MODEL STUDIES OF SNOWDRIFTS FORMED BY LIVESTOCK SHELTERS AND POND EMBANKMENTS 788-85

BY

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INTRODUCTION

Although artificial barriers are commonly used to protect livestock from winter winds, the optimum design has yet to be determined for locations with blowing snow. By reducing wind speed, barriers also cause snowdrifts that can bury livestock during major storms. A separate but related problem is how to design pit reservoirs to maximize snow deposition as a water source. This paper presents results from studies of small-scale models comparing alternative designs of shelters and pond embankments. All models were 1/30 scale, and were studied under natural blowing snow conditions on a frozen lake in southeastern Wyoming. Theoretical and practical aspects of "outdoor" modeling have been described by Tabler (1980) and Tabler and Jairell (1980).

RESULTS

All solid barriers tend to cause snow deposition, with initial accumulation being on the windward side and extending about ten times the shelter height, H, upwind. Little snow accumulates on the lee side initially because snow particles are entrained in the accelerated flow at the outer boundaries of the wake, and carried over or around the sheltered area (Fig. 1). As the windward drift becomes deeper, eventually approaching the top of the fence, the vertical deflection is reduced and more particles settle out in the sheltered region. The tendency for flow deflection laterally around the shelter would also diminish as the upwind drift grows and streamlines the shelter.

Figure 1. Snow particles blowing over the top of a 1/30 scale model of a livestock shelter 3.3 m tall and 33 m in diameter. This vertical deflection of particles reduces deposition within the sheltered region.

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To protect livestock from variable wind directions, shelters are typically V-shaped or semicircular. We compared these two shapes using 14-cm-tall models, with the semicircle having a 140-cm diameter, and the 90° V-shaped shelter having 100-cm walls. Drift shapes behind the two designs were nearly identical for winds alined symmetrically with the centers of the shelters. Both formed drift wings that extended downwind to approximately five times the shelter width (or diameter), D (Figs. 2-3). The minimum open space between the drift wings was 0.5D for the semicircle, and 0.75D for the V-shape, and was located about 1.5D downwind from the ends of the walls for both shapes. The drift upwind of the semicircle was slightly longer and reached the top of the shelter near the center, although the walls further downwind were scoured free of snow. There was very little deposition inside of the V-shaped shelter, but a shallow drift did develop inside the semicircle within a distance of 4H from the wall. We have observed a similar pattern inside a full-scale shelter 4.3 m tall and 60 m in diameter (Fig. 4). The drift inside the prototype was also confined within a 4H distance from the wall, but its depth was nearly equal to the height of the shelter. To test the idea that the larger interior drift in the prototype was caused by a 2.4-m snow fence located about 20 m upwind, we installed a 6-cm snow fence at a comparable distance upwind from the shelter model. With the snow fence, the drift upwind of the shelter was much longer and deeper and encroached on a wider portion of the shelter, and the interior drift was also deeper (Fig. 5). It seems therefore, that if a fence is placed too close to a shelter, it can reduce the deflection of particles and cause a larger drift to form inside.

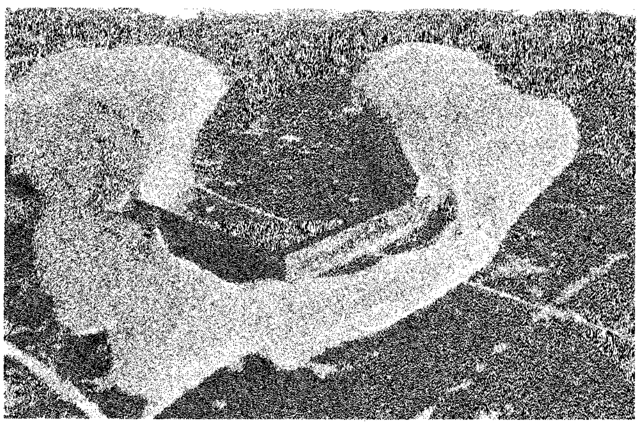

Figure 2. Snow drift formed by a 1/30 scale model of 90° V-shaped shelter 4.2 m tall and having 30-m walls. Wind direction is away from the camera.

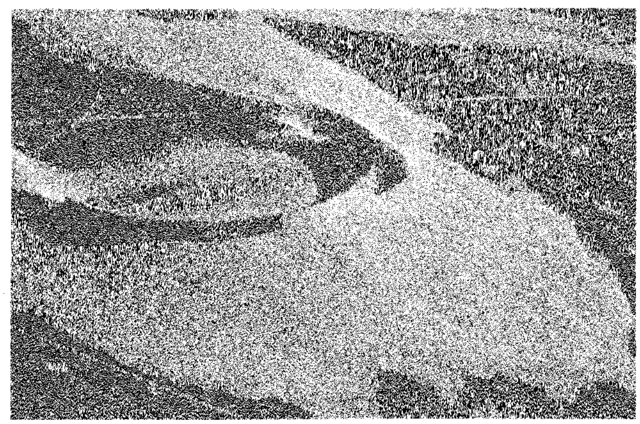

Figure 3. Snowdrift formed by a 1/30 scale model of a 4.2-m tall semicircular shelter 42 m in diameter, formed at the same time as the drift shown in Figure 2.

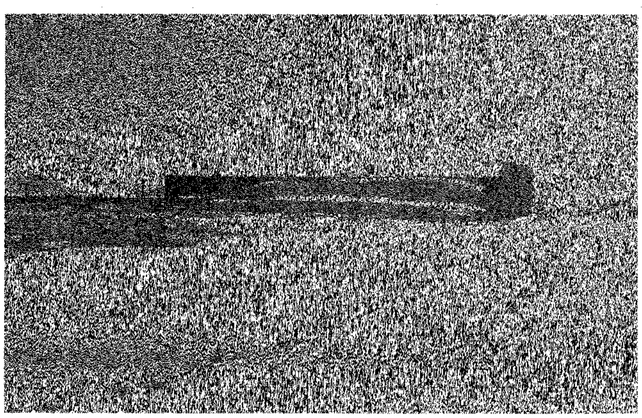

Figure 4. Drift inside a full-scale semicircular shelter 4.3 m tall and 60 m in diameter, located 30 km north of Medicine Bow, Wyoming.

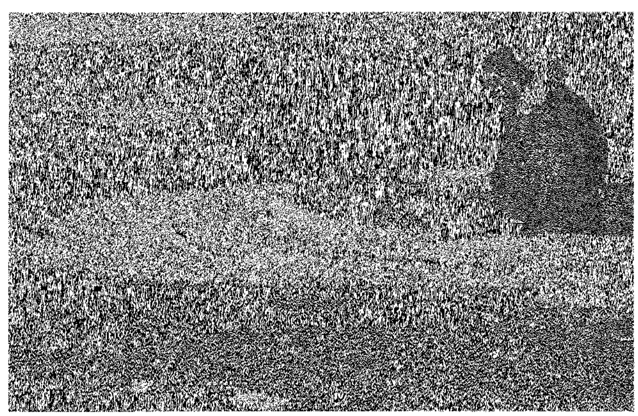

Figure 5. The same model shelter as described for Figure 3, but with a scale model snow fence placed upwind. The fence caused a larger drift inside the shelter.

Deflection of blowing snow must also be considered in the design of excavated stock ponds. It is common practice to dispose of the excavated material by constructing embankments around the pond. Although intuitively it might seem that an embankment on the windward side would cause a larger snowdrift to form in the pond, just the opposite is true when snow is diverted around the embankment or deflected over the top and carried across the reservoir. Model studies confirm that very little snow accumulates behind an upwind embankment (Fig. 6), while a pond with a downwind embankment fills with snow (Fig. 7). However, we were able to induce deposition within a pond by placing a 50% porous snow fence on top of the windward embankment, providing additional evidence that vertical deflection is important (Fig. 8).

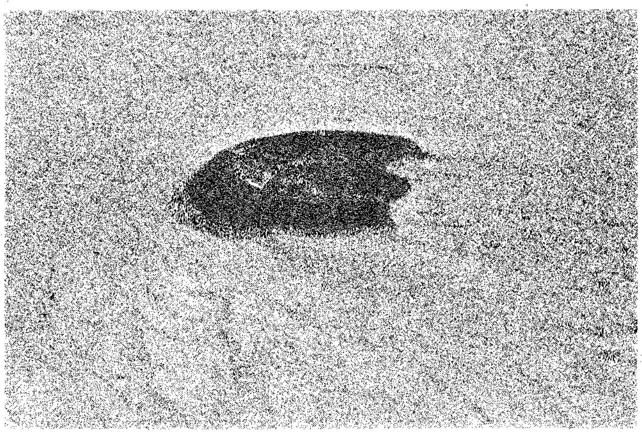

Figure 6. Little snow accumulates in the 1/30 scale model of a stock pond 18 m in diameter, 2.6 m deep, and with 3-m embankments on the windward sides. Wind is left to right.

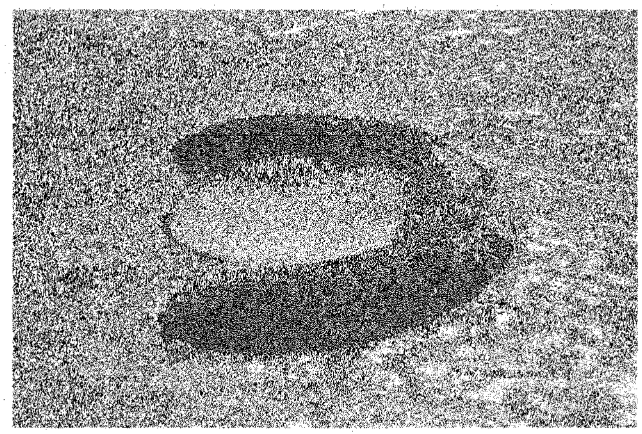

Figure 7. The same model stockpond as in Figure 6, but with the embankment on the downwind sides. Wind is left to right.

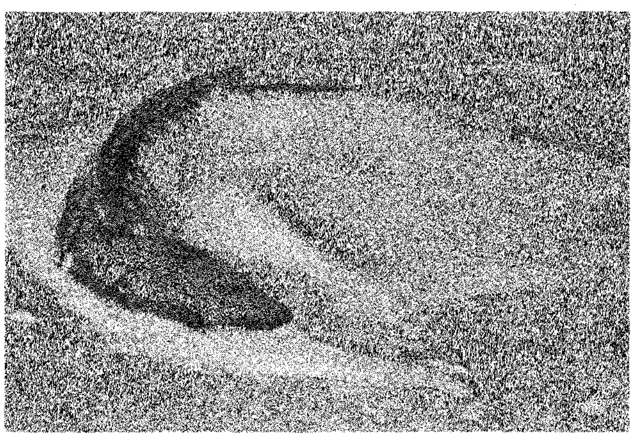

Figure 8. the same model pond as in Figure 6, with a snow fence on the windward embankment.

Figure 9. Snow accumulation is maximized by by placing a snow fence on the windward side of a pond with a downwind embankment.

RECOMMENDATIONS

Based on these model tests and field observations, we recommend that tall shelters (3.7-5 m) be used where there is a snowdrifting problem, with the diameter (or width) not exceeding 15 times the height. Snow fences are not needed upwind of tall shelters, but if used to protect an existing shorter shelter they should not be placed closer than (30h + 10H), where h and H are heights of fence and shelter, respectively. Semicircular designs seem preferable to more enclosed shelters having narrower openings because of the possibility that the opening could be blocked by a drift. The best site for a livestock shelter is one where the open (downwind) side faces some sort of natural snow accumulation area, such as an incised stream channel, in order to minimize the amount of blowing snow accompanying winds opposite to the prevailing direction. If a snow fence is used to protect the open side of a shelter, its minimum spacing from the shelter should also be (30h + 10H). An advantage of semicircular shelters is that they are more economical to build because the ratio of sheltered area to shelter length is about 27% greater for a semicircle than for a 90° V-shape requiring the same amount of material.

Embankments should be confined to the downwind half of excavated stock water ponds, and a 50% porous snow fence, placed near the upwind edge of the pond, will maximize snow deposition (Fig. 9). A snow fence placed on top of an existing windward embankment will increase snow deposition within the pond.

REFERENCES

Tabler, Ronald D. 1980. Self-Similarity of Wind Profiles in Blowing Snow Allows Outdoor Modeling. Journal of Glaciology 26(94): 421-434.

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