greatly increased the resistance of asphalt-aggregate mixtures to moisture damage. A U.S. patent filed by LETC researchers and describing the treatment process has recently been awarded. Two other papers have been published documenting these studies. There is considerable interest by the industry in the development which would utilize the shale oil byproduct. The shale oil byproduct also appears promising as a potential softening agent for recycling wornout asphalt pavements. This use, which would also conserve a valuable petroleum resource, is being actively investigated.

Spectroscopic Studies Related to Fossil Fuels

The questionable availability and increased cost of jet fuels derived from petroleum crude is of great concern, and the Air Force has initiated programs to evaluate jet fuels derived from alternate fossil fuel sources. Presently, oil from shale is the most promising alternate source of jet fuel. However, the chemical composition of shale oil crude differs considerably from petroleum crude. Because of these differences, refining methods and the performance of the jet fuels derived from shale oil must be thoroughly investigated. The jet engine performance, power output, engine life, and operation cost all are affected by the chemical composition of the jet fuel. A cooperative program between LETC and Wright-Patterson Air Force Base was established to investigate the potential of nuclear magnetic resonance spectroscopy (NMR) and mass spectrometry (MS) for the chemical characterization of shale oil-derived jet fuels.

NMR methods have been developed by which the hydrocarbon type of analyses of the jet fuels can be rapidly and quantitatively determined, and, using a combined gas chromatograph and mass spectrometer, the individual chemical components of jet fuels have been identified.

Correlations between NMR and MS data and combustion properties of jet fuels are being developed. If successful, the work will result in more cost-effective, less time-consuming performance evaluation tests for aviation fuel. These studies have resulted in three publications, and two more are in the final draft stage.

ACCOMPLISHMENTS IN THE UNDERGROUND COAL CONVERSION R&D PROGRAM

In 1975 LETC conducted the Hanna II, phase 1 UCG field test. This 38-day air gasification test produced 103 x 10^6 cu. ft. of 152 Btu/scf gas and consumed over 1000 tons of coal. The objectives of Hanna II, phase 1, were to determine directional in situ permeability, to examine reverse combustion linking of wells, to conduct a limited gasification test, to evaluate in situ instrumentation and real-time data acquisition. Sandia cooperated with LETC in evaluating the in situ instrumentation. Conclusions from Hanna II, phase 1, were:

- Directional air flow tests between wells were found to give more reliable results than oriented core analyses for the directional permeability properties of the coal seam.
- Creating a link between adjacent wells sufficient to sustain gasification simply by air injection proved to be infeasible.
- Reverse combustion linking was simple and dependable.
- In situ thermal instrumentation proved to be a valuable tool in determining the location of the link and evaluating the progress of the gasification.
- A linkage path in low- to mid-seam proved to be an important first step leading to an efficient coal gasification system.

In 1976 LETC conducted Hanna II, phases 2 and 3. These UCG field tests were designed to test a "line drive" concept which was projected to yield a high areal sweep efficiency. LETC conducted the tests and Sandia provided the instrumentation support.

The well pattern for Hanna II, phases 2 and 3, consisted of four wells numbered 5-8, each at a corner of a 60-foot square. The original phase 2 plan included reverse combustion linking between wells 7 and 8, reverse combustion linking between wells 5 and 6, and air gasification between wells 5 and 6. The original phase 3 plan was to link by reverse combustion from the 5-6 gasified zone to wells 7 and 8, and then gasify along a broad front from wells 7 and 8 to the 5-6 gasified zone. It was felt that if a broad front linkage path could be created between the 5-6 and 7-8 lines, then the entire coal resource in the 60-foot square could be effectively gasified.

Hanna II, phase 2 was completed as planned. During 25 days of air gasification between wells 6 and 5, 511 x 10^6 cu. ft. of 175 Btu/scf gas were produced and 2200 tons of coal were consumed. Upon completion of phase 2, phase 3 was conducted. The linkage from the 5-6 zone to wells 7 and 8 was complete but was believed to be narrow and primarily near wells 6 and 8. The "line drive" was abandoned and air gasification was conducted between wells 7 and 8. The modified Hanna II, phase 3 air gasification test was conducted for 38 days, during which time 721 x 10^6 cu. ft. of 138 Btu/scf gas were produced and 3500 tons of coal were consumed. During both phases, in situ instrumentation was used with

great success to determine the position, direction, and advance rate of the linkage pathways. Conclusions from Hanna II, phases 2 and 3, were:

- Production of high product heating value product gas over long duration is feasible.
- High thermal efficiency is attainable in UCG systems (90%).
- High production rate over long duration is practical.
- High overall sweep efficiency is attainable.
- Forward gasification model was confirmed.
- Thoroughly instrumented test is necessary for interpretation of results.

In 1977 LETC conducted the Hanna III UCG field test. This 38-day air gasification test produced 600 x 10^6 cu. ft. of 138 Btu/scf gas and consumed 2400 tons of coal. Hanna III was a two-well system, and the test was designed to meet environmental as well as process objectives. The objectives were to:

Environmental

1. Characterize the properties of the coal seam aquifer and of an overlying aquifer.
2. Determine pre-test water quality in both aquifers.
3. Determine post-test water quality.
4. Determine impacts of UCG on groundwater quality based on any observed compositional changes.

Process

1. Improve the mathematical model.
2. Test process control techniques.
3. Demonstrate constancy of product gas heating value by controlling the air-water ratio in the gasification zone.

Hydrologic measurements indicated that the coal seam permeability was low: 2-10 millidarcies, with an average of 5 millidarcies. The upper aquifer and the coal seam aquifer were not connected initially, but were interconnected during gasification. After completion of Hanna III, it was determined that water reinvasion of the gasified zone was extremely slow and little post-burn water quality data was collected. Conclusions from Hanna III were:

- Close, overlying aquifers can be contaminated by UCG water-soluble products.

- Ignition and linking problems can be field-soluble.

- Gasifier performance is repeatable.

- Automated process contol is practical.

In 1978 LETC began the Hanna IV UCG field test, a linear 3-well pattern. The original objectives of Hanna IV were to:

- Determine relationship between injection rate, well spacing, and sweep width.

- Determine the potential for gravity override of the link at these spacings.

- Define void shape and gasification front inclination with time.

- Determine in situ pressure and gas compositional gradients during linkage and gasification.

The planned sequence of events for operating Hanna IV was to be ignition at the middle process well (Well 2), reverse combustion linkage to the updip well (Well 1), gasification from Well 1 to 2, initiation of linkage from Well 2 downdip to Well 3 during the gasification from Well 1 to 2, and relaying gasification from the Well 1-2 system to the 2-3 system after completion of the 1-2 system.

Due to a complex series of events, the actual sequence was different from the plan and extended over a period of about 18 months. The maximum duration of air gasification was for 24 days during the latter stages of the test, during which 600×10^6 cu. ft. of 130 Btu/scf gas was produced and 1200 tons of coal were consumed. The major problems encountered were well completions and the natural fracture/fault system at the Hanna IV site. Hanna IV required larger process wells (12-inch) than any previous test (6-inch). The cement in none of the three process wells maintained its integrity even before being thermally affected. This resulted in preferred air flow pathways vertically up the casings and horizontally into permeable sandstone zones in the overburden. This also resulted in ignition difficulties in the wellbores because of excessive water influx from the overlying aquifers. This problem was solved by subsequent well recompletions.

The insoluble problem proved to be the fracture/fault system at the Hanna IV site. The fault pattern intersected the well line at a 45^o angle and the faults were of such high permeability that they became the major flow pathways. All attempts to complete reverse combustion linkage between wells resulted in tortuous links which followed the faults and eventually broke through to the appropriate wells, but always high in the coal seam. Repeated attempts to maintain linkages and gasification fronts low in the coal seam failed due to the natural permeable pathways.

The test was terminated after six different linkages were completed and three air gasification tests were conducted. Subsequent to Hanna IV, a high resolution seismic survey of the entire Hanna facility confirmed that Hanna IV was the only one of the five separate Hanna sites to intersect the fault system. It was the Hanna IV experience which resulted in more complete site characterization studies for subsequent UCG field tests at Rawlins, Wyoming and Tono, Washington for the DOE, and at Gillette, Wyoming for ARCO.

In 1979 LETC assisted Gulf R&D Co. in the operation of Steeply Dipping Beds (SDB) Test 1. LETC provided engineering support on site for Test 1, and provided Gulf with the complete data acquisition system.

In 1980 LETC began a hydrology/water quality monitoring program at the Hanna facility, and began a post-burn coring program at the Hanna facility. The hydrology program located and quantified the coal seam and overlying aquifers and the ongoing water quality program is determining the extent and longevity of the contamination of all aquifers due to the UCG process.

The post-burn coring program was designed to obtain data for confirmation and upgrading of the forward gasification and subsidence models. The Hanna II, phases 2 and 3, site was cored in 1980. The data shows that the overburden is extremely competent and subsurface caving occurred for about one seam thickness (30 ft) above the coal seam and a stable roof arch remains. Lateral extent of gasification was greater than predicted and the coal seam was gasified from floor to roof.

In 1980 LETC assumed administrative control of the Gulf R&D Co. contract for SDB Test 2. LETC provided ES&H support to Gulf, and became involved in the planning, design, and equipping of the test.

In 1981 LETC continued the post-burn coring program and completed the coring of Hanna III and Hanna II, phase 1. The cores are being analyzed. The coring of Hanna IV will be deferred. The hydrology/water quality monitoring program has shown that the water levels at all Hanna sites is at or approaching pre-burn levels.

Gulf R&D Co., with the assistance of LETC, completed SDB Test 2. This 70-day steam-oxygen test consumed 9000 tons of coal and produced 325 Btu/scf gas.

LETC and Gulf R&D Co. are planning the post-burn coring program for 1982. LETC will be responsible for the coring and analyses.

In 1981 LETC signed a cooperative project agreement with the State of Washington and the Washington Irrigation and Development Company (WIDCo). This agreement includes a modeling, laboratory, and field test program to investigate via UCG Washington's coal resource. Lawrence Livermore will perform most of the field work; LETC will provide the permits and the overall management of the project.

ACCOMPLISHMENTS IN THE TAR SAND R&D PROGRAM

Tar sand deposits in the United States are estimated to contain over 36 billion barrels of extremely viscous bitumen, a thick oil-like material. Over 80 percent of this material is found in several large deposits in Utah, although occurrences are known in 22 states. The bitumen is not recoverable by primary oil production methods due to the extreme viscosity and lack of reservoir energy. Thermal processes that reduce bitumen viscosity by heat and displace bitumen to wells for production appear to offer the greatest potential for tar sand oil recovery.

The U.S. tar sand resource and related recovery technology has never been a target of a major research effort by the private sector, perhaps due in part to the fact that most of the known resource is on federal land. The LETC tar sand activity has created the only multi-disciplined tar sand research staff in the U.S. The LETC tar sand program technical staff members and support staff represent approximately 200 man years of tar sand research experience in resource characterization, resource recovery, product treatment, reservoir access, environmental mitigation and control technology and compliance. The LETC assembled and managed tar sand data base is the only significant compilation of tar sand resource and technology data in the public sector. A program of informal data and information exchange has been developed and is maintained by the LETC technical program management staff between the LETC and all interested private and governmental concerns. This same LETC technical program management staff is responsible for the development of the several generations of the comprehensive tar sand research implementation program plan; this plan continues under development.

Resource Assessment

Standard petroleum reservoir core sample analytical procedures are not appropriate, without major modification, for the assessment of tar sand resources.

The LETC has developed standardized tar sand resource core sample analytical procedures. At the present, these LETC developed procedures are the standards that have been adapted by industry and commercial service laboratories.

Computerized data bases and calculative methods are required to correlate the characteristics of deposits of the tar sand resource with those of recovery technologies. This permits an assessment of development potential for specific tar sand resources. The LETC has completed the development of the computer data base framework and caculative methods to relate specific tar sand deposit characteristics to specific recovery technologies. This capability will insure that the most effective method for development of the resource at various sites can be selected and maximum recovery realized as deposits are characterized.

The need to characterize resource deposits has been recognized by all participants for resource evaluation and research planning purposes. The LETC staff has begun a process of characterizing major deposits by assembling all available resource data from all sources in the PR Spring

deposit in Utah into a single report, which will be published in February 1982. This activity is continuing for the Tar Sand Triangle deposit in Utah.

Development of the resource and recovery processes will require a water supply. To assist in the future development evaluations, the LETC staff contracted a study to determine the water availability for the Utah deposits and this report has been published.

Environmental Studies

No environmental data or information on tar sand resources and recovery existed in the U.S. The LETC designed and implemented a research plan to determine appropriate characteristics, environmental effects, and mitigation and control strategies for the in situ thermal tar sand recovery processes. The results of this effort constitute the only non-proprietary data and information currently available on tar sand recovery processes. The activity continues as new resource sites are identified and characterized.

Resource Recovery and Reservoir Access

The design of and completion procedures for well systems used in the recovery of tar sand resources did not exist before the LETC in situ thermal recovery field experiments. The LETC staff designed the system and developed the drilling and well completion procedures. Development continues but present commercial interests are using the LETC designs. In the field experiments, the LETC staff conducted the first U.S. hydraulic and pneumatic fracturing experiments to induce permeability in tar sand deposits. These experiments will continue until results are conclusive. In cooperation with Carbondale Mining Technology Center and through a contract with Ketron, the LETC staff is developing an improved base for estimating the U.S. mineable tar sand resource. Publication of this study is scheduled in early 1982.

Chemical Composition Studies

Product oils, waters, and gases from lab and field recovery experiments with tar sands have been evaluated. This work is aimed at determining the extent of upgrading of bitumen that results from the processing and to provide material balance information and data for environmental purposes. In order to provide data for experimental design and to assess the extent of upgrading, the original tar sands and bitumen are also characterized. Generally, it has been found that the product oils from in situ field experiments are chemically quite similar to the original oil (bitumen) in the formation. The composite product oil from in situ combustion does have significantly improved physical properties (much lower viscosity and pour point) compared to the in-place bitumen. Gases and waters from combustion appear to be capable of simple processing using existing technologies to be recycled or disposed. Product oils from the steam recovery experiment were very similar both chemically and physically to original bitumen. Ten publications have resulted from these studies, and two are currently being prepared.

R&D at the University of Utah

LETC has supported tar sand R&D efforts at the University of Utah (Departments of Chemical and Fuels Engineering and Metallurgy) for several years. Their efforts have been primarily dedicated to above-ground processing of tar sands or upgrading of oils produced from tar sands.

Hot Water Extraction of Domestic Tar Sands

Unlike Athabasca ore, most of the U.S. resource does not contain water-wetted sands, but rather the sand particles are coated with bitumen. The bitumen is usually more viscous from domestic ores. These differences indicate reasons why the hot water process used by the two commercial Canadian tar sand plants is not applicable to U.S. materials. A modified, hot water process was developed that recovers more than 95 percent of the bitumen from domestic ores. High shear in combination with hot water and added caustic is required. This process has been patented and is currently being developed at the pilot-plant scale by Enercor, a Utah company, operating with financing from the State of Utah and others.

Fluidized Bed Pyrolysis of Tar Sands

An alternate processing scheme being studied at Utah involves fluidized bed pyrolysis of tar sands. This process would likely require less water than the water-based separation and could result in one less major processing step in that the pyrolysis would accomplish first-stage upgrading by coking the bitumen. These studies have shown that liquid yields of 70 to 80 percent based upon bitumen are obtained. The coked sand is burned in a lower, second-stage fluidized bed to provide heat and fluidizing gas to the pyrolysis section. Another aspect that has been studied is the use of heated sand for preheating of air for the coke-burning section. The heat and material balances look promising for this scheme.

Upgrading Studies of Tar Sand Oils

Whatever recovery process is used, upgrading will be necessary before refining or end-use. Product oils from various recovery processes may contain too much residue, metals, sulfur, or nitrogen. Unsaturated compounds are present in pyrolysates. Utah personnel have done preliminary lab screening of visbreaking, delayed coking, catalytic cracking, and hydropyrolysis for upgrading of U.S. tar sand bitumens and oils recovered during LETC in situ combustion experiments. Although all of the processes have at least one advantage, hydropyrolysis has shown the most promise in providing high conversions (>85 percent in some cases) to distillable liquid products.

Studies at the University have resulted in 15 publications, two patents, three master of science theses, and four doctoral dissertations to date.

The following material represents a detailed description of the research to be performed in oil shale, underground coal conversion and tar sands. The activity and subactivity designations of proposed research are the same as those designations used in FY1982.

FY83 OIL SHALE RESEARCH PROGRAM

Oil Shale

Chemistry and Physics

Objectives and Tasks:

Mathematical Modeling

Develop mathematical modeling capabilities to predict retorting performance of nonuniform rubble configurations and combinations of rubble and fracture conditions. This capability is necessary to guide the identification of acceptable rubble and fracture conditions for low void retorting. The 2-dimensional model is also useful for evaluation of experimental relationships between flow distribution and oil yield losses in nonuniform oil shale rubble.

Verify the predictive capabilities of the 2-dimensional model in comparison with the experimental results of nonuniform rubble behavior in 10-ton and 150-ton retort tests.

Modify and improve the 2-dimensional model to predict the relative relationships of retorting parameters with rubble and fracture conditions at low void volumes.

Apply the 2-dimensional model to select only the most important rubble and fracture conditions for experimental confirmation of retorting performance at low void volumes.

Interpret 2-dimensional model predictions to identify the boundaries of acceptable rubble and fracture conditions for retorting oil shale at low void volumes.

Improve mathematical models to include the most current results of oil shale chemistry and physics research. These additional descriptions of reaction kinetics and shale oil drainage are necessary to improve the predictive capabilities for evaluation of experimental retort operations.

Add physical descriptions for the formation and deposition of suspended mist along with the drainage and recurrent distillation of product oil in oil shale rubble.

Incorporate reaction kinetics of shale oil coking into the physical description of product oil behavior in advance of the retorting zone.

Improve the kinetic descriptions and stoichiometry of kerogen conversion reactions during retorting.

Incorporate reaction kinetics for combustion of gases and hydrocarbon vapors to predict oil yield losses.

Reaction Kinetics

Develop CP/MAS and multiple pulse ^{1}H NMR techniques to distinguish organic hydrogen associated with the distribution of aliphatic and aromatic carbon in oil shale samples. These additional measurements are needed to evaluate the conversion of aromatic carbon in combustion and gasification reactions. This analytical technique may also be applicable for predicting relative reactivities of different oil shales with hydrogen.

Compare the distribution of aliphatic and aromatic hydrocarbons in oil shale samples from different U.S. deposits.

Evaluate the performance of field retorting experiments by determining the distribution of aliphatic and aromatic hydrocarbons in core samples.

Measure aromatic carbon recovery in novel processing experiments such as supercritical solvent extraction by determining the distribution of aliphatic and aromatic hydrocarbons in product shale samples.

Interpret measurements of aliphatic and aromatic hydrocarbons in different types of oil shale samples to identify chemical indications for reactivity with hydrogen or for reactivity of residual carbon in combustion and gasification reactions.

Develop a detailed chemical and kinetic description for conversion of oil shale kerogen. This description is necessary to identify more specific chemical indicators of retorting performance. A fundamental description of the reaction sequence may also identify novel processing concepts to increase kerogen conversion to product oil.

Measure isothermal production rates of oil and gas at different temperatures, and collect samples of all retorting products for chemical analysis.

Compare analysis of oil and gas samples by FT ^{13}C & ^{1}H NMR and mass spectrometry with shale analyses by CP/MAS NMR to identify any changes in the chemistry of kerogen conversion during the progress of thermal retorting.

Extract samples of soluble bitumen for analysis by FT ^{13}C & ^{1}H NMR to determine the reaction sequence for conversion of aliphatic carbon in kerogen to aromatic compounds in the product oil.

Interpret the reaction kinetics in combination with the chemistry of the experimental products to develop a fundamental description for kerogen conversion and to identify specific chemical indicators of retorting progress.

Utilize GC/MS analyses of specific biological markers in experimental products to identify more specific chemical indicators for retorting performance.

Develop a detailed chemical description for comparison of hydrogen reactivity with leaner oil shales. These descriptions are necessary to identify a specific chemical indicator for hydrogen reactivity. The measurement of hydrogen reactivity is necessary to evaluate processing alternatives for leaner oil shales.

Measure isothermal production rates of oil and gas at different temperatures and hydrogen pressures, and collect samples of all hydroretorting products for chemical analysis.

Compare analyses of oil and gas samples by FT ^{13}C & ^{1}H NMR and mass spectrometry with shale analyses by CP/MAS NMR to identify and changes in the chemistry of kerogen conversion during the progress of thermal retorting.

Determine the reaction sequence for conversion of aliphatic and aromatic carbon in kerogen to oil and gas products, and compare these results with conventional thermal retorting behavior.

Interpret the reaction kinetics in combination with the chemistry of the experimental products to develop a detailed comparison of hydrogen reactivity for different oil shales.

Develop reaction kinetics for coking of shale oil condensate in advance of an approaching retorting zone. This kinetic expression is necessary to predict oil coking losses in combination with the physical descriptions for formation and deposition of suspended mist and drainage of product oil in rubble beds.

Modify shale oil hydrotreating reactors to accommodate the simulation of a shale oil film on a rubble bed and the temperature profile of sweet gas from an approaching retorting zone.

Measure shale oil coking rates and product chemistry for shale oil films on inert rubble beds with different heating rates and temperature profiles for the sweep gas.

Measure shale oil coking rates and product chemistry for shale oil films on very lean shale rubble with different heating rates and temperature profiles for the sweep gas.

Interpret the reaction kinetics in combination with the chemistry of the experimental products to develop a fundamental description for shale oil coking and to identify specific chemical indicators for coking losses.

Develop sampling and analytical methods for real-time measurements of retort performance. These measurements are necessary to control operating conditions of laboratory retorting experiments. The real-time sampling and analytical techniques are also necessary to measure reaction kinetics for combustion of gases and hydrocarbon vapors in oil shale rubble.

Implement an experimental method for sampling gases and hydrocarbon vapors in operating retorts and for analyzing the samples on a real-time basis by mass spectrometry.

Measure chemical indicators of shale oil combustion and coking by mass spectrometry to provide real-time analysis of experimental retorting operations.

Measure the production of volatile sulfur compounds by mass spectrometry to provide real-time evaluation of sulfur chemistry in experimental retorting operations.

Measure the combustion of gases and hydrocarbon vapors during experimental retorting operations to determine the kinetics for these reactions in oil shale rubble.

Novel Process Concepts

Develop relationships between shale particle size and moisture levels to retort oil shale with sulfur trioxide. These relationships are necessary to determine maximum rubble sizes for practical in situ retorting applications. There may also be applications for sulfur trioxide reactions in surface retorting processes.

Measure sulfur trioxide reaction temperatures with different particle sizes of oil shale rubble at various preheat temperatures.

Measure reaction temperatures for different sizes of shale particles which are contacted with preheated sulfur trioxide at temperatures of 200-800°F.

Measure reaction temperature for different levels of surface moisture on varying sizes of shale particles which are contacted with preheated sulfur trioxide at temperatures of 500-800°F.

Identify relationships between shale particle size and moisture level for achieving retorting temperatures by reactions with preheated sulfur trioxide.

Develop material and energy balances for retorting oil shale rubble with sulfur trioxide. These material and energy balances are necessary to determine operable conditions of particle size and moisture levels for sulfur trioxide retorting. Analysis of the retorted shale is also necessary to determine the potential of sulfur trioxide retorting for mitigation of environmental impacts.

Collect and analyze products from sulfur trioxide retorting experiments with different sizes of oil shale rubble and varying moisture levels.

Collect and analyze products from sulfur trioxide retorting of western oil shales with different sulfur concentrations.

Collect and analyze products from sulfur trioxide retorting of leaner oil shales with different sulfur and moisture concentrations.

Calculate material and energy balances to compare oil yields and sulfur requirements for different types of oil shales and various size distribution.

Develop a detailed understanding of supercritical fluid extraction (SFE) behavior for both western and eastern oil shales. Additional experiments are needed to compare results with existing conversion technologies. The chemical and/or physical phenomena that result in the lower temperature conversion to liquids need to be interpeted with regard to similar extraction schemes that have been applied to coal.

Determine reaction kinetics for kerogen conversion to liquids during SFE.

Determine the extent of organic solvent loss or incorporation into products.

Evaluate the need for solvent clean-up before recycling.

Compare liquid yields for SFE processing of Devonian shales with yields from the IGT Hytort process.

Provide detailed characterization of liquids, inorganics, gases, and residual carbon for SFE processing of western oil shales. Data are needed for comparisons with other processing technologies.

Analyze product oils using techniques that are available for heavy fossil liquids.

Coordinate analysis of residual carbon with studies using CP/MAS NMR for other characterization.

Complete the evaluation of alternations in inorganics. This study will coordinate closely with similar studies on inorganics in shales that are primarily to address environmental questions.

In coordination with other environmental studies, analyze gases from SFE with emphasis on sulfur species that might result.

Chemistry of Heteroatoms

Determine the chemical structures associated with heteroatoms in oil shale kerogens. The study may be applied to whole oil shales to avoid the need for kerogen isolation.

Analyze Western and Eastern oil shales by CP/MAS NMR and FTIS for species associated with heteroatoms.

Perform selective oxidations of nitrogen and sulfur compounds in kerogens with peroxides to oxygenate these heteroatoms. Analyze by the same spectroscopic techniques as above.

If available, determine the chemical environments of heteroatoms in kerogens and selectively oxidized products by FAB high-resolution mass spectrometry.

Determine if selective oxidation of heteroatomic species in kerogens reduces their content in primary products from thermal processing.

Perform a series of pyrolysis experiments on slightly oxidized oil shales.

Compare the elemental composition of product oils from such experiments with those from control experiments in which kerogens were not oxidized.

If results warrant, complete detailed analyses of gases, oils, and chars from the recovery experiments.

Determine the extent of oxidation that can be accomplished without significant loss of liquid product yields.

Develop analytical approaches to arsenic compounds in oil shales and shale oils.

Complete a comprehensive literature survey on arsenic analysis and chemistry in inorganic and organic forms.

Select and apply the most promising analytical methods to analysis of specific arsenic forms in oil shales.

Select and apply the most promising analytical methods to analysis of specific arsenic compounds in shale oils, chars, and product gases.

Compare the results of analysis to provide a hypothesis concerning the origin of arsenic species in products.

Complete evaluations of shale oil fractions as asphalt replacements or as rejuvenators for aged asphaltic pavements.

Extend empirical correlations between basic nitrogen content and usefulness of high-boiling fractions of shale oils as recycling agents.

Complete the studies of shale oil residues as petroleum asphalt replacements.

Continue to analyze raw and upgraded shale oils for nitrogen compound types as available.

Compare the utility of these by-products with the better materials in use for these purposes from current commercial sources.

Rock Fragmentation

Objectives and Tasks:

Nonuniform Rubble Behavior

Develop experimental relationships between flow distribution and oil yield losses in nonuniform rubble beds. These relationships are performance specifications for rubble uniformity in terms of minimum variations in rubble size and bed porosity. Direct measurements of sweep efficiencies will also provide an experimental basis for development of remote gas tracer techniques to predict oil yields in advance of retort operations.

Determine experimental sweep efficiencies for ideal symmetrical flow channels as a result of radial variations in rubble size and bed porosity over the cross-section of the 10-ton retort.

Measure oil yield losses as a result of radial variations in rubble size and bed porosity corresponding to ideal cylindrical flow channels in the 10-ton retort.

Identify relationships between sweep efficiency and oil yield losses for 3 different sizes of cylindrical flow channels and 3 radial variations in rubble size and bed porosity.

Test the relationships between sweep efficiency and oil yield losses for 3 different combinations of multiple flow nonuniformities in 150-ton rubble beds.

Develop remote gas tracer techniques to predict retorting performance of nonuniform rubble beds. These predictions are necessary to evaluate explosive rubbling experiments in advance of actual retort operations. Determination of experimental sweep efficiencies will verify interpretation of remote tracer measurements.

Determine the flow distribution through 3 different sizes of cylindrical channels in oil shale rubble as a result of radial variations in rubble size and bed porosity over the cross-section of the 10-ton retort.

Determine the changes in flow distribution through cylindrical channels in oil shale rubble for 3 different radial variations in rubble size and bed porosity.

Interpret remote gas tracer measurements to predict the sweep efficiency of retort operations with 3 different sizes of cylindrical flow channels and 3 radial variations in rubble size and bed porosity.

Test the interpretation of remote gas tracer measurements to predict sweep efficiencies and retorting performance for 3 different combinations of multiple flow nonuniformities in 150-ton rubble beds.

In Situ Rubble Interrogation

Develop remote capabilities of downhole TV systems to control visual inspection and to perform multiple functions. These capabilities are necessary to interrogate void spaces as well as rubble surfaces and to control other downhole functions such as the placement of remove release tracer canisters.

Interrogate experimental field retorts with high resolution, full color TV logging to a depth of 2500 feet in either air- or water-filled wellbores.

Interpret downhole TV logging data to estimate the distribution of rubble size and void volume, and to describe the nature and location of specific nonuniformities.

Incorporate image transfer devices into the downhole camera viewing system to interrogate void spaces by remote control of camera rotation and directional orientation.

Implement visual control of a grappling system to locate remote release tracer canisters in experimental rubble beds by communicating control functions through the single coaxial cable for operation of the downhole TV camera.

- Instrument experimental field retorts with remote release tracer canisters to measure local variations in flow distribution. The release of the gas tracers in individual regions of the experimental rubble beds is controlled remotely by separate frequencies of VLF electromagnetic waves. These techniques are necessary to evaluate the performance of explosive rubble experiments.

  Construct 5 tracer canisters with different control frequencies, and shield the individual canisters to survive an in situ rubbling test.

  Install the 5 canisters in the interior of an experimental rubble bed with the downhole TV camera system.

  Release the gas tracers from individual canisters by remote control, and detect the gas tracers to evaluate the performance of the explosive rubbling experiment.

  Design and build an amplifier and encoder for individual control of about 40 canisters to provide more thorough evaluation of large experimental retorts.

- Develop interpretive procedures for evaluating gas tracer data to determine the volume and distribution of voids in oil shale rubble. These improvements in the interpretation of tracer response data are necessary to increase the accuracy and reliability of remote procedures for estimating sweep efficiency in nonuniform oil shale rubble.

  Determine the effect of rubble particle size on the measurement of void volume with gas tracers.

  Determine the effect of particle shape on gas tracer measurements of void volume in rubble beds.

  Determine the effect of rubble size distribution on the measurement of void volume with gas tracers.

  Identify the most reliable procedures for interpreting gas tracer measurements to determine the volume and distribution of void space in oil shale rubble.

Monitor the progress of explosive rubbling tests at industrial field sites. These tests are opportunities to demonstrate the practical applications of remote techniques for evaluating explosive rubble performance. Remote interrogation procedures provide the opportunities for participation in the industrial field experiments to determine progress in the empirical development of explosive rubbling methods.

Identify opportunities for application of remote interrogation procedures to evaluate explosive rubbling experiments through cooperative research agreements with industrial operators.

Determine results of explosive rubbling experiments to provide guidance in the selection of nonuniform rubble configuations for simulating field experience with 10-ton and 150-ton retorting equipment.

Interpret performance of nonuniform rubble tests with the 10-ton and 150-ton retorts to provide recommendations for the design and evaluation of industrial explosive rubbling experiments.

Determine the utility of remote predictive techniques and laboratory experiments for evaluating field rubbling experience, and recommend new research objectives to advance progress in the development of explosive rubbling technology.

Low Void Rubble Configurations

Identify significant operating parameters that control oil yield losses in uniform rubble and fracture conditions at low void volumes. The relationships of retorting parameters with rubble and fracture conditions are necessary to develop specifications for explosive rubbling technology. The verification of mathematical model predictions is also dependent on experimental determination of these relationships.

Determine effects of shale oil production rates on oil yield losses with uniform rubble and fracture conditions at a constant low void volume.

Determine effects of shale grade on oil yield losses with uniform rubble and fracture conditions at a constant low void volume.

Determine oil yield losses for different void and rubble distributions between vertical and horizontal fracture planes at a constant low void volume.

Determine oil yield losses for different sizes of oil shale fragments with rubble-filled fractures at a constant low void volume.

Determine operable conditions to ignite and sustain combustion retorting at different rubble and fracture conditions in the range of 8-15% void volume. The limiting relationships between shale grade, fragment size, and interstitial rubble with void volume are necessary to design an acceptable explosive rubbling method. The determination of acceptable rubble and fracture relationships is also necessary to develop novel in situ process concepts for shale oil production from lean oil shale deposits.

Determine operable shale oil production rates and oil yield losses for uniform rubble and fracture conditions in the range of 8-15% void volume.

Determine operable shale oil production rates and oil yield losses for different grades of oil shale with uniform rubble and fracture conditions in the range of 8-15% void volume.

Determine operable shale oil production rates and oil yield losses for different sizes of oil shale fragments with rubble-filled fractures in the range of 8-15% void volume.

Interpret the importance of oil shale rubble in the interstices between oil shale fragments of different sizes to determine the design specifications for acceptable explosive rubbling methods at low void conditions.

Rock Mechanics

Determine significant mechanical properties that limit the minimum void conditions for application of explosive rubbling technology. These interpretations are necessary to guide the selection of experimental rubble and fracture conditions for development of explosive rubble specifications.

Measure strain rate, tensile strength and compressive strength for large diameter oil shale cores from different locations.

Evaluate creep behavior for oil shale samples from different locations.

Perform triaxial testing of oil shale samples from different locations, and determine 3-dimensional constitutive relationships.

Interpret mechanical properties of different shale samples to determine initial void requirements for producing acceptable rubble and fracture conditions with explosive rubbling technology.

Environment

Objectives and Tasks:

Geochemical Regimes for Selected Feedstock Constituents

Determine distribution of sulfur in Green River oil shales using existing sample archives at LETC, and oil shale geology, stratigraphy, and lithographic skills. This activity is necessary for developing emission factors for sulfur and eventual source terms for long-term oil shale development and environmental mitigation.

Assemble existing data and select locations and samples for mineralogy and petrography.

Perform X-ray analyses of core samples for sulfur forms and chemical analyses for organic sulfur.

Determine lithology and petrography to identify primary and secondary pyrites and correlate results by lithology and Fischer Assay stratigraphy technique.

Utilize computer capabilities to generate cross sections, contour maps and tables showing sulfur distributions by strata and location in Green River Formation oil shales.

Utilizing process chemistry and emission control cleanup capability scenarios which will vary in detail, develop emission factors for sulfur as a function of location.

Determine resource requirements for shale oil recovery processes. Since each process has its own set of requirements for economical resource recovery and its own effects on the environment, it is necessary to know those requirements and effects in order to match resources with appropriate recovery processes. Information will be assembled from the appropriate subactivities to define the resource requirements for mining, fracturing, retorting, etc. of the resource.

Evaluate resource areas in relation to process requirements established in determining development potential for shale oil recovery processes. Definition of resource recovery processes can be applied to achieve efficient utilization of the oil shale resources. Resource characteristics which relate to environmental considerations and limitations will also be taken into account.

Determine distribution of arsenic and other sensitive elements in Green River oil shales in conjunction with and in analogy to sulfur distribution activity.

Chemistry and Physics of Mobilization

Develop and refine environmental fractionation and analysis methodology for environmental control technology research. Special methodology is needed for characterization and evaluation of complex materials in synfuels process streams and effluents. Much detailed analytical data exists for raw products and some by-products. Techniques used in these analyses have been too cumbersome, expensive and unfocused for control technology development research. The methodology developed will form the basis for measurements in the subsequent activities in Product/By-Product, and Process Evaluation and the Environmental Control Process Operations Research and in the very long term, project monitoring activities.

Develop aqueous product analyses based on environmental/process mimetic fractionation and HPLC and GC fingerprints for organics.

Develop ionic analyses using ion chromatography for rapid turn around as for example in stripper operations on site to determine sulfur species, ammonia and fixative anions.

Develop and validate methodology for sulfur and sulfur species determination in retort and stripper gaseous streams.

Develop and validate methodology for trace elements and their species determination in retort gaseous streams.

Characterize products and by-products in retorting and environmental control process operations streams. For a systems approach in control technology research the essential nature of all parts of the process must be defined. The level of analytical detail will vary from cursory fingerprinting to detailed species identification as required for evaluation.

Characterize gaseous streams from retorts, from gas control operations, from strippers, and from evaporation pond.

Characterize aqueous streams from retort, from gas control operations, and from water treatment operations.

Characterize nonaqueous liquid products from retort, from gas control operations, and from water treatment operations.

Characterize residuals from retort from gas control operations, and from water treatment operations. The in-house RCRA project will be accessed for standardized solids testing.

Environmental Control Process Operations Research

Perform a series of product gas stream environmental control technology research experiments for process/product evaluation. These experiments are necessary because of the transient nature of many of the materials and conditions produced. From these scoping experiments and the operating conditions observed, laboratory simulations may be devised for certain aspects of the system to develop detailed understanding of the chemistry, physics and engineering.

One 150-ton scale experiment evaluating liquid scrubber performance over a bounding range of variables. Samples of all phases will be collected for evaluation.

Three 10-ton scale experiments evaluting mist eliminator performance alone, in comparison with liquid scrubber and these units in series. Samples of all phases will be collected for evaluation. Institute novel processes.

Six 2-ton (low Void) scale experiments evaluating gaseous stream product (gas/liquid/solid) correspondence at three scales (150-ton, 10-ton, 2-ton). Samples of all phases will be collected for evaluation.

Design and implement laboratory simulations of aerosol collection and sulfur removal.

Perform a series of process/product water environmental control technology research experiments for process/product evaluation. These experiments are necessary to produce materials for effluent and by-product research and operating information for process/system evaluation. Unit processes being evaluated singly and in compound process trains are as follows.

Coagulation - Flocculation

Foam Fractionation

Dissolved Air Flotation

Powdered Activated Carbon (Batch)

Granular Activated Carbon (Continuous Flow)

Reverse Osmosis

Wet-Air Oxidation

Land Application

Electrochemical Coagulation

Biotechnology

Evaporation (Including Ponding)

Characterize and evaluate mobilization processes important in environmental control technology research. The mobilization or demobilization process is the basic element in environmental impact control through process engineering and therefore needs to be well understood for each species of potential concern evolved in oil shale processing.

Sulfur chemistry in the retort process.

Chemistry of arsenic and other potentially deleterious elements in the retort process.

Fate of hydrocarbons in gaseous and liquid streams including oil/water separators.

Exchange phenomena in gaseous/liquid/solid systems, equilibria, kinetics, mass transfer.

Develop fundamental relationships to describe wet scrubbing concepts to control the chemical character of oil shale conversion process streams. Long-term goals of trace material recovery and increased product recovery are being addressed in these 1983 goals and objectives.

Evaluate data from venturi contacting wet scrubber of off-gas emissions from oil shale retorting on pilot-scale 10 and 150-ton retorts at the North Site.

Establish a quality data base for fossil energy use by using uniform scientific procedures for sampling and analytical characterization of fossil fuels and wastes. There is a need for long term monitoring concerns to be included in the oil shale program for evaluation of fossil energy waste associated with promising technologies both in the process of liquid production and control of effluent for an integrated waste management program.

Implement sampling and analysis projects to earn and maintain technical expertise for hazardous waste management of facilities in the fossil energy oil shale program.

Implement sampling and analysis tasks for shale oil process waters, intermediate products, and spent shale on all retorting research to determine leachate quality of feedstocks and wastes.

Maintain fundamental reference data base on this broad spectrum of fossil based fuel feedstock, intermediate products, and waste materials from existing and emerging technologies.

Assess costs/benefits of residuals from process streams. This work is needed from an environmental and process standpoint for ultimate process cost and environmental impact-tradeoff analysis, and development of advanced recovery systems.

Collect/determine residuals in gaseous stream effluents.

Collect/determine residuals in aqueous streams, retort water condensate, stripper bottoms, other unit process sludges, brines, foamates, ashes.

Interact with in-house RCRA project for standard hazardous waste testing.

Evaluate residuals for potential for use of organic materials.

Evaluate residuals for potential for strategic metals recovery and toxic materials immobilization.

Systems Evaluation

Evaluate processes relating to retorting and environmental control technology from an overall systems perspective. The overall objective of the whole project is, having a sufficient operational and product characterization data base, to be able to evaluate units, combination of units, processes and systems. Evaluation of the total energy recovery system is a goal, but is a long way off. Current work in a first phase aims at evaluating first order models of processes being studied in Environmental Control Process Operations Research and testing them in conjunction with that activity.

Test ammonia/hydrogen sulfide/carbon dioxide stripper models in conjunction with stripper operations.

Begin model construction for hydrogen sulfide scrubbing in aqueous amine solutions.

Develop models for water treatment unit process operations and begin study of coupled systems.

Begin model of sulfur conversion in retorting operation.

Design Research Spent Shale Pile. In the event of continued operation at the Anvil Points Facility, an environmentally safe and secure disposal facility is necessary. Design of the research spent shale pile is to be completed in September 1982. The research design is being conducted by the U.S. Army Corps of Engineers Waterways Experiment Station's Geotechnical Laboratory Storage Piles and will consist of environmental design provisions for a 40 year period of retorting research. The final design will be for a stable configuration of 1.25 million cubic yards of fill. The initial through final design will be provided with instrumentation and wells to monitor groundwater in and below the fill, fill temperatures, fill moisture, heat, settlement and embankment stabilities.

The research design will include the following integrated engineering and scientific objectives:

Select site.

Select permanent surface fills for spent, reject, and run-of-mine shale.

Select temporary surface fills for stockpiled raw feed shale for retorting and run-of-mine raw shale.

Determine fill location, foundation, and hydrologic character.

Determine engineering fill properties of Paraho retorted shale.

Analyze alternative fill configurations.

Analyze stability under static and dynamic conditions, both with and without seepage forces.

Select fill stability monitoring instrumentation alternatives.

Design compactive efforts required for spent shale embankment, including controlled channelization of seepage and runoff for shale leachate contaminant control.

Design compactive efforts for layered raw and spent shale to create impermeable barriers preventing combustion and water infiltration.

Determine alternative hydrologic and water quality monitoring well locations.

Complete surface and subsurface restoration of the Rock Springs and Talley sites in agreement with Wyoming DEQ guidelines.

Monitor groundwater chemical constituents to determine the need for aquifer restoration work.

Complete the revegetation on the Rock Springs site.

Complete well sealing and surface revegetation at the Talley site.

Assure compliance with applicable federal, state, and local laws and regulations at the North Site.

Dispose of solid and liquid waste materials to assure continued operation of the 10-ton and 150-ton retorts.

Obtain required permitting to keep the North Site operating in accordance with current compliance and safety regulations.

FY83 UCC RESEARCH PROGRAM

DATA EVALUATION

The objective of the Data Evaluation activity is to develop and maintain the UCG technology data base including all data from DOE-sponsored field tests. This activity resulted in the compilation of process data from all federally-sponsored UCG tests into a common format for comparison and correlation. This activity provides for evaluation of UCG test results. Major subactivities include process data evaluation, thermal data evaluation, and test series evaluation.

Process Data Evaluation

This subactivity provides for the assembling, collating, and organizing of all available process data from all known UCG tests. In FY 1981-82 operating data from eleven federally sponsored tests were collected and formated. Updates will be required as data become available.

Objective and Tasks

The objective of this subactivity is to update the process data base to include data from most recent tests. Tasks include:

- Include SDB Test 2 process data to data base
- Include Tono project large block test process data to data base.

Thermal Data Evaluation

This subactivity provides for the assembling, collating, and organizing of all available thermal data from all known UCG tests.

Objective and Tasks

The objective of this subactivity is to develop and maintain the thermal data base for all available UCG tests. Tasks include:

- o Thermal data acquisition for Hanna series of tests
- o Thermal data acquisition for Hoe Creek series of tests
- o Thermal data acquisition for North Knobs series of tests
- o Thermal data acquisition for Pricetown I
- o Thermal data acquisition for Tono project tests

Test Series Evaluation

This subactivity provides for detailed evaluation of all data for a series of field tests performed at one site.

Objective and Tasks

The objective of this subactivity is to correlate field test results with all possible conditions: geologic, hydrologic and process. The FY 1983 tasks will be:

- o Complete collection, compilation, and publication of all data pertinent to the Hanna UCG test series.

SUPPORTING RESEARCH

The objective of the Supporting Research activity is to develop or improve instrumentation or techniques for data collection, site interrogation, reaction zone mapping, laboratory experimentation, mathematical modeling, linking, gasification, etc. This activity has produced laboratory experimental and modeling programs at ETC's, NL's, and univerities; TV cameras, logging tools, and other interrogative site characterization tools and the cornering water jet drill. Major subactivities include

laboratory experimental, mathematical modeling, site interrogation tools, and the cornering water jet drill system.

Objective and Tasks

The objective of this subactivity is to simulate field test conditions in the laboratory in order to correlate coal characteristics with the UCG process and to qualitatively predict scaling effects. Tasks include:

- o Perform lab experiments on Texas lignites, New Mexico subbituminous, and Illinois bituminous to determine cavity development
- o Perform lab experiments on various coal types to determine materials properties effects on UCG

Mathematical Modeling

This subactivity has been a continuing effort since 1974. Both one-dimensional and multi-dimensional models have been developed to study reaction, flow, and rock mechanics problems; drying, pyrolysis, water intrusion, and other process phenomena are also being investigated. Several UCG process models have been developed to describe the reverse combustion and forward gasification phenomena. To various degrees these models include the effects of physical, chemical, and geological phenomena incident to UCG. These modeling efforts will be continued, and the models will be correlated and combined into one or a few process models which accurately predict the relative merit and utility of UCG at any specific site.

Objective and Tasks

The objective of this subactivity is to develop mathematical modeling capabilities to predict the performance of UCG in any specific set of process conditions, i.e., coal type, geologic setting, hydrologic setting, seam thickness, depth, injectant. Tasks include:

- o Continue the comparative analysis of UCC models at LETC
- o Continue the 2-D process modeling effort
- o Continue the cavity formation modeling effort
- o Continue the general modeling of UCG in Texas lignites
- o Continue the subsidence modeling effort
- o Continue the reverse combustion and water influx modeling effort
- o Continue the forward combustion modeling effort

PROCESS TECHNOLOGY DEVELOPMENT

The objective of the Process Technology Development activity is to develop a commercially acceptable energy production technology by UCG. Development of the technology is by investigation of the critical variables of UCG which will result in a predictable and reliable technology. This activity provides for field tests to resolve the major technical uncertainties which impede predictability and reliability. The technical uncertainties include:

- o Effects of coal and overburden properties on the process
- o Effect of early time cavity development on the process
- o Process control
- o Reliable methods for connecting boreholes
- o Reliable methods for completing wells
- o Scaling effects of the process

This activity is designed to resolve these uncertainties through a series of field tests in various ranks of coal, in various types of overburden, and in various well pattern configurations.

Subbituminous Projects

This subactivity provides for the field testing of UCG in subbituminous deposits, primarily in Wyoming, New Mexico, and Washington. Since 1973,

twelve field tests have been conducted in subbituminous seams: six at Hanna, Wyoming; three at Hoe Creek, Wyoming; two at North Knobs, Wyoming; and one set of five large block tests at Centralia, Washington. The results of these tests have demonstrated the technical feasibility of UCG in subbituminous seams. The field tests, while successful, have highlighted some technical uncertainties.

Objective and Tasks

The objective of this subactivity is to investigate the critical variables of UCG in subbituminous coal seams through field testing. Since FY 1980 the subactivity has been implemented at a field site near Centralia, Washington. A series of five shallow, well-instrumented, and controlled outcrop or large block tests was conducted. The five tests indicated good product gas and insensitivity to steam/oxygen ratio and flow rates. The next step is to conduct larger tests. The tasks for FY 1983 include:

- Conduct a 30-day coal face test using the CRIP method of gasification on a large enough scale to allow for several injection point retractions and burn cavity interactions.

- Prepare for a 90-day CRIP test at the same site for conduction in FY 1984

Bituminous Projects

This subactivity provides for the field testing of UCG in bituminous deposits, primarily in Illinois and Ohio. In FY 1982, Williams Brothers Engineering Company, under contract to DOE, completed an assessment of UCG in bituminous coal seams. The assessment described the bituminous coal resources of the U.S., identified those resources potentially amenable to UCG, identified products and markets in the vicinity of target areas, identified UCG concepts, described the state of the art of UCG in

bituminous coal, and presented three R&D programs for development of the technology to the point of commercial viability.

Objective and Tasks

The objective of this subactivity is to investigate the critical variables of UCG in bituminous coal seams through field testing. Since 1974 the subactivity has been implemented by METC at a field site near Pricetown, West Virginia. One field test, Pricetown I, was completed and confirmed the feasibility of UCG in bituminous coal seams. The Pricetown site has less than optimal site characteristics, and was abandoned in FY 1982. The Williams Brothers study and results of the Tono project large block tests have indicated that the logical next steps in this subactivity are to conduct small scale field tests. The tasks for FY 1983 include:

- Characterize sites in Ilinois and Ohio designated by Williams Brothers study
- Begin engineering designs for testing designated by Williams Brothers study.
- Begin engineering designs for coal outcrop tests involving CRIP and WJD systems.

Post-burn Evaluation

This subactivity provides for the burn coring and interrogation of all UCG field tests. Of the thirteen federally sponsored UCG field tests in the U.S. since 1973, eleven have been cored and the Tono large block tests have been excavated. The one remaining field test to be cored is Hanna IV. Coring has become part of the field test evaluation, and will be included in all future UCG field tests.

Objective and Tasks

The objective of this subactivity is to correlate the post-burn in situ conditions with the pre-burn conditions and the UCG process. The techniques for post-burn evaluation include drilling and coring, high resolution seismic surveys, sonar surveys, geophysical logging, TV logging, core and chemical analyses. Tasks for FY 1983 include:

- o Complete evaluation of Hanna III and Hanna II Phase I analyses
- o Complete evaluation of Steeply Dipping Beds Test 2 analyses
- o Complete field program at Hanna IV, including drilling, coring, geophysical and TV logging, high resolution seismic survey, sonar survey, and core description
- o Begin core and chemical analyses for Hanna IV cores
- o Plan for coring program at Tono project CRIP I

ENVIRONMENTAL, SAFETY AND HEALTH

The objectives of this activity are: to provide compliance documentation (permits and reports) to regulatory agencies and DOE in accordance with the DOE 5480 series of orders; and to develop the environmental monitoring and mitigation procedures and equipment needed for development of the technology. In FY 1983, LETC will assume responsibility for environmental compliance at all DOE UCG field sites: Hanna, Hoe Creek, Pricetown, and Centralia. LETC will also maintain a presence at Gulf's North Knobs site. The Pricetown site is scheduled for abandonment in FY 1982. The Tono project large block tests near Centralia, Washington, were fully permitted by LETC, but little effort is required. The property owner, WIDCo, intends to assume full environmental responsibility for further field tests, e.g., CRIP I and II or Tono I. Therefore, LETC terminated its Tono I permitting tasks, and LLNL its site characterization tasks. The major environmental compliance efforts will be made at the Hanna and Hoe Creek sites. Each site is permitted by the Wyoming DEQ and each permit requires a 4-5 year water quality monitoring program.

In assuming responsibility for the Hoe Creek site, LETC will necessarily assume the land use agreement with BLM, and will need to resolve the performance bond issue with the DEQ.

In addition to environmental compliance, LETC will continue a modest effort in environmental R&D, i.e., environmental control technology. The primary environmental concern in UCG is groundwater contamination, and research will continue in the areas of groundwater contaminant dispersion and cleanup.

Major subactivities include environmental compliance and environmental R&D.

Environmental Compliance

This subactivity provides for environmental compliance at all DOE UCG sites. The specific compliance requirements vary from state to state and from site to site. At Hanna, LETC is committed to a groundwater monitoring program through FY 1984 before the Wyoming DEQ makes a decision about groundwater restoration requirements. LETC is also committed to surface reclamation/restoration responsibilities. LETC will negotiate for a decision by DEQ on the action required for filling the surface collapse at Hoe Creek III. At North Knobs, Gulf R&D Co. is responsible for reclamation/restoration, and LETC is monitoring Gulf's actions. LETC manages the Gulf R&D Co. contract for the North Knobs UCG work, and LETC might be required to assume reponsibility for compliance if Gulf R&D Co. defaulted. At Tono (Centralia), LETC is responsible for compliance on the Large Block Tests, including the site excavation. Since Tono I is deferred, no permitting or compliance at the Tono I site will be considered, although LETC in FY 1981-82 laid the groundwork for the necessary permitting, and could reinstitute the permitting process on short notice. At Pricetown, METC will abandon the site in FY 1982, but LETC is monitoring METC's action. LETC might be required to assume any further responsibility at Pricetown in the future.

Objective and Tasks

The objectives of this subactivity are: to provide compliance documentation (permits and reports) to regulatory agencies and DOE in accordance with the DOE 5480 series of orders; and to acquire the data necessary and agreed to for the compliance documentation. Tasks include:

- Hanna

  The Hanna UCG facility has been in use since 1972. Six UCG field tests, Hanna I-IV, have been completed. Until the late 1970's federal agencies were under no constraint to obtain state permits for federal-sponsored R&D. Since 1978, LETC has cooperated with the Wyoming Department of Environmental Quality to bring the Hanna facility into compliance with state regulations. LETC's and the state's concerns at Hanna are for surface reclamation and for groundwater quality restoration. Surface reclamation is expensive but straightforward. The Hanna I-III sites have been cleaned up and require only successfully reseeding. Hanna IV needs to be cleaned up, recontoured, and reseeded. Assuming successful reseeding in FY 1982-83, the remaining surface work will be removal of the two permanent buildings, and reclamation of the main roads. These tasks will be delayed until the year Hanna is abandoned.

  Groundwater quality restoration is the major concern at Hanna and all UCG sites. LETC has an agreement with the state to monitor quarterly the groundwater quality in a minimum of 31 wells at the Hanna facility for a period of five years (1980-1984). After the monitoring period, the state will decide to release DOE from its commitment, extend the monitoring period, or insist upon active cleanup of the groundwater, e.g., by pumping all water to the surface, cleaning it, and reinjecting it. While it is impossible to predict the cost of active cleanup, worst case estimates in excess of 1000K$ per year per site have been submitted to LETC.

Subtasks include:

- Restoration of Hanna IV
- Reseeding of Hanna I, II, and III
- Groundwater monitoring
- State contacts, report preparation, and site audits

o Hoe Creek

The Hoe Creek UCG facility has been in use since 1974. Three field tests, Hoe Creek I-III, have been completed. Since 1975, LLNL has generally cooperated with the state to obtain permits and comply with State regulations. LLNL holds a performance bond of 200K$ if they do not restore the facility to the state's satisfaction. Surface reclamation is complete except for successful reseeding. LLNL has an agreement with the state to monitor quarterly the groundwater quality in selected wells at the Hoe Creek facility for a period of five years (1979-1983). After the monitoring period, the state will decide on passive versus active groundwater quality restoration. The agreement is quite similar to the LETC agreement for the Hanna facility.

In FY 1982, LETC, with the concurrence of the UCC program manager, decided to assume full responsibility for compliance at the Hoe Creek facility in 1983. LETC requires no performance bond at Hanna as is required at Hoe Creek. LETC will propose the bond be eliminated in FY 1983 based on performance record at Hanna since 1980.

Subtasks include:

- Revegetation
- Groundwater monitoring
- Subsidence monitoring/mitigation
- State contacts, report preparation, and site audits

o North Knobs

The North Knobs UCG facility has been in use since 1977. Two UCG field tests, SDB T1 and T2, have been completed by Gulf R&D Co. through a cost-shared contract with the DOE. Gulf R&D has been responsible for all permit acquisition and compliance. Since FY 1980, LETC has been responsible for related contract management and has monitored all ES&H tasks under the contract. While Gulf R&D has immediate responsibility for environmental compliance, DOE shares the ultimate responsibility since DOE is the 95% partner in the contract. LETC recognizes the possibility of legal responsibilities and, therefore, monitors all Gulf R&D environmental tasks. Gulf R&D has an agreement with the state similar to those for Hanna and Hoe Creek.

Subtasks include:

- Monitoring of Gulf R&D Co. compliance

o Centralia

The Centralia UCG facility has been in use since 1980. Five small outcrop tests have been completed by LLNL and the property owner, Washington Irrigation and Development Co., WIDCo. LETC acquired all necessary permits for the tests.

Due to the nature of the tests, the planned use of the test site by WIDCo, and the flexibility of state regulations and state interpretation of the regulations, no reclamation/restoration of the site is anticipated.

Subtasks include:

- State contact, report preparation, and site audits

o Pricetown

The Pricetown UCG facility has been in use since 1973. One UCG field test, Pricetown I, has been completed by METC. Since 1973, METC has cooperated with the State of West Virginia and the EPA to acquire permits and maintain the facility in compliance with state regulations. In early FY 1982, it was decided by LETC and HQ to abandon the Pricetown facility by the end of FY 1982. METC intends to complete abandonment in FY 1982, but if necessary, LETC will assume responsibility in FY 1983.

Subtasks include:

- Monitor abandonment of site

Environmental R&D

Regulatory environmental standards to protect air, water, and land resources are the driving forces to providing acceptable emission effluent, and control of chemical species mobilized or produced by UCG. Intimate knowledge of the process in terms of what species are produced is required to provide regulatory agencies and industries with procedures to monitor chemical species release in air, groundwater, and land environments. Advanced monitoring research is needed to sample and analyze sources of emissions or effluent and show how control of any species released by UCG is effective. Analytical methods traceable to acceptable standards and the appropriate sampling frequency need determination before adequate monitoring approaches and control or mitigating alternatives can be implemented.

Objective and Tasks

The objectives of this subactivity are: to determine the chemical contaminant species origin and fate as related to UCG; and to develop environmental impact mitigation methods, especially relating to groundwater restoration. Tasks include:

- Environmental Monitoring Research
  - Key indicator sampling and analytical techniques
  - Environmental overflights at Hanna, Hoe Creek, and North Knobs

- Environmental Impact Mitigation Research
  - Water contaminant dispersion and control modeling
  - Groundwater cleanup

FY83 TAR SANDS RESEARCH PROGRAM

RESOURCE ASSESSMENT

To define the size and nature of the tar sand resource by supporting continued development of a unified, comprehensive, and integrated data base incorporating all available tar sand deposit charcteristics. Although tar sands of the U.S. have been recognized as a potential source of petroleum products, their development has not been undertaken to any significant degree. In fact, evaluation of major deposits has been conducted only on a small scale and no one tar sand area has been thoroughly assessed.

Resource Characterization - Major deposits must be characterized prior to their consideration as potential significant sources of petroleum products. Their development depends on thorough and complete knowledge of their extent, both vertically and horizontally. This and other parameters which would affect development of the resource must be integrated in a computerized data base, available to both government and industry.

Reservoir Evaluation - At present there exists a little knowledge about a number of deposits but not an adequate amount about a single deposit. Additional evaluation work should be done on those major deposits which are most attractive for future development. Geologic, hydrologic, and engineering data should be obtained and evaluated to determine the best methods of extraction of hydrocarbons.

Resource Characterization - Assemble, coordinate, and interpret existing knowledge and develop new knowledge of the U.S. tar sand resource and the characteristics of each deposit.

Develop methods for determining, acquiring, interpreting and integrating tar sand resource information into a tar sand resource and deposit characteristics data base, employing computerized methods to improve usefulness of the data base and to improve transfer of tar sand information to the public.

To select target deposits for detailed characterization and production testing.

New efforts are presently underway to establish a computerized data base for tar sand information at LETC. By the end of FY '82 the data base will be established as to the type and potential volume of data available for input and a certain amount of data will be placed therein. This input will continue in FY '83 and establishing of the base to the point of retrievability should be accomplished.

Updating of Monograph 12 is underway by Lewin & Associates, the subcontractor for the task. The new report will provide all presently known data on 446 tar sand occurrences as determined by the original (1965) Monograph 12, plus any new deposits discovered in the past 16 years. The information will be the basis for further and more detailed investigations of potentially developable tar sand deposits.

New and continuing efforts should be made towards developing information on tar sand as a supplemental source of hydrocarbon products because of the volumes available in U.S. deposits.

Objectives and Tasks

Prioritize Major Deposits - A ranking of tar sand deposits as to the favorability and suitability for economic development

- o publish methodology
- o apply methodology to both major and minor deposits
- o add new data to applicable portions of the report
- o place information in computer data base

Major Deposit Evaluation - Maintain a current, unified, and continually growing computerized assessment of various parameters of tar sand resources which influence recovery technologies and their potential commercial application.

- o Publish report on the P.R. Spring, Utah, deposit including all available information not previously published
- o Publish report on the Tar Sand Triangle, Utah, deposit including all information not previously published

Objectives and Tasks

Resource Data Base - Develop organized resource data base together with methods to interpret deposit characteristics in terms of suitability to specific production technologies. Establish and maintain a tar sand resource data base on all tar sand information as it is acquired or generated.

- o Record geologic data as location, depth thickness, etc., including hydrological data.
- o Record all engineering data as porosity, permeability, oil and water saturations, etc.
- o Develop interpretation methods to coordinate the data base.
- o Provide retrievability of the information.
- o Make technology transfer to the public an established procedure.

Reservoir Evaluation - Characterization of the more significant potentially commercial tar sand deposits using geological, geophysical, hydrological, engineering and laboratory equipment and methods which will eventually aid in medium to large-scale, economic development of tar sand as a source of liquid fuels.

The research of tar sand deposits and their contents are currently those of the petroleum industry with very few specialized methods or techniques developed, especially for tar sand evaluation. Drilling, coring, analyses, and evaluation is standard for conducting in situ research.

Selection of an appropriate site to conduct future small scale in situ research will be conducted in 3 phases. The drilling, coring, core analyses, etc., of 3 separate areas leading to the selection of 1 area; the drilling, coring, core analyses, etc., of the selected area to obtain the subsurface condition of the site for planning the experiment; the implementation of the experiment design and the experiment itself.

Objectives and Tasks

Coring Tar Sands - Provision of raw materials for principally geologic and some engineering information in tar sand research is the initial step of evaluating a deposit. Improvement of equipment and methods specifically for obtaining samples of tar sand will be researched.

- Core tar sand deposits, both candidate areas and the single selected area. Tasks to be accomplished herein are:

  Diagnostic Tools and Techniques - Although it would be desirable to develop new tools and techniques for evaluating tar sands, funding to support such a level of effort is beyond the scope and budgetary limit and will not be considered in the FY '83 planning.

  Tar Sand Analyses - Data from the deposit is necessary for an intelligent evaluation and design of a process experiment and engineering data from core analyses are an important part of the program.

- Obtain engineering data from cores of both candidate areas and the single selected site.

- Improve and enhance standard techniques and lab equipment to better analyze tar sand cores and standardize the processes for providing uniform data flow from all sources.

Hydrology - Information on both surface and subsurface waters is not available in the detail necessary for site specific scientific research and the obtaining of such data is vital to in situ experiments.

- Locate and test aquifers, aquicludes, water flows, transmissivity, etc., for potential domestic or industrial (process) use.

- Perform most of the tests during both 3-area and single site drilling and coring operations. Since the testing will occur principally in Phase I, further testing during Phase II may not be necessary.

Geoscience Evaluation - Fully evaluate tar sand deposits using scientific equipment and methods to determine factors affecting site selection.

- Conduct a high frequency, shallow depth seismic study which would reveal any subsurface structural or stratigraphic anomalies or features

- Run a set of electric logs to aid in the interpretation of both geologic and engineering conditions at the site and to correlate with the core analytical results

- Examine the mineral content of the reservoir beds both as to primary matrix and cementing material using X-ray difraction and petrographic miscroscope methods.

RECOVERY

Development and evaluation of processes relating to the recovery of hydrocarbons from tar sand deposits is the objective of this activity. Laboratory scale experimentation of thermal recovery and alternate extraction techniques are emphasized. Alternate extraction techniques as used here, refers to surface plant extraction processes, modified in situ processes and new or novel concepts.

The major development of tar sand recovery processes has taken place in Canada and directed toward the large tar sand deposits of Alberta. To date, there are two commercial scale surface extraction plants in operation in addition to several operating in situ pilots and planned surface plants. In the U.S. the tar sand development has been on a lower level with limited laboratory studies, in situ testing in California, Utah, Texas and Kentucky and surface plant development in Utah and Kentucky. The only commercial tar sand oil production has been from several small projects in California which produced a total of about 12,500 BOPD in 1981. Almost all of that production was oil with viscosities less than 25,000 cp. The U.S. development effort has been directed mainly at modification of processes developed for the Canadian resource. Further laboratory work on development of processes for U.S. deposits still remains to be done due to the variability of the U.S. resource and the characteristic differences between the U.S. and Canadian resources.

Thermal Recovery

In situ thermal processes are very attractive for the production of hydrocarbon from tar sands for several reasons: 1) by supplying additional heat to the tar sand, the viscosity of the bitumen is significantly reduced and its mobility is increased; 2) in addition to the heat supplied, thermal processes add energy to the normally energy deficient deposits enabling production of the mobilized oil; and 3) large quantities of materials do not have to be handled as is the case with surface or modified in situ processes. Laboratory investigation of the effect of various thermal processes on the production of oil from tar sand will lead to the development of controlling parameters for individual process, plus the development of a set of variables by which a comparison of processes may be made. Thermal processes to be considered are: in situ combustion, steam stimulation and flooding, combinations of combustion and steam, and steamflooding with various additives.

Several laboratory studies and pilot scale field tests have been conducted in Canada on the large Alberta tar sand deposits. In the U.S., limited laboratory and field studies have been conducted on tar sands in Utah, Kentucky, Texas and California. The LETC has been a major contributor in this area with laboratory tube studies of reverse combustion and steamflood with and without additivies and field tests of reverse combustion, reverse-forward combustion and steamflooding of Utah tar sand. The work done by LETC and others have only scratched the surface of what needs to be done to develop viable thermal processes for tar sand oil production.

The thermal recovery subactivity is divided into four mutually supportive research areas: laboratory experiments, computer modeling, field experiment and engineering assessment.

Objectives and Tasks

Determine the relationships of oil recovery and various processes, process parameters and tar sand characteristics in laboratory tests on 32 inch long reconstituted sand packs and on 2 foot cubes of consolidated tar sand.

- o Vary experimental operating conditions and determine the effects on oil production and oil viscosity modification
- o Determine optimum operating parameters for various processes
- o Develop comparative relationships for the evaluation of the various processes
- o Construct and operate a large scale, high pressure reactor capable of handling consolidated blocks fo tar sand.
- o Conduct tests of various thermal processes, based on criteria from tube studies, and determine recovery efficiencies and displacement mechanisms.
- o Determine effect of various injection production configurations on oil recovery.
- o Determine process sweep patterns and residual oil saturation or coking patterns.
- o Determine any matrix modification due to degradation or migration of matrix material.

Computer Modeling - Continued investigation and evaluation of available thermal process simulation model(s).

- o Use laboratory produced data to evaluate model.
- o Use a proven and reliable model to help predict laboratory tests and optimize the critical operational parameters.

Field Experiments - Mini field experiments will be utilized to supplement tne laboratory experiments by generating data which cannot be practically generated in the laboratory.

- o Identify process parameters (from lab experiments) which require field experiments.
- o Develop conceptual experimental design for required mini field experiment(s).

Engineering Assessment - Conduct basic economic analysis of a process or processes which are deemed to have technical merit based on the laboratory experiments and computer modeling.

- Complete economic analysis of steamdrive process based on LETC TS-1S experimental data.

- Initiate economic analysis of process(es) subjected to laboratory experimentation.

PREPARATION

The Preparation Activity is aimed at development of data to assess whether or not domestic tar sands can be processed such that product oils can be refined in existing facilities with little or no alterations. It is generally conceded that some upgrading will be required after recovery but before refining. The work is divided into two subactivities, separation and upgrading. The current state-of-the-art and plans for FY 83 tasks are outlined in subsequent descriptions.

Separation

To assure that methods and equipment are available to separate produced tar sand oil from water, solvents, gases, and particulates that are incidental to various recovery processes.

Numerous methods have been demonstrated to be useful for separation of conventional crude oil from co-produced water, gases, and particulates. Most of these methods have been applied to tar sand oil recovery by LETC at the Vernal site with some modifications due to high viscosities of product oils. Water removal at times is difficult when emulsions are encountered; however, heat treatment, centrifugation, electrostatic methods, chemical demulsifiers, and various combinations of these have proven acceptable. In particular, the use of demulsifiers and heat treatment has been quite successful.

Removal of co-produced gases from oils is not a problem even with high viscosity products. The use of regular 2- and 3-phase separators, in conjunction with a demist tower, can successfully remove fine 0:1 particles.

Solvent or diluent removal can readily be accomplished by distillation if required. The diluent may be used as a means of viscosity reduction for transport and can be used during upgrading for easier processing.

Guidelines from the Canadian experience with the northern Alberta tar sand deposits are available; however, the Canadians are still involved in extensive research to modify and improve separation technology. This indicates that improvements are necessary in currently existing technology even though they have many years of experience in separations.

Literature and private contacts with Canadian researchers indicate that sand control in well bores during oil recovery is not considered a problem, but emulsion separation can be serious, particularly when fine clays are present. Clays are also the primary cause of difficulties in Canada for recycling of process water because of very slow sedimentation rates. LETC experience has shown that clays are not generally a problem with U.S. tar sands, but we have had some problems with fine sand. Removal of other particulates such as fine sand or coke presents a very difficult problem, especially if the product oil is a high pour point, viscous material. Centrifugation of mixtures of produced oil and diluents from downstream processing has been the most successful method for solids removal from product oils.

The needs in this subactivity relate generally to tests that must be done on a scale at least as large as the LETC field experiments. Verification of demisting of process gas streams, solids-oil separation, and emulsion breaking are all required on a case-by-case basis; however, only the emulsion-breaking work can provide meaningful results on lab-scale recovery.

Objectives and Tasks

The objective of emulsion-breaking research is to assure that existing or developing technology will provide convenient separation of product oil and process water.

- Screen demulsifiers from regular suppliers for efficiency in demulsification of product oils from lab combustion recovery.
- Apply demulsification technology as needed for LETC upgrading experiments.

Upgrading

To develop techniques for upgrading tar sand bitumen to produce pipeline quality oil or oil that can be processed in existing refineries with little or no alterations.

Two commercial plants are on stream in northern Alberta for producing synthetic crude from tar sand bitumen that is separated from ore by a hot water process. Both use a form of coking followed by hydrogenation to reduce the bitumen to a product that is pipelined to refineries. SunCor uses a delayed coking process followed by hydrodesulfurization of three distillate streams using the Universal Oil Products process called Unifining. Naphtha is mildly hydrogenated, kerosene is treated under intermediate conditions, and gas oil requires rather severe conditions. The hydrogenated products are recombined for transport. Syncrude uses a fluidized bed coking process from Exxon called Flexicoking followed by hydrodesulfurization in two streams. Both processes make a low sulfur, low pour point synthetic crude; however, both produce excess coke that is stockpiled.

Numerous other processes have been used to upgrade heavy oils from around the world, but limitations on success of direct transfer of these technologies may result because of a relatively larger molecular size and higher viscosities of bitumen compared to heavy oils. These parameters can cause diffusion problems in catalytic processes.

Oils produced during lab and field recovery experiments conducted at LETC or by LETC research contractors at the University of Utah and the University of Wyoming have typically been viscous oils with high pour points and high nitrogen content. Such oils certainly require further processing prior to pipelining or refining. University of Utah researchers have also been investigating some upgrading methods for LETC field-produced oils as well as those oils from their lab recovery research. Visbreaking, delayed coking, catalytic cracking, steam pyrolysis, and hydropyrolysis have been screened. In most cases, hydropyro-

lysis has produced the product with the best qualities--lower pour point, molecular weight, less residue, and lower viscosity. LETC has also initiated lab efforts to assess sequential processing using either visbreaking followed by catalytic hydrogenation or hydropyrolysis followed by hydrogenation.

In extreme cases, product oils from various tar sand recovery efforts including those of Esso Resources (Cold Lake, Alberta), Conoco (South Texas), and various companies in California have been used as boiler fuels. This seems to be a waste of the potential of these materials.

Quite a number of needs can be associated with the upgrading effort including:

Quality specifications for synthetic crude oils resulting from upgrading need to be developed in cooperation with industry personnel, by literature surveys and other means.

Product oils from field and laboratory recovery tests must continuously be extensively evaluated as the basis for determining the need for additional processing, the extent of upgrading resulting from the recovery process, and for environmental considerations.

Screening and evaluations of various upgrading processes will be done at LETC or under small-scale University contracts to develop promising means for preparation of syncrudes.

Conduct small-scale catalyst research for cat cracking, hydrocracking, hydrogenation, etc., in order to assess effects of larger pore size catalysts in processing of large molecules present in tar sand bitumens.

Evaluate mild hydrogenation of product oils mainly for stabilization but also for upgrading.

Determine advantages or disadvantages of the use of localized, smaller scale upgrading units that may be required by the localized nature and lesser extent of domestic tar sand deposits.

In this subactivity, many of the needs can only be addressed with larger scale upgrading and/or processing such as the near commercial-scale work being done with shale oils under DOD contracts with Sohio, Chevron, and others. Unit size evaluations, and setting of syncrude quality specs should be done in conjunction with larger scale activities. Other needs can be investigated more efficiently during lab-scale experimentation.

Objectives and Tasks

Syncrude quality specifications - Provide quality criteria as a basis for selection of the most economical upgrading process for each recovery method. This is to avoid excessive upgrading that would be unnecessary for existing refinery processes.

- a low-level effort of information gathering and contact with industrial researchers will be ongoing to provide input to this work.

Product Characterizations - Evaluate and understand the nature of recovered tar sand oils. All of the following work applies to all lab recovery experiments.

- Determine elemental composition of oils
- Perform simulated distillations on product oils
- Determine physical properties (pour points, viscosities, specific gravities, etc.) of oils
- Relate the above properties of products to original materials (bitumens) in ores and to the recovery process
- Analyze and evaluate product chars, waters, and gases from recovery efforts.

Upgrading Process Evaluation - Apply new or assure that existing upgrading techniques will result in syncrudes that can be refined.

- Continue to evaluate upgrading methods at the University of Utah
- Process tar sand oils by sequential process schemes to essentially the same syncrude quality in order to assess preliminary economics (Division of Engineering, LETC)
- Provide analytical support for the upgrading studies such as that provided for recovery efforts.

Catalyst Research - Process materials with large molecular size (tar sand bitumens or primary product oils) efficiently for catalytic cracking or hydrogenation. However, the funding and resulting level of effort available precludes such studies in this fiscal year. The work will involve use of catalysts with large pore sizes and diffusion rate studies.

Mild Hydrogenation Evaluation - The objectives are to stabilize primary products that contain olefins and to assess whether or not this technique can provide pipeline quality syncrudes. No significant effort is planned this fiscal year.

Upgrading Unit Size Evaluation - The objective of this work is to provide a meaningful engineering economic evaluation on the sizing of recovery units so that rationale sizing of upgrading units can be proposed. The advantages and disadvantages of smaller scale, on-site upgrading as opposed to larger, centralized facilities will be compared. The fact that recovery technologies have not yet been associated with specific deposits precludes meaningful work in this area during fiscal year 83.

ENVIRONMENT

Perform laboratory research which supports LETC's tar sand oil research program as well as providing answers to basic environmental questions. The uniqueness of the tar sand resource ensures that properly constructed environmental research will have state-of-the-art application. The research proposed for FY '83 has not been attempted elsewhere. The techniques employed may bear similarities to those tried in other areas, but refinements achieved only through well designed research are needed. It is critical to establish environmental research programs which function at two levels. These are: Direct support of LETC's in-house tar sand research program; and provide answers to long range environmental questions answered only with high risk, long lead time research. For FY '83, the LETC effort is directed at finding answers to the control technology questions inherent in tar sand oil extraction. This program uses process waters generated in previous experiments to address long term environmental questions.

Monitoring and Characterization

No activity is planned in this area for FY '83 due to the absence of a field experiment.

Control and Disposal Methods

Current environmental activity in support of LETC's tar sand extraction program includes a systematic research effort to determine appropriate process water treatment schemes. This program is structured to identify two separate and statistically defensible tasks. These are: determination of optimum unit process selection; and determination of optimum unit process operation. While most of the processes being evaluated achieve this distinction because of the uniqueness of the waters being treated, two areas of interest are unique in themselves. These are: the wet air oxidation work and the application of experimental surfactants in the foam fractionation work. In order, the wet air oxidation work currently being evaluated simulates the hydrostatic pressure generated in deep (i.g. ~5000 feet), wells together with the temperatures achieved and captured during pollutant oxidation. In addition to treatability evaluations, this effort will generate design criteria as well as an estimate of waste heat produced. The specific process being evaluated by LETC has been identified as a possible alternative to conventional technology for steam generation in Canadian tar sand extraction. The state-of-the-art work being conducted in LETC's foam fractionation efforts involves the selection of specific, heretofore untested in synfuel applications, surfactants. Various vendors are supplying polymers and surfactants to this effort. Some of these are still classified as experimental. The results coming from this research will be available in public literature and will include evaluations never attempted before. To evaluate appropriate unit processes and to determine their optimum configurations and sequences for the treatment of process waters resulting from tar sand oil extraction, these evaluations must include efforts into defining appropriate use and/or disposal options for the residuals resulting from these treatment alternatives.

Objectives and Tasks

Further define appropriate treatment process operations and applications to stored tar sand waters.

- o Initiated in-house operations parameter definition for those unit processes identified during previous work.
- o Complete preliminary cost and design basis necessary for full sized treatment system.

Continuation of basic unit process evaluation of tar sand process water treatability.

- o In-house evaluation of additional unit processes and configurations.
- o Anaerobic treatment evaluation of TS-2C wastewater

Establish monitoring and characterization program to evaluate treatment efficiencies.

- o Establish in-house capability for broad parametric and constituent analyses for raw and treated tar sand waters.
- o Characterization of heavy metals and their environmental significance in raw and treated tar sand process waters as well as in residuals left after treatment.
- o Chemical characterization of treated tar sand effluents by HPLC and GC.
- o Perform biological parametric study of treated tar sand effluents.

VI. BUDGET FOR FY1983

The budget is presented in three forms: (1) by fossil energy type; (2) by organizational structure; (3) in total.

(1) By Fossil Energy Type

A. Oil Shale

Personnel	
57 Full Time Equivalents @ $30,000	$1,710,000
Fringe Benefits @ 18%	308,000
Services/Supplies	420,000
Travel	58,000
Equipment	150,000
Subcontracts	
Faculty Research	550,000
A.W.U.	120,000
Support Activities	380,000
Total Direct Costs	3,696,000
Indirect Costs @ 39%	1,441,000
Subtotal	5,137,000
G&A Expense @ 10%	514,000
Subtotal	5,651,000
Fee @ 5%	283,000
Total for Oil Shale	$5,934,000

B. Underground Coal Conversion

Personnel	
22 Full Time Equivalents @ $30,000	$ 660,000
Fringe Benefits @ 18%	119,000
Services/Supplies	150,000

Travel	22,000
Equipment	50,000
Subcontracts	
Faculty Research	250,000
A.W.U.	50,000
Support Activities	80,000
Total Direct Costs	1,381,000
Indirect Costs @ 39%	539,000
Subtotal	1,920,000
G&A Expense @ 10%	192,000
Subtotal	2,112,000
Fee @ 5%	106,000
Total for Underground Coal Conversion	$2,218,000

C. Tar Sand

Personnel	
20 Full Time Equivalents @ $30,000	$ 600,000
Fringe Benefits @ 18%	108,000
Services/Supplies	130,000
Travel	20,000
Equipment	50,000
Subcontracts	
Faculty Research	200,000
A.W.U.	30,000
Support Activities	40,000
Total Direct Costs	1,178,000
Indirect Costs @ 39%	459,000
Subtotal	1,637,000
G&A @ 10%	164,000
Subtotal	1,801,000

Fee @ 5%	90,000
Total for Tar Sand	$1,891,000

D. Director's Office

Personnel	
3 Full Time Equivalents @ $45,000	$ 135,000
Fringe Benefits @ 18%	24,000
Services/Supplies	15,000
Travel	15,000
Equipment	10,000
Direct Costs	199,000
Indirect Costs @ 39%	78,000
Subtotal	277,000
G&A @ 10%	28,000
Subtotal	305,000
Fee @ 5%	15,000
Total for Director's Office	$ 320,000

E. GRAND TOTAL $10,363,000

(2) By Organizational Structure

A. Engineering

Personnel	
46 Full Time Equivalents @ $30,000	$1,380,000
Fringe Benefits @ 18%	248,000
Services/Supplies	350,000
Travel	46,000
Equipment	120,000
Subcontracts	
Faculty Research	460,000
A.W.U.	100,000
Support Activities	350,000

Direct Costs	3,054,000
Indirect Costs @ 39%	1,191,000
Subtotal	4,245,000
G&A @ 10%	425,000
Subtotal	4,670,000
Fee @ 5%	233,000
Total for Engineering	$4,903,000

B. Physical Science

Personnel	
36 Full Time Equivalents @ $30,000	$1,080,000
Fringe Benefits @ 18%	194,000
Services/Supplies	240,000
Travel	36,000
Equipment	90,000
Subcontracts	
Faculty Resarch	340,000
A.W.U.	60,000
Support Activities	100,000
Direct Costs	2,140,000
Indirect Costs @ 39%	835,000
Subtotal	2,975,000
G&A @ 10%	298,000
Subtotal	3,273,000
Fee @ 5%	164,000
Total for Physical Science	$3,437,000

C. Environmental Science

Personnel	
17 Full Time Equivalents @ $30,000	$ 510,000
Fringe Benefits	92,000

Services/Supplies	110,000
Travel	18,000
Equipment	40,000
Subcontracts	
Faculty Research	200,000
A.W.U.	40,000
Support Activities	50,000
Direct Costs	1,060,000
Indirect Costs @ 39%	413,000
Subtotal	1,473,000
G&A @ 10%	147,000
Subtotal	1,620,000
Fee @ 5%	81,000
Total for Environmental Sciences	$1,701,000

D. Director's Office

Personnel	
3 Full Time Equivalents @ $45,000	$ 135,000
Fringe Benefits	24,000
Services/Supplies	15,000
Travel	15,000
Equipment	10,000
Direct Costs	199,000
Indirect Costs @ 39%	78,000
Subtotal	277,000
G&A @ 10%	28,000
Subtotal	305,000
Fee @ 5%	15,000
Total for Director's Office	$ 320,000

E. GRAND TOTAL	$10,361,000

(3) Overall Budget Summary

Personnel	
99 Full Time Equivalents @ $30,000	$2,970,000
Fringe Benefits @ 18%	535,000
3 Full Time Equivalents @ $45,000	135,000
Fringe Benefits @ 18%	24,000
Services/Supplies	715,000
Travel	115,000
Equipment	260,000
Subcontracts	
Faculty Research	1,000,000
A.W.U.	200,000
Support Activities	500,000
Direct Costs	6,454,000
Indirect Costs @ 39%	2,517,000
Subtotal	8,971,000
G&A @ 10%	897,000
Subtotal	9,868,000
Fee @ 5%	493,000
GRAND TOTAL	$10,361,000

(slight discrepancies between the three Grand Totals are due to rounding)

The University considers the FY1983 baseline budget to be $10,361,000 and it is this sum with necessary inflation and salary adjustments that is used in determining the five year D.O.E. cost projection.

Year I	Year II	Year III	Year IV	Year V
$10,361,000	$11,262,000	$12,345,000	$8,947,000	$4,940,000

Inflation is estimated to be 7%, 8%, 8%, and 9% between each pair of years, and an average above inflation salary increase of 3% is provided for each year.

COMPARISON OF SATELLITE AND MICROWAVE CARRIER SYSTEMS

	MICROWAVE	SATELLITE
Transmission and Distance Coverage	1. Straight line, point-to-point transmission. 2. Covers 75 miles maximum: requires multiple installations to cover great distances. 3. Reception limited to point of microwave reception unless signal is rebroadcast via radio or TV translator (up to 15-mile radius).	1. Requires earth station up-link. 2. Retransmission from satellite would cover all of Wyoming. 3. Requires satellite earth receiving station: earth stations are portable so signal could be received anywhere in the state.
Flexibility	1. Microwave could accommodate television and radio transmissions: TV use would be compatible with additional audio channels. 2. Capable of handling multiple circuits. 3. Relatively easy to add two-way capabilities. 4. Always available for use.	1. Satellite would accommodate television or radio: use for TV would preclude use of additional audio channels. 2. Reception capabilities at any location. 3. Relatively low cost earth receiving stations could be portable. 4. Exceptional quality and high reliability.
Limitations	1. Difficulty in reaching remote sites. 2. Cannot be made portable. 3. Difficult access to remote locations for service or maintenance of equipment. 4. Depending on system layout, one malfunctioning relay point could cause loss of entire system.	1. Transponder availability is limited. 2. Transponders are shared and may not be available at all times or as needed.

	MICROWAVE	SATELLITE
Cost		
	1. Relatively low cost depending upon size of network. 2. Site development may require power to be brought in at considerable expense (average $7,000 per mile). 3. Required maintenance costs would increase as number of stations increased.	1. Earth uplink very costly. 2. High cost of transponder rental time. 3. Two way system would require expensive uplink at each site. 4. Transponder might be purchased for $8 million.
Cost Summary		
	ONE WAY	
1. Originate	$ 15,000	$500,000
2. Relay	25,000	None required
3. Receiving Site	15,000 per site	15,000 per site
4. Use Time	0	$500 to $700/hour
	TWO WAY	
1. Send and Receive	$ 22,500 per site	$515,000 per site
2. Relay	37,500	0
3. Use Time	0	$500 to $700/hour