PROGRESS OF PHASE II OF THE DOE/OOSI COOPERATIVE AGREEMENT

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ABSTRACT

Phase II of the Department of Energy (DOE)/-Occidental Oil Shale, Inc. (OOSI) Cooperative Agreement covers a 41-month program, begun in June 1979, which has the overall objective of demonstrating the technical feasibility of OOSI's vertical modified in situ oil shale retorting process. OOSI will construct and simultaneously process two side-by-side large scale retorts (Retorts 7 and 8) formed by blasting to a horizontal free-face. In addition, small scale start-up tests on two quarter-size retorts will be conducted prior to ignition of Retorts 7 and 8. During 1980 the access drifting, void mining, and blasthole drilling for formation of 7 and 8 were completed. The quarter-size retorts were rubbled and tracer studies were made. Burner tests were run on the first of these in a start-up attempt, however burner failure resulted in the ignition attempt being unsuccessful. Further tests will be run with burners of improved design in 1981. The instrumentation program was expanded to include remote sensing equipment, being developed by the Lawrence Livermore National Laboratory and Occidental Research Corporation, and a sophisticated computerized data acquisition system developed by the Sandia National Laboratory.

DISCUSSION

The OOSI agreement with the DOE is divided into two phases. The first phase, begun in 1976, was the engineering development of two vertical modified in situ (MIS) retort designs (vertical free face retort system vs. horizontal free face retort system), Retorts 5 and 6. The second phase, begun in June 1979, is the technical feasibility demonstration of the design selected.

The major Phase II objective is to construct and simultaneously process two side-by-side commercial size retorts (Retorts 7 and 8) formed by blasting to a horizontal free face (the Retort 6 design). In addition to this task, other tasks include collecting mine stability data, monitoring seismic and air blast effects resulting from the rubbling blasts for the retorts, conducting mini-retort start-up tests and burner ignition tests, collecting environmental data, performing marketing studies, and supporting DOE funded tests.

For this 41-month program, the milestones are numerous. In the Mini-Retort (MR) area, OOSI plans to form five mini-retorts. Four have already been rubbled, the fifth may not be rubbled until 1982. Two MR's were selected for start-up/burner testing, MR3 and MR4. Prior to the start-up tests, these mini's were tracer tested in July and September 1980, respectively. The first burner test on MR3 started in November 1980; the second in April 1981. The MR4 test started in January 1981. For Retorts 7 and 8 the milestones are listed in Table 1.

Table 1. Retorts 7 and 8 milestones.

Complete access & void mining	December 1980
Rubble - Room 8X	January 1981
- Retort 7	February 1981
- Retort 8	April 1981
Tracer test Retorts 7 & 8	Summer 1981
Complete construction	Fall 1981
Ignite and start processing	Fall 1981
Begin shutdown	Summer 1982
Project end	Fall 1982

The current budget estimate for this work is about $75 million from June 1979 through project completion in October 1982. The DOE share of this cost will be some $25 million or approximately 33%. The DOE share is based on a $45 million ceiling for the entire project; i.e., Phase I (on which DOE spent $20 million) and Phase II. The three largest areas of expenditure are mining, engineering and construction, and support activities (maintenance, environmental monitoring, and site services).

The DOE funded activities include process instrumentation and monitoring as well as environmental monitoring and testing. Figure 1 illustrates the areas of DOE involvement, with process instrumentation and data acquisition by the Sandia National Laboratory being the largest. Sandia has been on site since late 1979. In preparation for Retorts 7 and 8, Sandia has been debugging and testing their systems operation on MR3 & 4.

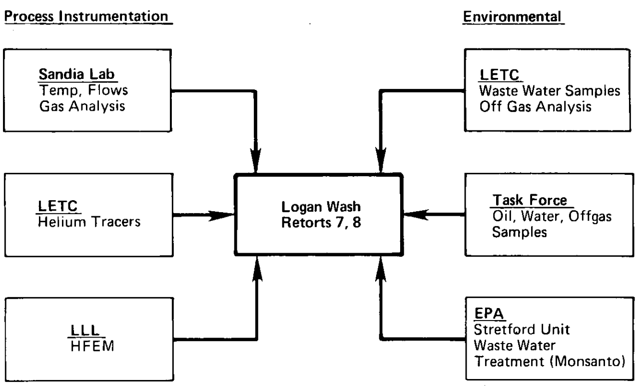

Figure 1. DOE only funded activities for Logan Wash under Phase II of the Cooperative Agreement.

OOSI's MIS Process

OOSI has developed a "modified in situ" oil shale process which has undergone extensive testing at its Logan Wash development mine in Garfield County, Colorado, since 1972. OOSI's process recovers shale oil by the partial combustion of oil shale in underground chambers or "retorts". These retorts are formed by creating voids through mining, thus removing 20 to 25 percent of the shale, and then expanding a volume of oil shale rock into them through fragmentation with conventional explosives. The explosives are placed in blast holes drilled vertically through the solid shale between the voids (Figure 2). The fractured shale appears intact after blasting with the shale layers readily seen. However, it is intensely fractured to allow gas flow paths through the retort.

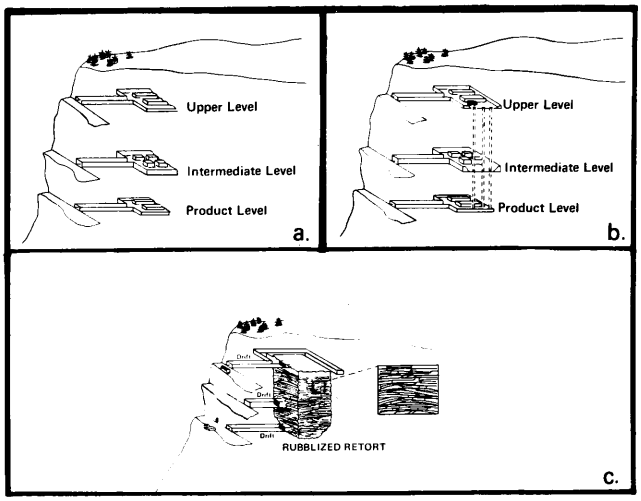

Figure 2. Creating an MIS retort by a. mining the voids, b. drilling the blast holes, and c. fragmentation with explosives.

Combustion is initiated at the top of the retort using an external fuel source to ignite some of the shale, thus producing shale oil, combustible gas and residual carbon. After a predetermined amount of oil shale has been processed, the external fuel is discontinued. The combustion process is made self-sustaining by introducing air to the retort. The residual carbon in the shale becomes fuel for continued burning. The flame front moves downward through the retort at the rate of a few meters per week, retorting the organic kerogen contained in the shale into oil vapor, low-Btu offgases, and residual carbon. As shown in Figure 3, four zones occur in an operating retort: gas preheat/spent shale cooling zone; combustion zone; retorting zone where kerogen decomposes at approximately 480°C; and the raw shale preheat/vapor condensation zone. The shale oil condenses, flows downward by gravity, and is collected at the bottom of the retort where it is pumped to the surface. Air and steam introduced at the top of the retort are used to control the rate of flame front advance and the retorting temperature.

As the combustion zone approaches the bottom of the retort, the offgas temperature increases. When the offgas temperature exceeds a certain predetermined temperature at the retort outlet, the inlet air and steam will be shut off and the retorting process is shutdown.

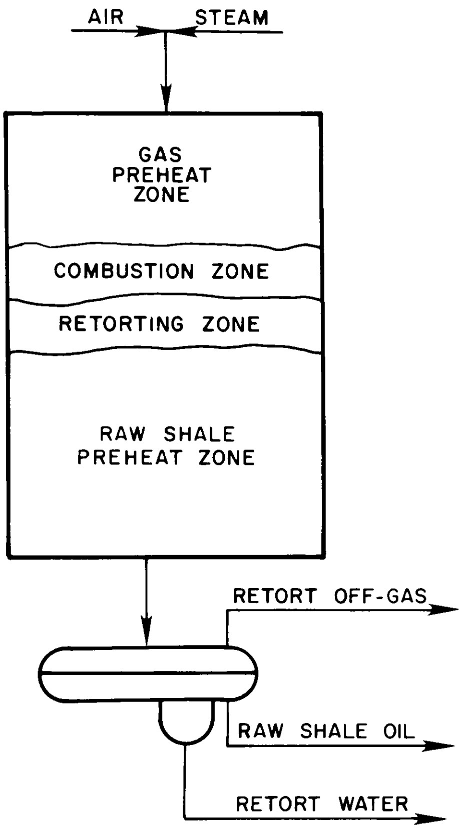

Figure 3. The four zones of an operating MIS retort shown schematically.

Progress at Logan Wash

Retorts 7, 8 and 8X, shown schematically in Figure 4, have all been rubbled. Retort (or Room) 8X was formed to determine whether or not there is communication between retorts separated by a 15-meter nonbearing pillar. Retorts 7 and 8 are separated by a 46-meter bearing pillar containing access and instrument drifts. These retorts are each 50 meters square by 75 meters tall. The average Fischer Assay of the rubbled shale is 20.4 gallons per ton (or 86.3 l/mt) resulting in more than 170,000 barrels of oil in place in each retort.

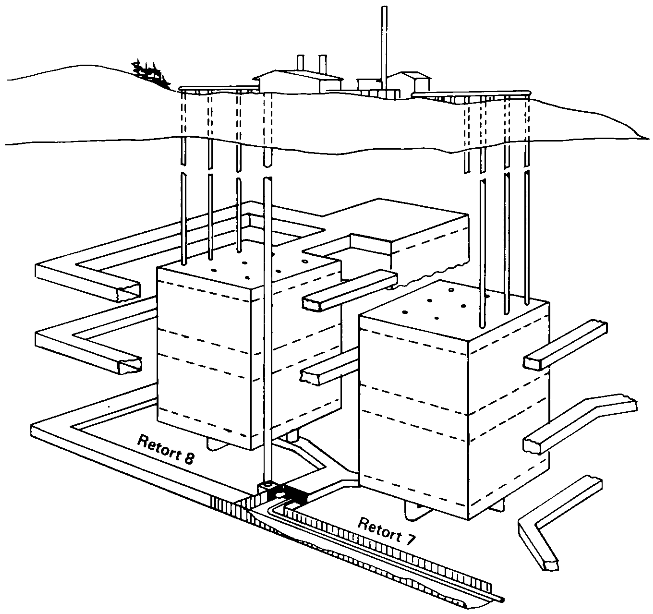

Figure 4. Schematic of Retorts 7 and 8 with a partial retort, 8X, situated behind Retort 8. The access and instrument drifts are cut away for easy viewing.

Mining for these retorts took over a year with headings on three levels plus mini-retort work in what is called the Research Mine as shown in Figure 5. The crosshatched areas show the mining associated with Phase II. The three raises, manway, ventilation, and offgas, each took approximately one month to bore. Preparation of the retorts for blasting is a tremendous job as seen by the mining statistics, listed in rounded figures, in Table 2.

Table 2. Retorts 7, 8 and 8X mining statistics.

Begin Mining	August 1979
Labor expended	157,000 manhours
Shale mined	421,000 metric tons
Drift length	1,830 meters
Rockbolts installed	29,000 rockbolts
Wire mesh installed	26,800 sq. m.
Ventilation tubing hung	6,400 meters
Utility pipe hung	4,600 meters
Drilling	195,000 meters
Complete Mining	December 1980

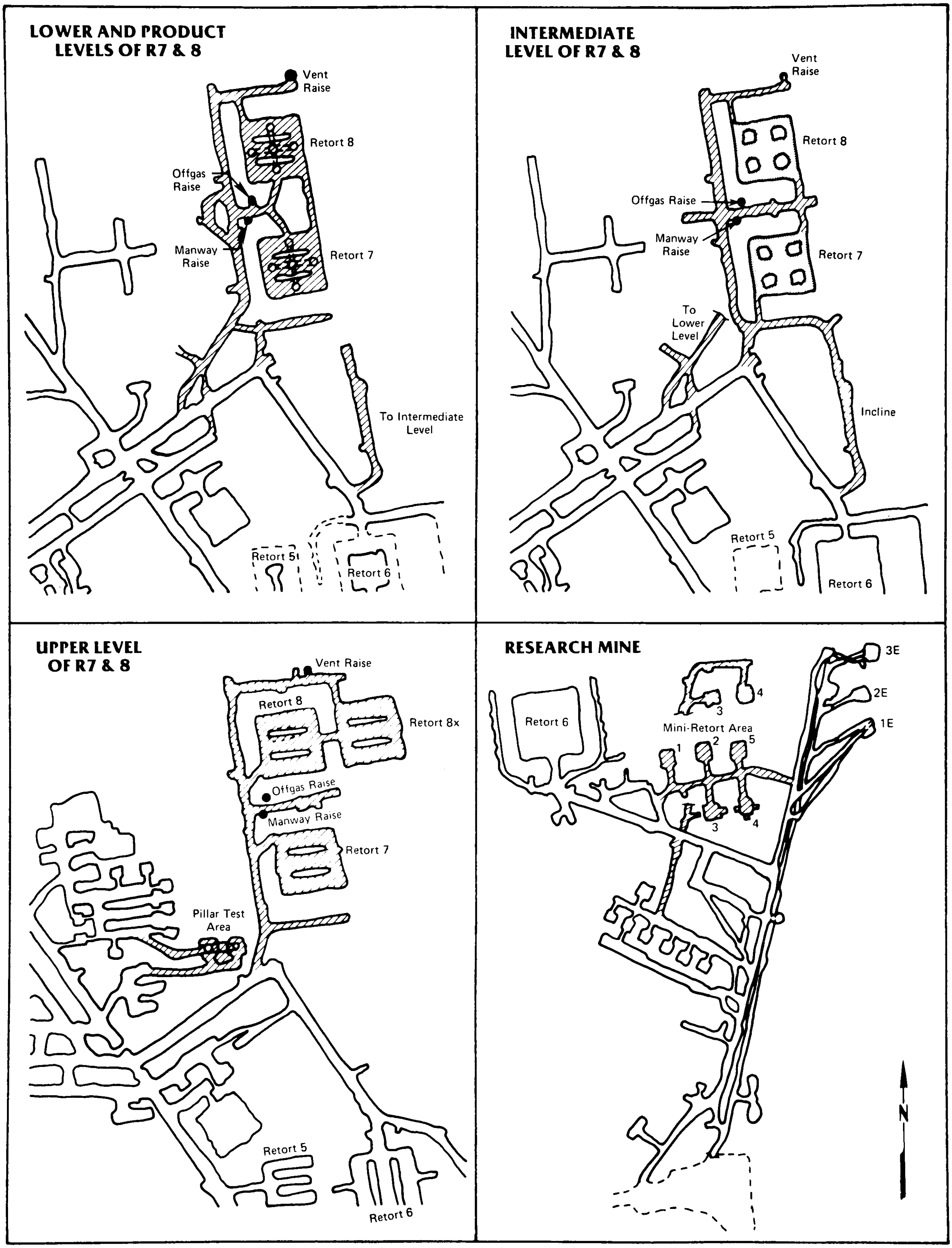

Figure 5. Mining on three levels for Retorts 7 and 8 and at the Research Mine area for the Mini-Retorts.

An example of the retort cross section is shown in Figure 6 for Retorts 8 and 8X. The crosshatched area is the solid rock, including room pillars, into which the blast holes are drilled. At the base of Retort 8 are the product raises. The cut taken for this section is taken through the pillars, south of the retort centerline, from the top down through the Lower Void Level and then through the centerline from the Lower Void Level to the bottom of the Product Recovery Level.

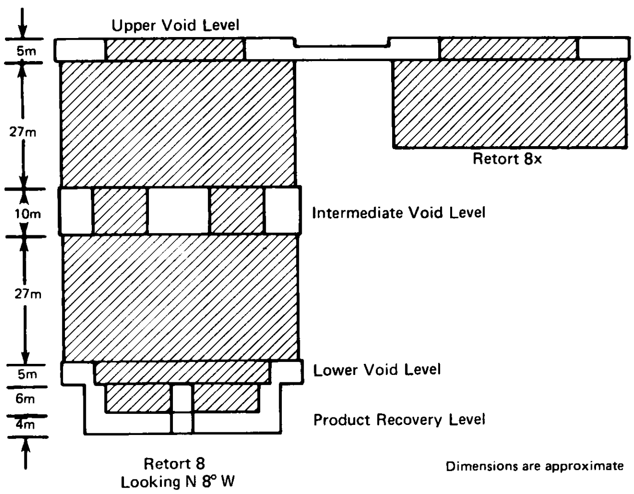

Figure 6. Retorts 8 and 8X design configuration, vertical section.

Retort 8X, 7 and 8 were shot on January 24, February 21 and April 4, 1981, respectively. Retorts 7 and 8 each had approximately 90,900 metric tons of shale removed leaving 23% void. In each retort some 309,000 metric tons of shale were rubbled with over 227,000 kilograms of explosive. The top of the rubble piles for Retort 7 and 8 are both essentially flat with an average void height between 4.3 and 4.6 meters for both. Retort 6 was designed to be mounded; Retort 7 and 8 to be flat.

Mini-Retort Start-up/Burner Tests

The main objective for the mini-retort (MR) program is to obtain information and data needed for successful ignition of Retorts 7 and 8. Two types of burners were selected for testing in connection with the MR start-up tests. The first was a Foster Miller downhole burner used on MR3; the second a John Zink inert gas generator used on MR4. MR4 is shown schematically in Figure 7. Neither retort was bulked full as the drawing implies. At the bottom is the product collection piping. The downhole burner was placed down a hole through the sill pillar near the center of MR3.

The first ignition attempt on MR3 in November 1980 was a failure because of numerous problems with the burner. MR4 burner testing and ignition in January 1981 was successful. Further work is planned for MR3 and one other mini-retort. An improved design of the downhole burner will be retested on MR3 and the Zinc burner will be tested in a different configuration.

Construction Progress

Most of the construction work to date has centered on the surface facilities. The layout of the major building and process equipment in relation to the retorts is shown in Figure 8. These facilities are on the top of a mountain (actually on a finger on the edge of the high plateau of the Piceance Basin). The dotted lines running across the figure mark the edge of the finger where the mountain sides drop off abruptly.

The major construction items completed are:

- upgrading the gravel road to the surface to accommodate heavy equipment and facility access;
- construction of the surface buildings;
- placement of the contact condensers for the offgas stream;
- setting in place the blower skids and drives;
- installation and hookup of the primary 4160 volt electrical system;
- pouring the foundation for, and setting in place, the fin fan cooler;
- relocating the boilers to the surface;
- installing an additional Heater Treater and product tank at the load out facility; and
- installing support for the product draw holes.

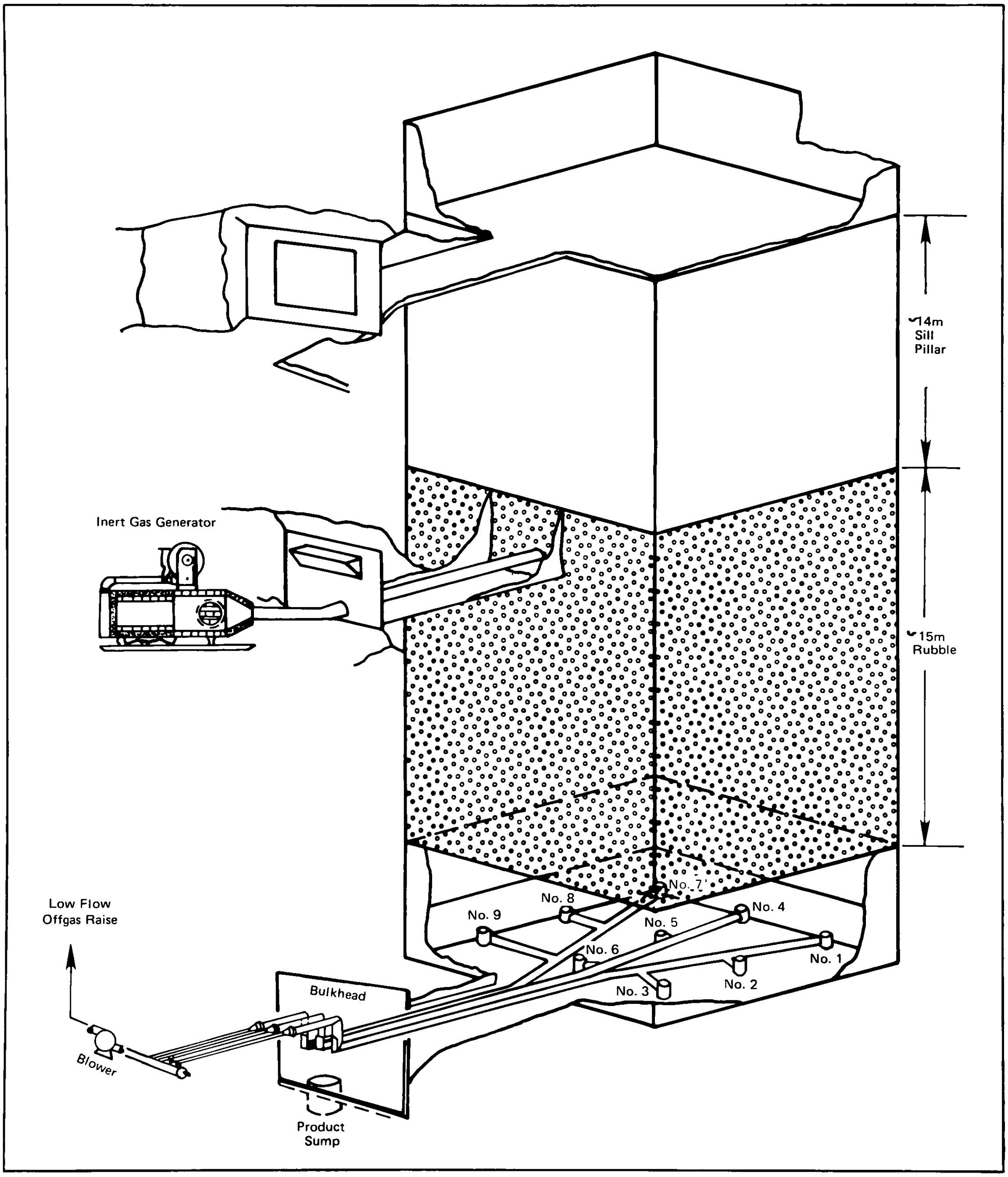

Figure 7. Schematic of Mini-Retort 4 which is part of Phase II of the Cooperative Agreement.

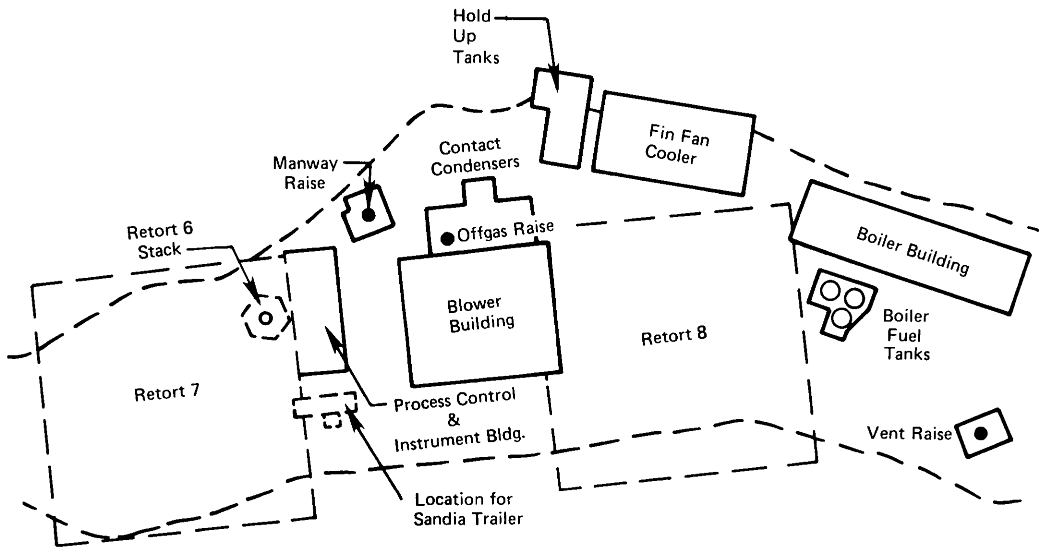

Figure 8. Plot plan of the surface facilities for Phase II shown in relation to Retorts 7 and 8 underground. Dotted lines indicate where the mountain top drops off.

The bulk of the construction remaining is that work which could not be completed (and in some cases started) until after the retorts had been rubbled. Those construction items are the:

- retort bulkheads,
- product gas and liquid, boiler, water and steam, and Heater Treater piping,
- burner system,
- retort wellheads,
- instrumentation, (thermocouples and process),
- generators and electrical hookup, and
- insulation and winterizing.

Sampling

An extensive sampling program is planned for Phase II covering environmental and process sampling. Items to be sampled are: shale, spent and raw; offgas at underground, inlet/outlet, condenser, and stack locations; ambient air at the Heater Treater and meteorologic tower locations and various locations with a portable unit; oil, raw, dry, offgas condensate and composite; gas, void and rubble; water, retort (bulkhead), offgas condensate, water treatment effluent, boiler blowdown, condensed steam, and monitoring wells; and mine air for safety.

The DOE is also planning to take additional water, oil and offgas samples for future research work.

Instrumentation

The instrumentation program covers all phases of the retort formation and operation from rock mechanics and mine stability through processing and shutdown. The items instrumented are listed in Table 3. A great deal of this information (processing, offgas handling and shutdown) will be taken by the Sandia data acquisition system. The rubble evaluation will be a joint effort of Sandia, LETC and OOSI. The rubbling data was taken by OOSI only.

Table 3. Retorts 7 and 8 instrumentation.

Rock Mechanics/Mine Stability	Rubbling
Roof movement	High speed photography
Pillar strain	Down hole detonation detection
Rib movement	Seismic measurements
Rock stress	Air blast measurements
Rock temperature	**Processing/Offgas Handling/Shutdown**
Rubble Evaluation	I/O streams - flow
Cold tracers	- temperature
Hot tracers	- pressure
Mass spectrometer monitoring	- composition
Pressure drop	Rubble temperatures
HFEM	Pillar temperatures
Mining	Rubble gas samples

CLOSING

In the fall of 1981, OOSI will be igniting two commercial size vertical modified in situ retorts for simultaneous operation. Successful ignition will culminate over two years of work in preparation for this field demonstration. The data collected from the operation of these retorts will be the most comprehensive and timely data gathered from a VMIS field operation. The knowledge gained will be applied directly to the Cathedral Bluffs commercial facility being built by OOSI and Tenneco Shale Oil Company.