SNOWMELT LYSIMETER

593-75

By

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There is a need to investigate in detail the mechanisms of evaporation and sublimation from snow and ice surfaces, and to further investigate snowpack properties in general, to facilitate development of snowpack management procedures. Textural and structural characteristics of snowpacks and ice layers, and the influence of meteorological variables are of particular interest. The effectiveness of various agents, and the timing, staging and amounts of application must be evaluated in relation to the range of water saving achieved. Procedures need to be developed for analytical evaluation of stream-flow responses to large-scale watershed treatments, using the information derived from a detailed study and other field-scale programs.

The project was conceived in 1971 as a collaborative venture between the University of California and the U.S. Bureau of Reclamation; the latter agreed to provide a major share of the financing. Between early 1972 and the summer of 1973 the two organizations collaborated on design of the lysimeter, and the University fabricated it. In the fall of 1973, the Bureau installed the device at a site provided by the U.S. Forest Service at its Central Sierra Snow Laboratory (CSSL). The CSSL is in the Sierra Nevada mountain range near Norden, California, at an altitude of approximately 2100 m above sea level. During the first half of 1974 the University tested the lysimeter under actual snowfield conditions and developed initial operational procedures. In the fall of 1974 the University began operating the lysimeter in pursuit of the primary investigation. As the experiment proceeds the University, the Bureau, and the Forest Service will consult on the findings.

A sketch (Figure 1) shows the major features of the installation. An aluminum cylinder of approximately rectangular cross-section is divided into two cells and serves to isolate the test snowpack from the surrounding snow. The vertical position of the cylinder is mechanically adjustable to accommodate varying snow depths. Floor pans are provided in each cell at ground level to support the snow and catch melt water for collection in measuring tanks. A pit below the test site, approximately 4 m by 5 m in plan and 7 m depth, houses the cylinder, mechanical equipment, and measuring apparatus. Ready access during the snow season is provided through a tower and tunnel as shown in the sketch.

Each of the cells of the cylinder is approximately 2 m by 3 m in plan. One cell is designated for treatment; the other is used as a control. The floor pan beneath the treated cell is vertically adjustable so that the entire mass of treated snow may be raised or lowered as required to maintain an even surface when the treated snow depth differs from the natural snow depth. Maximum adjustment is 1/2 m above or below ground level.

Each of the floor pans, fabricated from steel plate, has sides 20 cm high and a drain in the center. The pans are filled with soil and are provided with water circulation manifolds for use in the event that soil temperature control is required. The drains are connected to 3 m high, 25 cm diameter melt water tanks in the pit below.

The aluminum cylinder can be raised to a maximum extension above ground level of 4.4 m. The walls are 5 cm thick, and the upper edges of the cylinder are sloped to minimize adherence of snow.

Continuous chain loops near each of the four corners of the cylinder, driven by a gearmotor through mechanical linkage, move the cylinder at a rate of 2.5 mm/sec. The chain sprockets are mounted on the floor pan support columns. The cylinder walls are coated with a thin layer of silicone grease for lubrication. Rubber seals at ground level prevent leakage of melt water into the pit.

The test site (shown in Figure 2) is located at the center of an area of about 20 m by 21 m in extent which was prepared to provide a flat support for the snowpack, without protusions, to minimize horizontal snowpack movement and to eliminate wind cupping effects.

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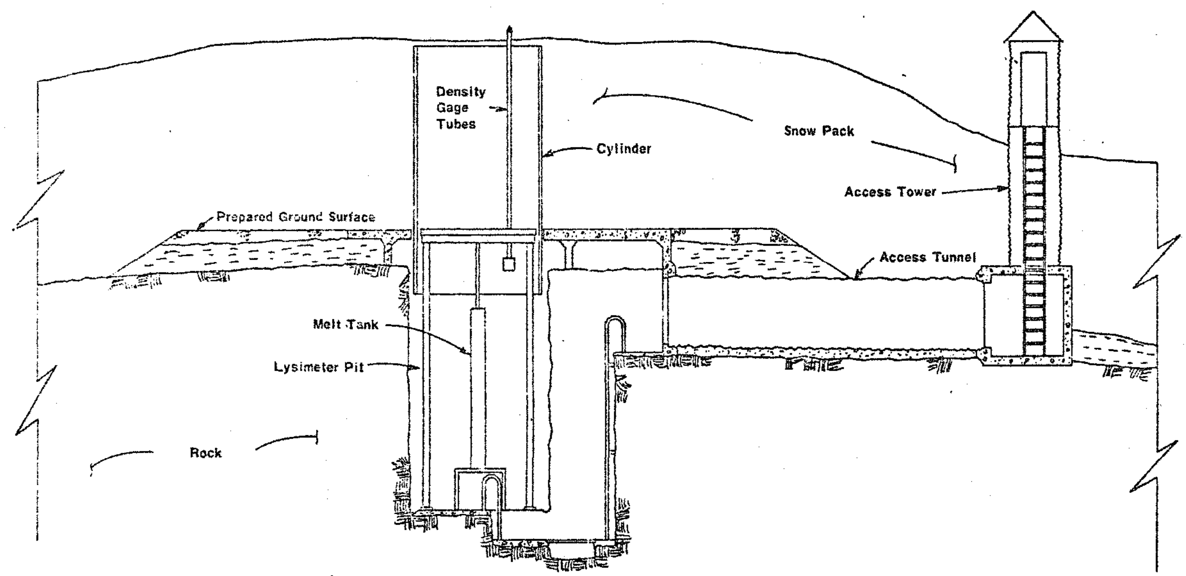
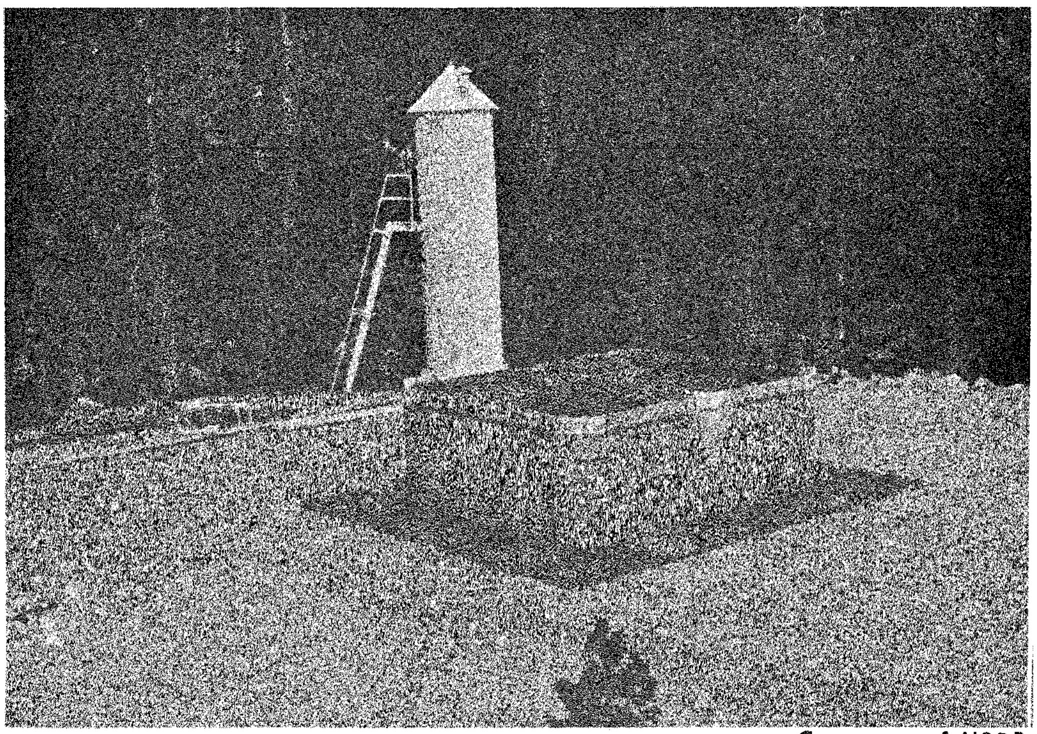


FIG. 1. SNOW MELT LYSIMETER
Simplified Cross-Section



Courtesy of USBR

Fig.2 Lysimeter Test Site

The original ground surface extending about 8 m from all sides of the cylinder has been sloped for drainage and covered with a level layer of gravel. A free-draining redwood deck immediately surrounding the cylinder covers concrete and metalwork.

Measurements of properties of the treated and natural snowpacks are remotely controlled and recorded at the laboratory house. Properties to be measured are snowpack density and temperature profiles, melt rate and volume, and soil temperature. Two 2-probe gamma-ray density gages (Smith, et al., 1972), especially adapted for this installation, provide the density profiles. Temperatures are sensed by a thermistor system. Melt measurements are made by water level sensing devices, operating on a variable capacitance principle, mounted in the melt tanks.

Operation of the aluminum cylinder is governed to 1) maintain separation of the experimental snowpack from its surroundings, thus allowing vertical adjustment of the experimental pack in case of a depth differential, and 2) to minimize lateral movement of melt water across the experimental and control snowpack boundaries. The test site is shown with a 4 m snowpack in Figure 3. (Experimental and control density gage tubes, normally retracted below the snow surface, are shown here.)

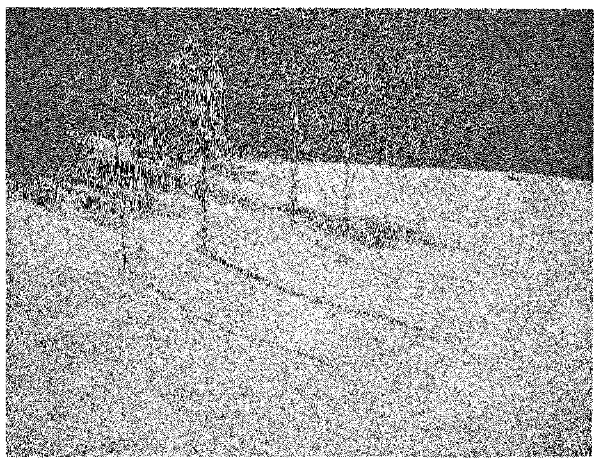


Fig. 3 Lysimeter Test Site with 4 m Snowpack

Recent efforts have been devoted to 1) improving operation of the cylinder to minimize disturbance of the snowpack, 2) preparation of the floor pan soil, drains, and seals to prevent leakage and to gain fast response time in detecting the snowmelt, 3) installing equipment for transmission of data from CSSL to Davis and Berkeley, 4) investigating temperatures and heat flow in the snowpack, soil, and lysimeter pit, 5) development of methods for treating the snow surface with hexadecanol and evaluating the uniformity of application, and 6) accumulating snowmelt and density data regularly.

A record of the melt collected separately from the experimental and control snowpacks, together with the outside air temperatures, is shown in Figure 4. During the period shown the experimental snowpack was not treated with hexadeconal. As can be seen, the quantities are nearly identical. The maximum deviation was caused by the presence of an electric light left burning under the experimental snowpack during February.

Figure 5 illustrates typical density profiles measured with the lysimeter experimental and control density gages, and with a U.S. Forest Service density gage located approximately 20 m to the north of the lysimeter. Snowpack water equivalents were computed from the density profiles and are indicated in the figure. There is reasonably good agreement among the three measurements.

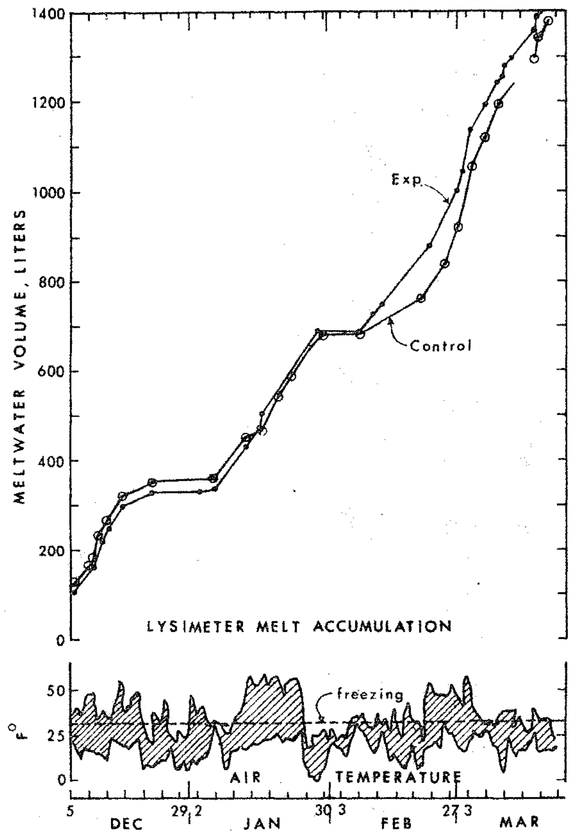


Fig. 4 Melt and Temperature Record

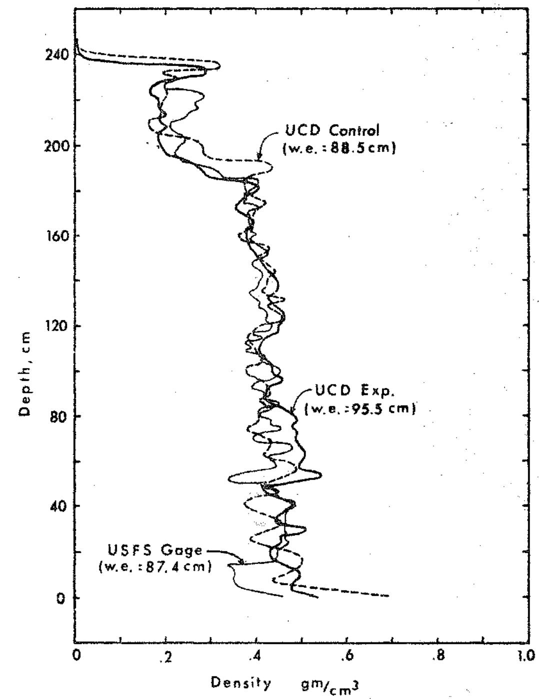


Fig. 5
COMPARISON OF TYPICAL DENSITY PROFILES, 3/12/75
UCD Experimental and Control Gages, USFS Gage

Parameters for the natural snowpack and for various treatment procedures will be selected and adapted for use in a complex mathematical model of the snow melting process developed by Amorocho and Espildora (1966). These, combined with meteorological data, can be used in the model to generate a statistically representative sample of watershed yields. Consideration of yields together with other impacts of treatment yet to be studied are hoped to lead to a rational approach for selection of snowpack management techniques.

REFERENCES

Amorocho, J., and B. Espildora, Mathematical Simulation of the Snow Melting Processes, Water Science and Engineering Paper No. 3001, University of California, Davis, California, February, 1966.

Smith, J., H. Halverson, and R. Jones, Central Sierra Profiling Snow Gage: A Guide to Fabrication and Operation, USAEC Technical Information Center Publication No. TID-25986, February, 1972.