all the extras associated with a first-time application, was $9.00 per cubic yard ($6.75 per ton) broken down as follows:

Project planning	$0.158
Investigation of mine openings	.542
Preparation of wells and manifolds	2.350
Fill material and handling	2.832
Injection	2.818
Site restoration and reporting	.300
Total cost per cubic yard	9.000

These costs reflect the demonstration of the process only and do not include the preceding site studies or the subsequent evaluation program. The cost per acre, about $62,500, is excessive, of course, and reflects the disadvantage of applying the method wherever only a relatively few mine voids are to be backfilled. The success of the test, however, which proved that 19,500 cubic yards of sand could be inserted into mine voids through a single borehole, promised invaluable aid to mining communities, fully justifying the cost of the experiment.

Reports

The Department of Housing and Urban Development, in cooperation with the city of Rock Springs, Wyo., arranged with Candeub, Fleissig and Associates, Consultants, Newark, N. J., to make a study of the demonstration project and a comprehensive report on the backfilling technique and its possible application in other mining areas of the Nation (3).

After the demonstration, the city of Rock Springs initiated a broad study of its overall community needs under the Community Renewal Program with assistance from the Department of Housing and Urban Development. This study has led to the establishment of priorities not only for subsidence control, but also for the treatment and renewal of other sources of deterioration and blight (19).

A comprehensive study of the general geology and underground mining in the Rock Springs area, in conjunction with the Community Renewal Program for the city, was made for the purpose of determining the economic feasibility of backfilling the mined-out areas. The report was made by the firm of Johnson-Fermelia & Crank, Inc., Consulting Engineers and Land Surveyors, Rock Springs, Wyo., and was completed March 1, 1972 (9). Two recommendations are included in the report: (1) That an extensive exploratory drilling program be conducted in various parts of Rock Springs to verify existing mine map data; and (2) that Federal funding be obtained for a large-scale mine backfilling project under the Belmont-Kerback area to assess the effectiveness of the process in arresting the continuing subsidence in that area.

FIRST LARGE-SCALE TEST

Scranton, Pa., was selected by the Bureau as the locale for the full-scale pumped-slurry demonstration project in 1972-73 because of its subsidence history and the active local interest in subsidence control. Population

centers in the Anthracite region of northeastern Pennsylvania have had a history of subsidence problems as a result of multiple-bed mining over a period of 150 years. Scranton is the largest of the cities in the Anthracite region. As many as 11 different coalbeds have been mined under Scranton, and most of the central part of the city overlies 6 mined beds. The demonstration project site is in an area of potential subsidence due to past mining in five abandoned coalbeds. Subsidence had not yet become apparent at the ground surface in this area, and caving below ground was not believed to be sufficient to block effective movement of slurry.

A 30-acre residential area was stabilized by injecting about 450,000 cubic yards of crushed mine refuse into two coalbeds through five injection boreholes. Nearly 200,000 cubic yards was injected through one borehole from which the material moved into the mine workings on all sides; the injected material reached a maximum lateral distance of 640 feet and filled mine openings from floor to roof. The new method, designed for inundated mines, proved successful also in mine workings above mine-water pool level (22).

HYDRAULIC MODEL STUDIES FOR BACKFILLING MINE CAVITIES

In October 1973, the Bureau of Mines arranged for model studies of the pumped-slurry method of backfilling mine cavities to be conducted by the U.S. Bureau of Reclamation at their hydraulic laboratory in Denver, Colo. The purpose of the studies was to obtain qualitative and quantitative data on the deposit pattern of fine sand, such as that at the Rock Springs projects, when used for backfill material and injected into cavities of a simulated coal mine. The results of the first series of 18 tests are given in a report entitled, "Hydraulic Model Studies for Backfilling Mine Cavities," by E. J. Carlson of the U.S. Bureau of Reclamation, which is included as an appendix in Bureau of Mines Information Circular 8667 (22).

A second series of model studies of the pumped-slurry method using the same fill material and simulating conditions not covered in the first series was made by the Bureau of Reclamation for the Bureau of Mines in 1974. That report was also by E. J. Carlson, U.S. Bureau of Reclamation; dated March 1975, it is included as an appendix to this report.

THREE LARGE-SCALE PROJECTS AT ROCK SPRINGS

The success achieved with the pumped-slurry technique at Rock Springs and at Scranton, where for the first time extensive mine voids in two beds under about 30 acres were filled from only five injection boreholes, prompted the Bureau to initiate several more large-scale subsidence control demonstration projects in both the Anthracite region and Rock Springs. Experiments were needed to determine the various types and sizes of material as well as the optimum range of conditions under which the pumped-slurry method could be used more effectively in minimizing adverse environmental problems associated with underground coal mining. In addition to the original 20,000-cubic-yard test, this report covers the three large-scale demonstration projects that were conducted in Rock Springs during the period 1973-76.