Development of Underground Cold Storage at Pine Ridge Forest Nursery[1]

J. Roger Hamilton[2]

Abstract.--Three 72 foot (21.6 m) squash culverts were buried under 5 feet (150 cm) of soil at an especially selected site at Pine Ridge Forest Nursery, Alberta, Canada. The culverts were flooded with ice in the winter and provide a passive refrigeration cold storage unit for 2.5 million seedlings.

INTRODUCTION

In 1980, the Alberta Forest Service started a reforestation program called maintaining Our Forests. The objective of this program was to reforest old burns and convert off site aspen to conifer forests, in order to make up for lands lost to agricultural and petrochemical expansion in Alberta's green zone.

At that time, Pine Ridge Forest Nursery was asked to develop the necessary plans and infrastructure to increase its production from 10 million container seedlings to 20 million and 10 million bareroot seedlings to 18 million.

Part of the increase in bareroot production meant that additional cold storage for bareroot seedlings would be necessary. The conventional cold storage at Pine Ridge Forest Nursery could hold 12.5 million seedlings, leaving a balance of 5.5 million seedlings to be stored or otherwise hot lifted etc.

OBJECTIVES

Several objectives were set for the cold storage addition:

1. The storage structure should hold 2.5 million trees.
2. The storage structure should be built at least cost and have a low maintenance and running cost.
3. This project would be a prototype for field satellite storage.

Figure l.--Culvert installation at Pine Ridge.

Keeping these objectives in mind, several alternatives were looked at. As a result, snow caches, ice houses and root cellars were investigated. Our forefathers used the concept of root cellars and ice houses for cold storage and preservation for many years, so we thought that a combination of the two concepts would meet all our above-noted objectives. During construction of the seed processing system, the seed cold storage building at Pine Ridge was placed underground. It was discovered that 4 feet (120 cm) underground, providing the surface is never disturbed, the soil had a constant temperature of +39^{0}F (+4°C). Cooling in summer and heating in winter was very inexpensive. Another added feature was the constant temperature of the soil and large masses of soil meant that the temperature would change very slowly if a power failure occurred. Some work had been done in the past with ice in culvert structures, but this was above ground.

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[1]Paper presented at Intermountain Nurserymens Association meeting (Fort Collins, Colorado, August 13, 14-15, 1985).

[2]J. Roger Hamilton is Production Forester, Alberta Energy and Natural Resources, Alberta Forest Service, Pine Ridge Forest Nursery, Smoky Lake, Alberta, Canada.

Putting all of the foregoing together it was decided to bury squash multi plate culverts underground with 5 feet (150 cm) of soil over them. In the dead of winter, the culverts would be flooded until a foot of ice was built-up. Trees would be moved in on pallets on the ice and stored until spring. It was hoped that the ice would last until the end of the shipping season, around the first of July.

A squash culvert design was chosen as the nursery's bareroot boxes can be stacked only six high before the bottom box starts to collapse. Thus height for the ice, pallets and boxes should not exceed 8 feet (2.4 m). Culvert suppliers were consulted and the widest squash culvert of 8 feet (2.4 m) height was 13 feet (3.99 m). This set the width parameter. In order to store 2.5 million trees at 500 trees per box, and using our height and width specifications, a total length of culvert of 216 feet (64.8 m) was derived. It was decided that this length was impractical for a single culvert. The length was divided in three and thus three 72 foot (21.6 m) culverts were installed.

A survey of the nursery site was done at this time, looking for a gulley or depression where these culverts could be installed facing north (shading doors). A suitable site near the north fence was found that had a shaded depression big enough for the three culverts with suitable drainage and allowing for a road to be built for access by a semitrailer truck and 45 foot (13.7 m) reefer van.

Department of Highways bridge branch was consulted, and it was found out that most of these large culverts are bid installed by the manufacturer. Thus tenders for the culverts were let.

CONSTRUCTION

All the excavation work was done using the Nursery's D6 cat. The site had been a dump for waste sand and ash from the nursery clearing. An area 55 feet (16.5 m) by 80 feet (24 m) had to be dug out and leveled. A bed of sand 1 foot (30 cm) thick was laid for each culvert. The bed had to have a very slight grade at 1 percent to provide drainage and was made of sand and/or gravel to prevent the culverts from shifting. At this point, the erection crew came in and installed the culverts. Each culvert was spaced about 8 feet (2.4 m) from the other. Erection took a day per culvert.

Once the culverts had been installed and checked, construction of the back wall commenced. Native pine from the nursery site which was peeled and treated to prevent rot and backed by a 3/4 inch (19 mm) plywood with steel bracing was used for the wall.

Backfilling had to be done very carefully in order to prevent distortion of the culverts. Sand was placed in 6 inch (15 cm) layers and tamped. Layers had to be placed evenly. This had to be done until backfilling was "over the hump" on the sides of the squash culverts. At that point, a large front end loader with a 12 yard bucket was brought in to complete the job until 5 feet (150 cm) of soil covered the culverts.

In the front, three telephone poles were cemented in an upright position between each culvert. Then logs were placed horizontally to form a front wall. Deadman logs were placed between the culverts and cable installed to hold the tops and center of the telephone poles in place.

Double airlock doors were installed, with the inner door having 4 inches (10 cm) of styrofoam for insulation. Air vents were installed in the roof at 1/3, 2/3 and at the end. A manifold was built at the end and a fan used in the winter to increase air circulation during freezing.

Each culvert had a water pipe with spaced nozzles installed in the roof. A water truck is hooked up to the water pipe in the winter and flooding can be completed in a matter of minutes.

The final phase of construction was landscaping the site to channel spring run-off away. A leaching pit was constructed in the roadway by the doors to collect run-off from rain and snow melt. The site was seeded to grass and planted with trees to prevent erosion. The site is to remain undisturbed.

COST

The following is a summary of the costs of building the three culverts:

Culverts and assembly (bid price) $ 42,233.00
Wages 13,963.00 Materials and supplies 453.00

Administration costs 2,882.00 Equipment operating costs 4,206.00

Total Construction Costs $ 63,737.00

OPERATION

The culverts were flooded for the first time in the winter of 1983/84. Freezing weather occurred in the first part of November and the doors were opened and a temperature monitor was installed. The first thing that was noticed was that the air temperature did not come down below freezing despite temperatures on the outside that were well below freezing. A circulating fan was installed and cold air blown into the culverts. Slowly the temperature decreased until by early December, ice making could commence. In order to make ice properly, a thin layer of water had to be sprayed over the interior to seal all the cracks before larger amounts of water could be laid on. Even then it was discovered that only a 1/2 inch (1 cm) of water could be flooded on the ice at a time as thicker layers melted the seal and took a long time to freeze.

By mid January, air temperatures had decreased from +28^{0}F (-2^{o}C) to +25^{0}F (-4°C) and a foot of ice had built-up. The doors were closed and a hydrothermograph probe installed so we could monitor the inside air temperature. Air temperatures were +28^{o}F (-2^{0}C) all winter despite the -40^{0}F (-40^0 C) outside temperatures experienced.

Toward the spring several hundred boxes of bareroot trees were taken from the conventional cold storage and placed on pallets in the culverts. Temperature probes were installed and the trees were held till spring planting. Temperatures in the box stayed from +28 F (-2$^{'0}$ C) to +32^{o}F (0^{0}C) until outplanting. A trial outplanting was conducted in May of 1984, and the trees showed good regeneration potential.

The empty culverts were sealed until mid-summer 1984 when some modifications to the irrigation and air circulation system were made. Even in mid August the culverts still had ice remnants in them.

In November 1984 the culverts were again made ready for use. Ice was slowly built-up over time until a foot of ice was on the floor. In March 1985 all three culverts were loaded up with bareroot from conventional cold storage and extracted containers were added in late March. In box temperatures again remained at +28^{o}F (-2^{o}C) to +32^{o}F (0 C) during storage until spring planting in may.

At the end of shipping, the doors were again closed and the intervening space was filled with bagged vermiculite. It is hoped that ice will be retained year round if proper care is taken to reduce air circulation.

CONCLUSIONS

It appears at this time that all our objectives have been met. An inexpensive, effective cold storage alternative has been proven to be a reality. Tree quality seems to be excellent after storage in this structure. The large mass of soil around the culvert acts as an excellent cold sink in that it is very slow to cool off, and alternately, very slow to warm up. To aid ice making culverts should be sealed when installed. Drainage is important, make sure no water builds up in or around the culvert and prevent the likelihood of heaving. Our final consolation is the fact that there is some advantages to living in the cold northern latitudes.

LITERATURE CITED

Lawrence, Tomas W. 1980. Eight Foot Diameter Squash Culvert For Seedling Tree Storage. Pamphlet. 10p. No publication data given.