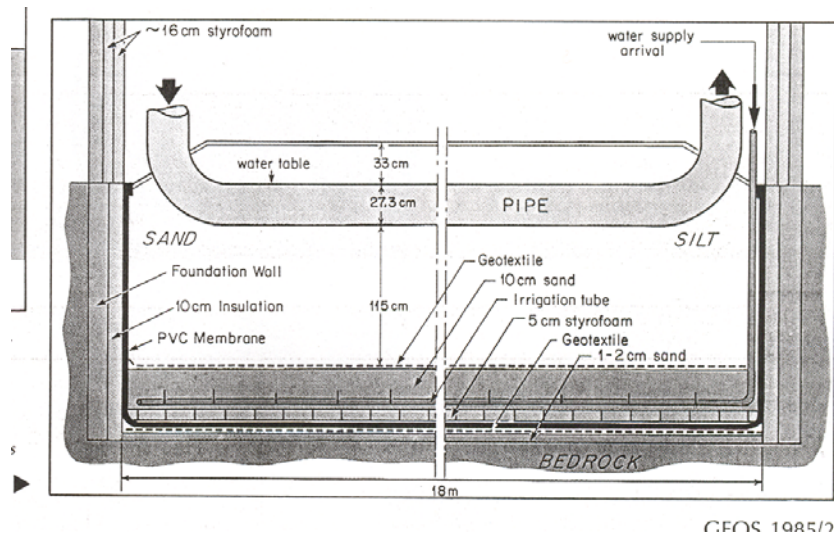


Appendix K

Selected Figures & Photographs Relating to Full-Scale Test Facilities

Caen Frost Heave Test Facility



Schematic Test Arrangement (After Burgess 1985)

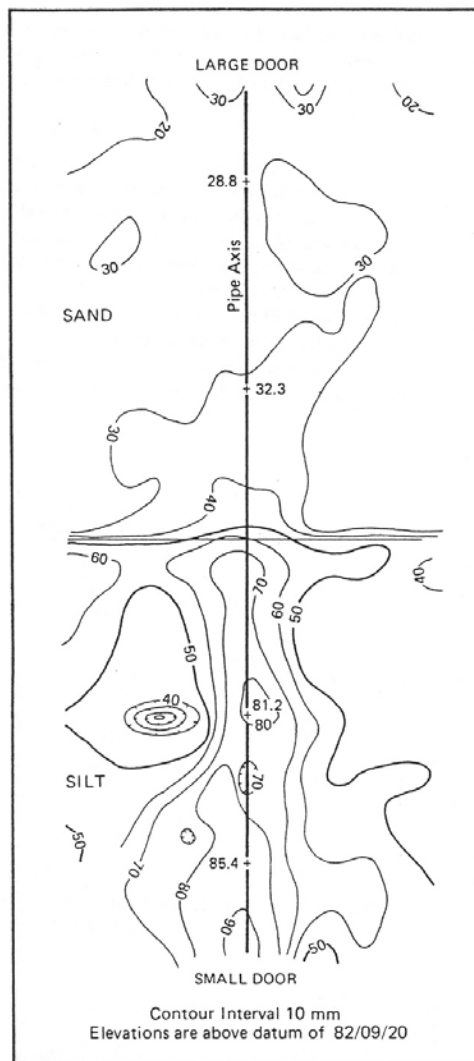
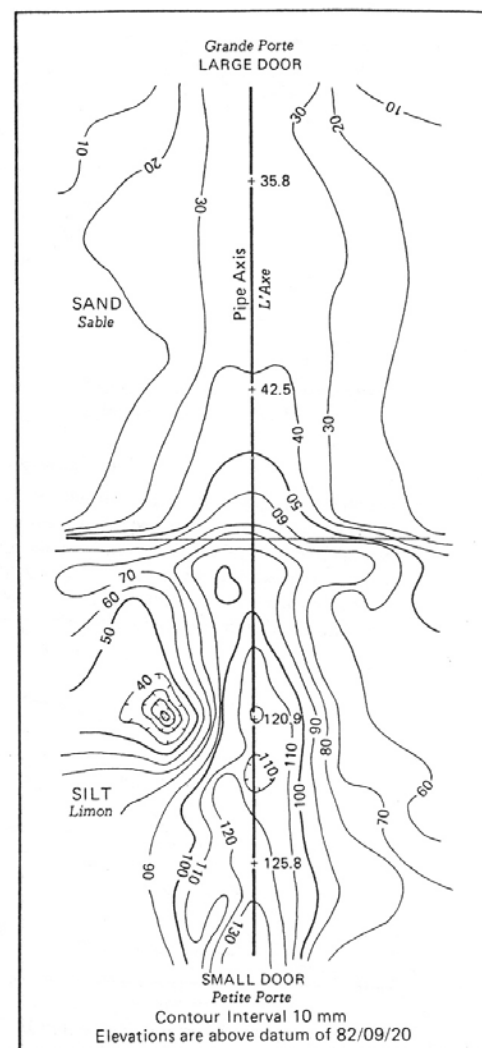
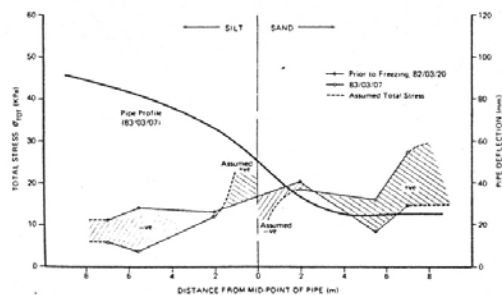
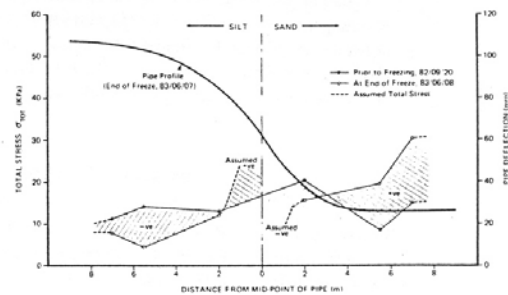


Figure 3.6 Elevation of soil surface. 83/01/05

Figure 3.7 Elevation of soil surface. 83/06/07
End of first freeze periodFigure 3.8 Total stress in soil beneath pipe during
first freeze period (83/03/07)
(Pressure cells located initially 46 cm beneath pipe)Figure 3.9 Total stress in soil beneath pipe at
end of first freeze period (83/06/08)
(Pressure cells are located initially 46 cm beneath pipe)

10

Sample Measurements of Soil and Pipe Behaviour (After Pipelines and Frost Heave 1985)

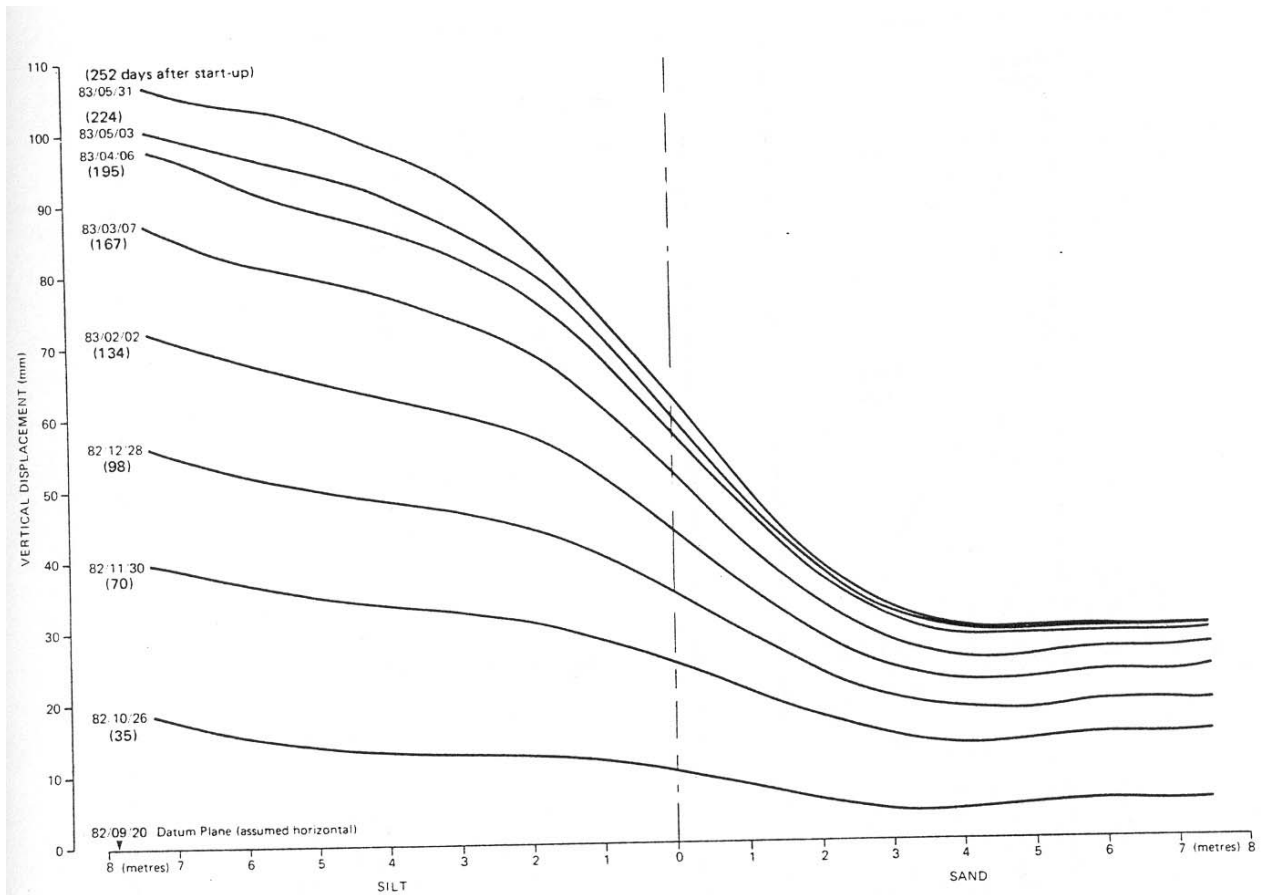


Figure 3.4 Deformation of pipe as measured by displacement of rods fixed on axis of pipeline from 82/09/20 to 83/06/07

Measured Pipe Heave (After Pipelines and Frost Heave 1985)

Calgary Frost Heave Test Facility

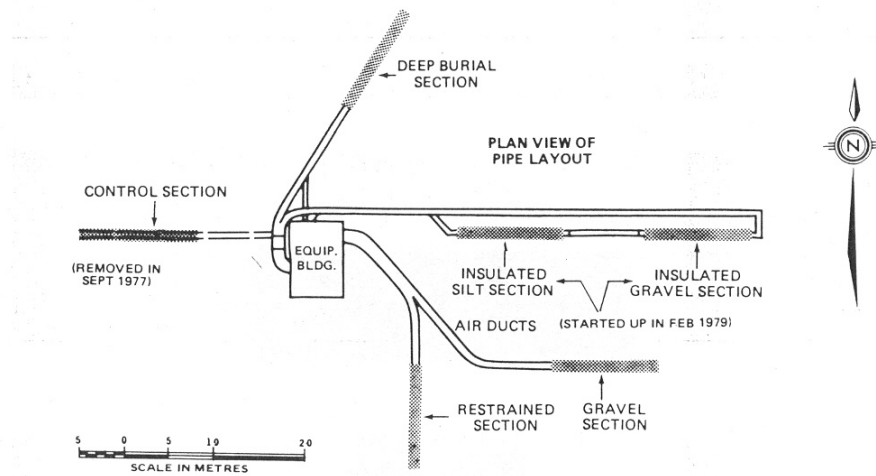
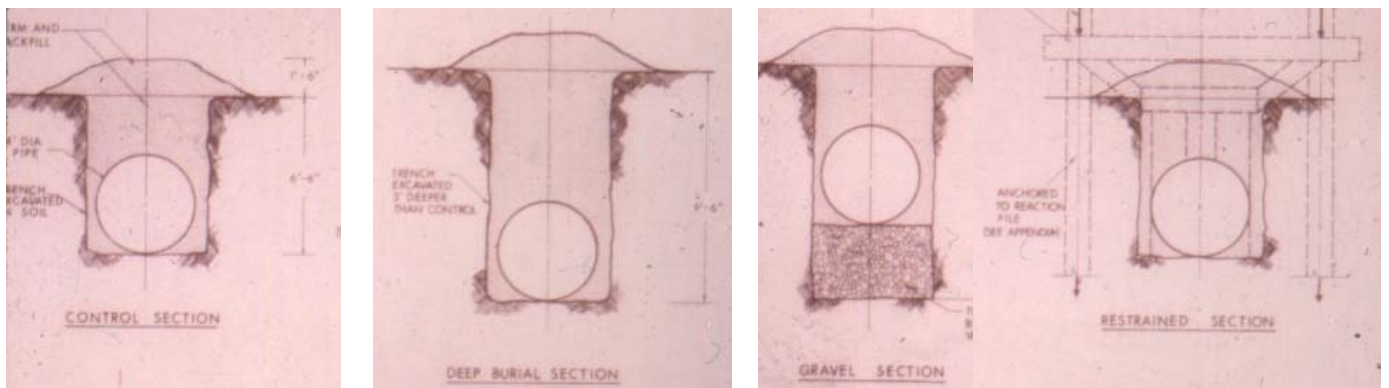
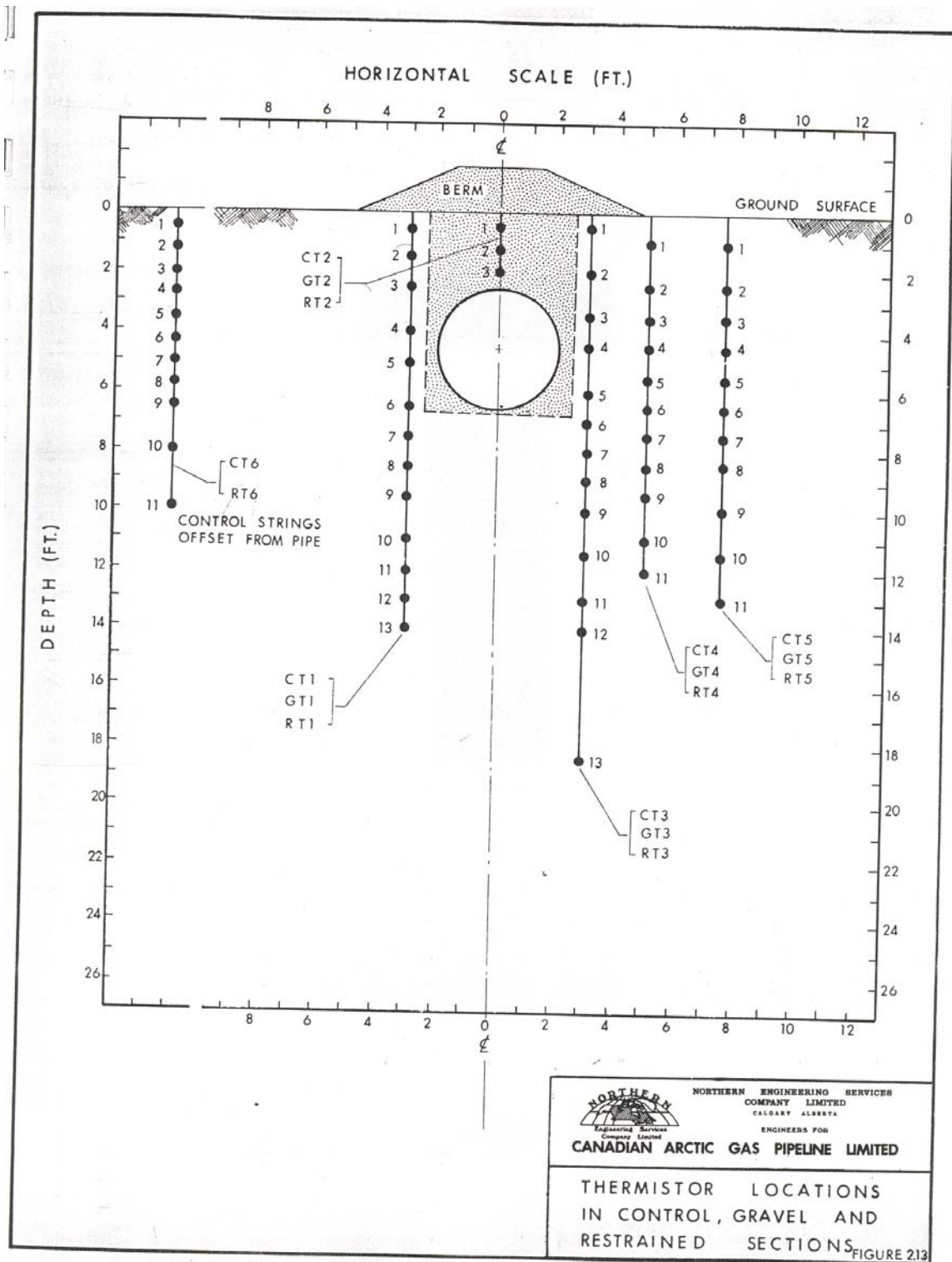


FIGURE 1. Schematic layout of Calgary frost heave test facility.

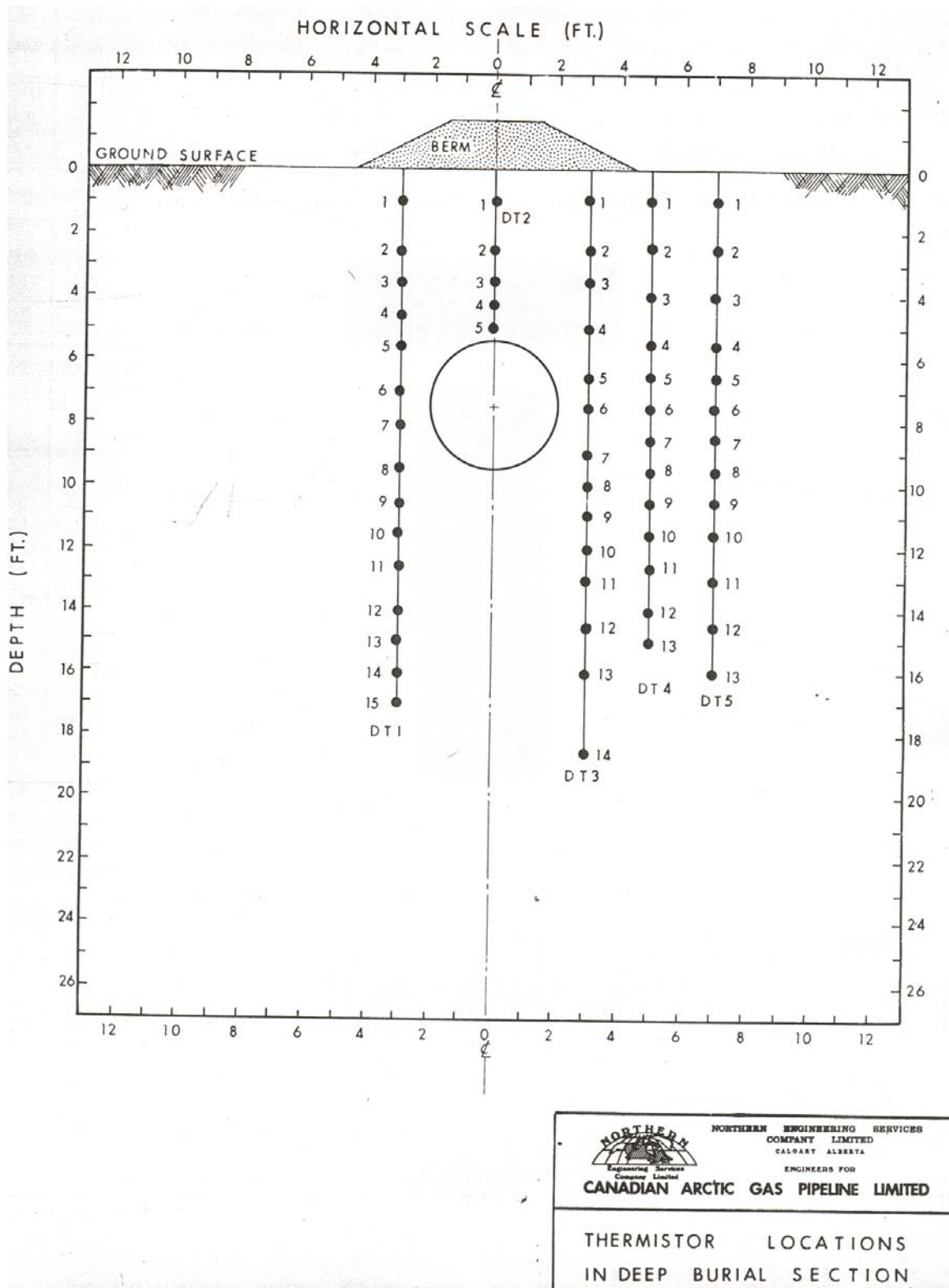
Test Site Layout (After Carlson et al 1981)



Burial Configurations of Initial Pipe Sections (From JICA Library)



Instrumentation Location – Control, Gravel & Restrained Sections (After NES 1976)



Instrumentation Location – Deep Burial Section (After NES 1976)

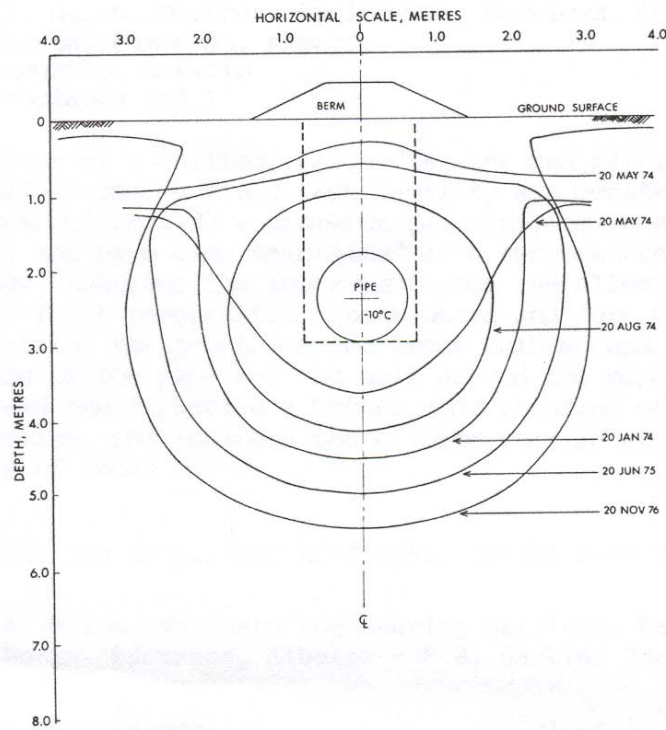


FIGURE 3 FROST PENETRATION AROUND DEEP BURIAL SECTION

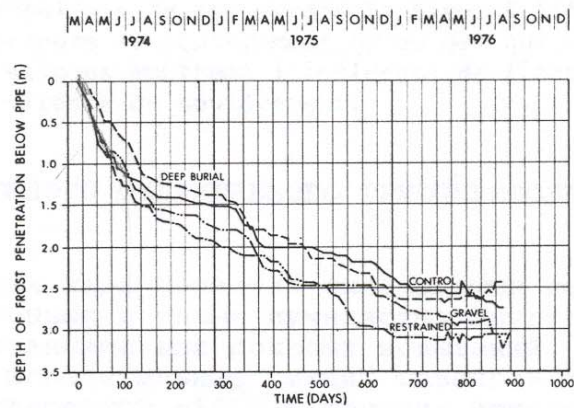


FIGURE 4 FROST PENETRATION BELOW PIPE SECTION

Typical Measurements During Test (After Slusarchuk et al 1978)

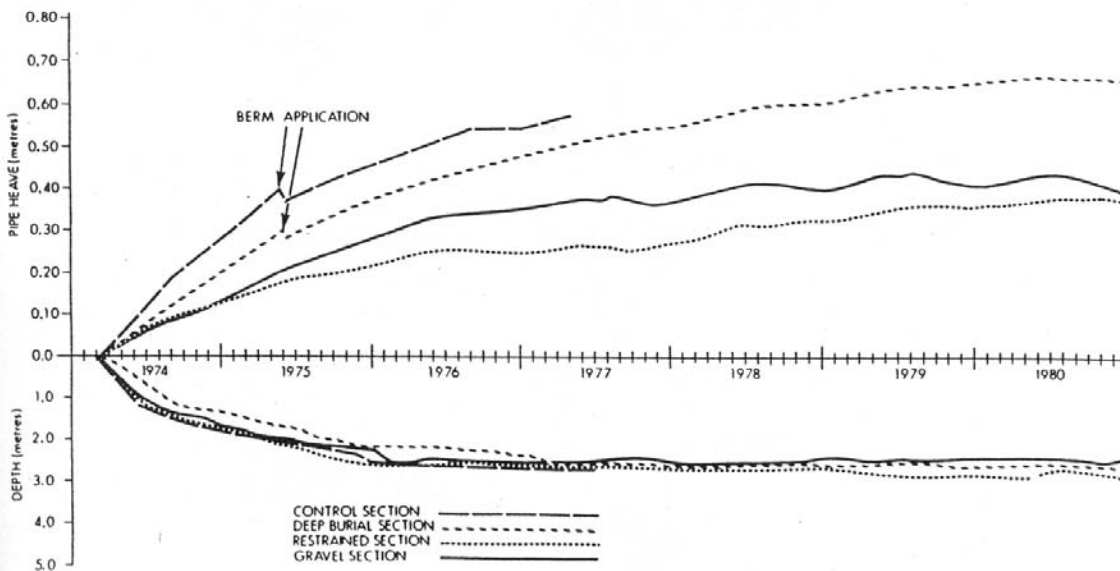


Figure 2 Calgary frost heave test facility — observed pipe heave and depth of frost below bottom of pipe

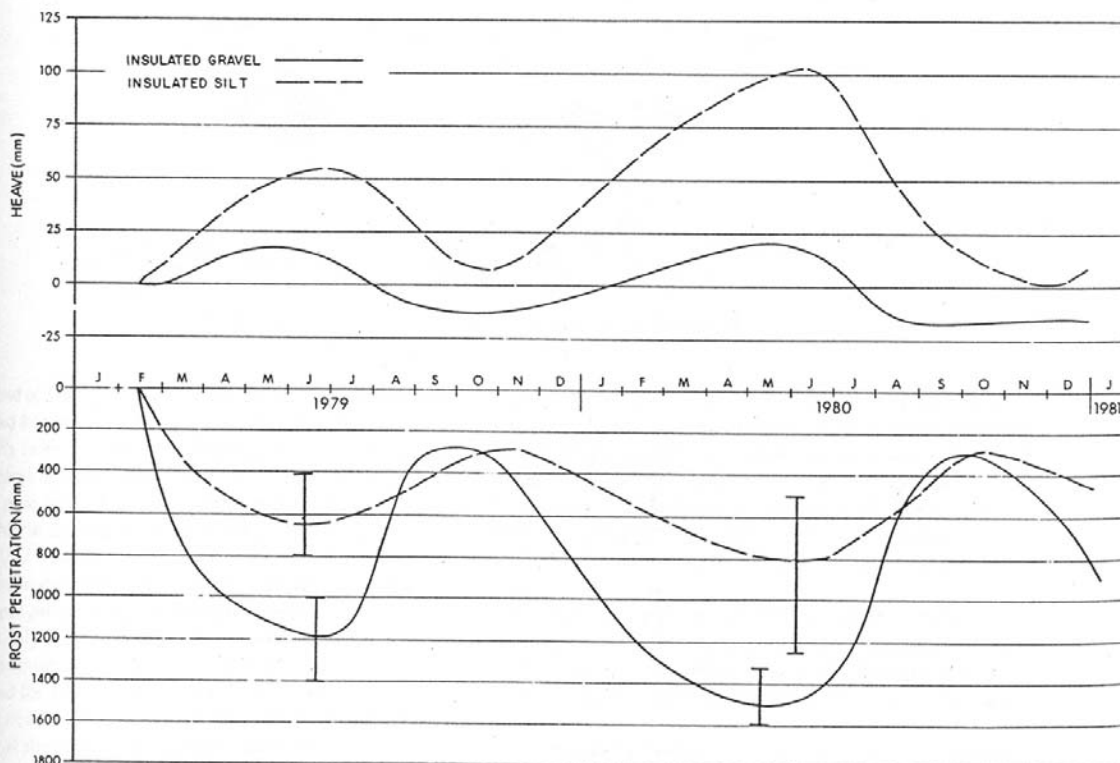
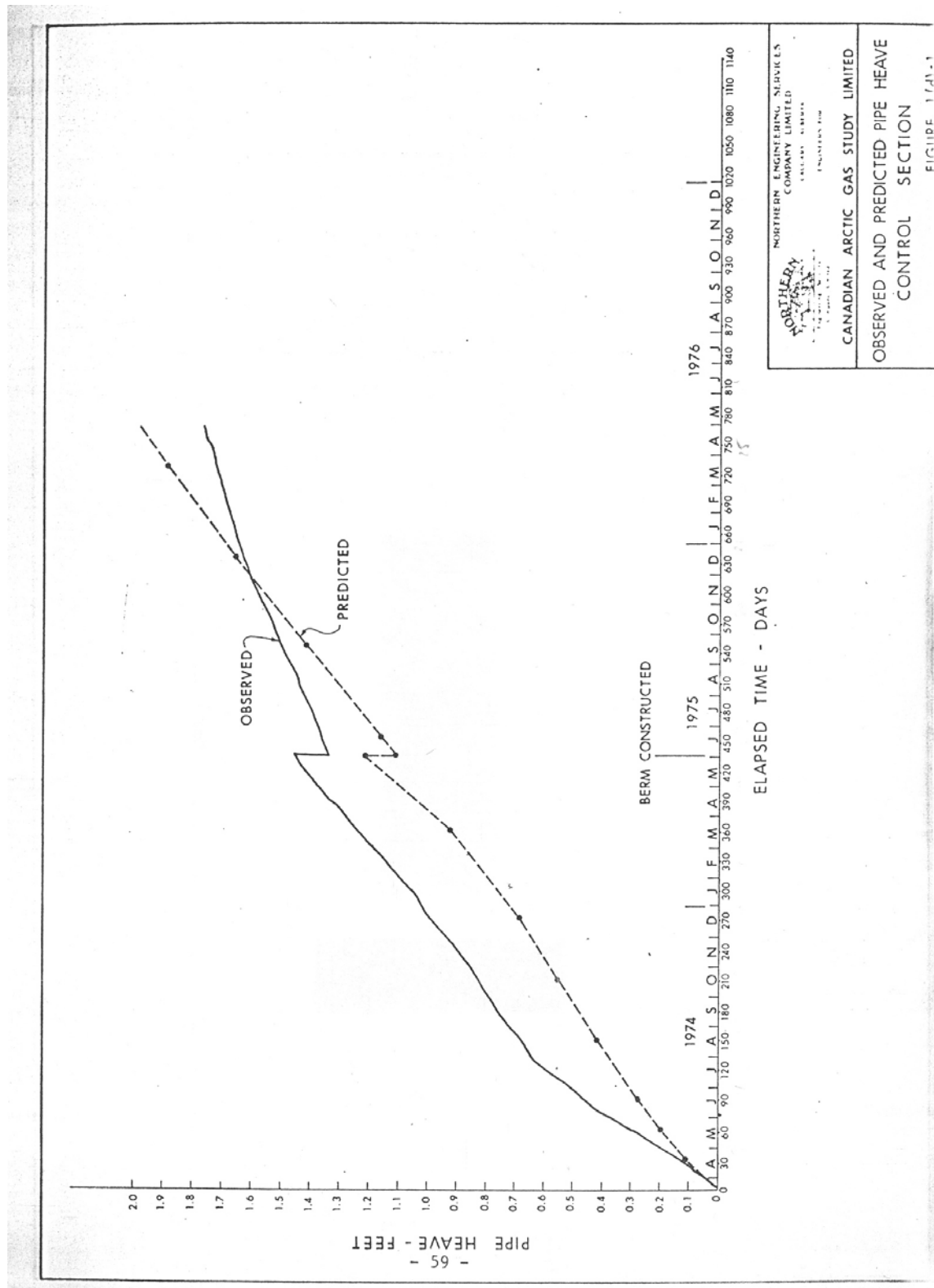
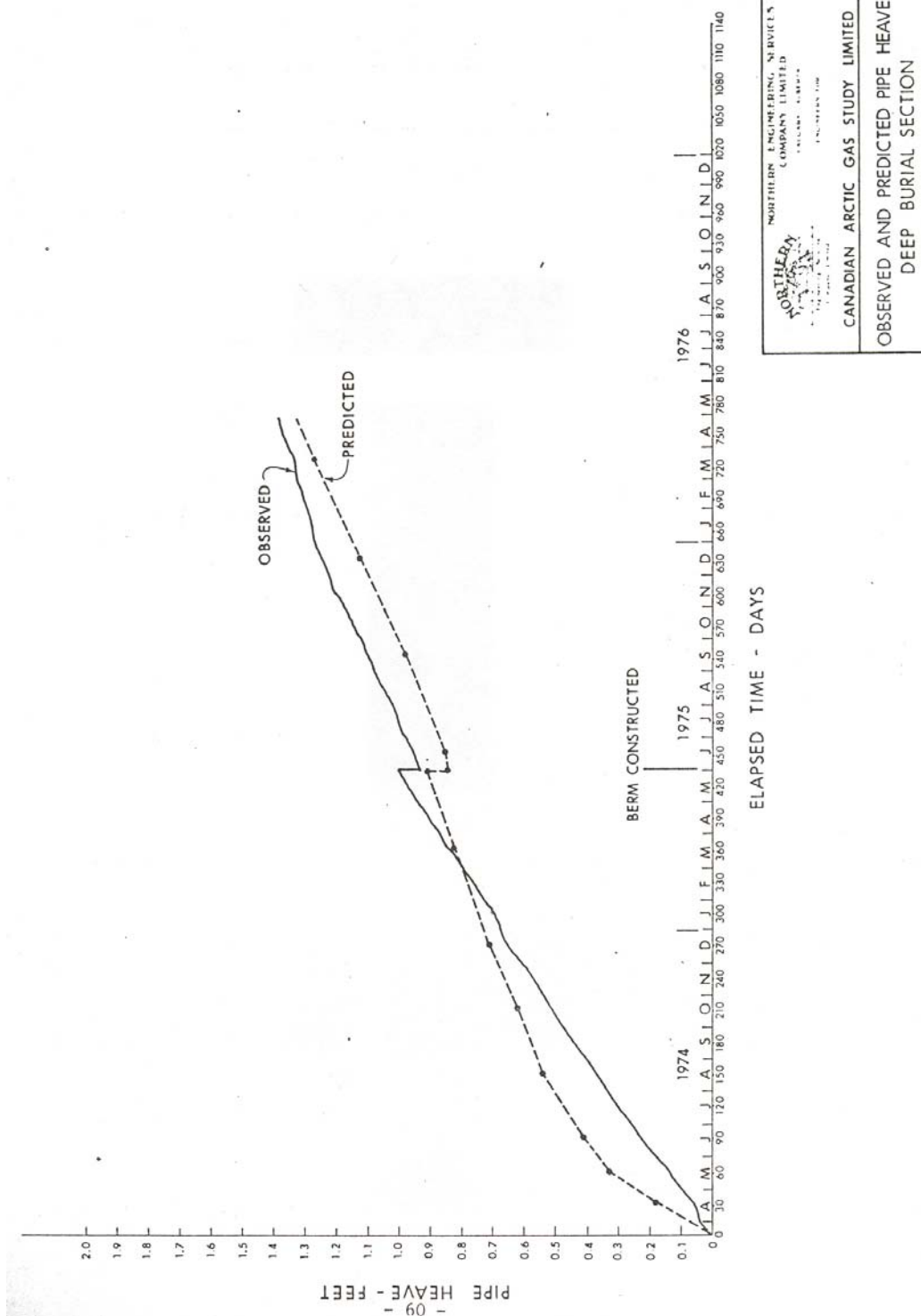


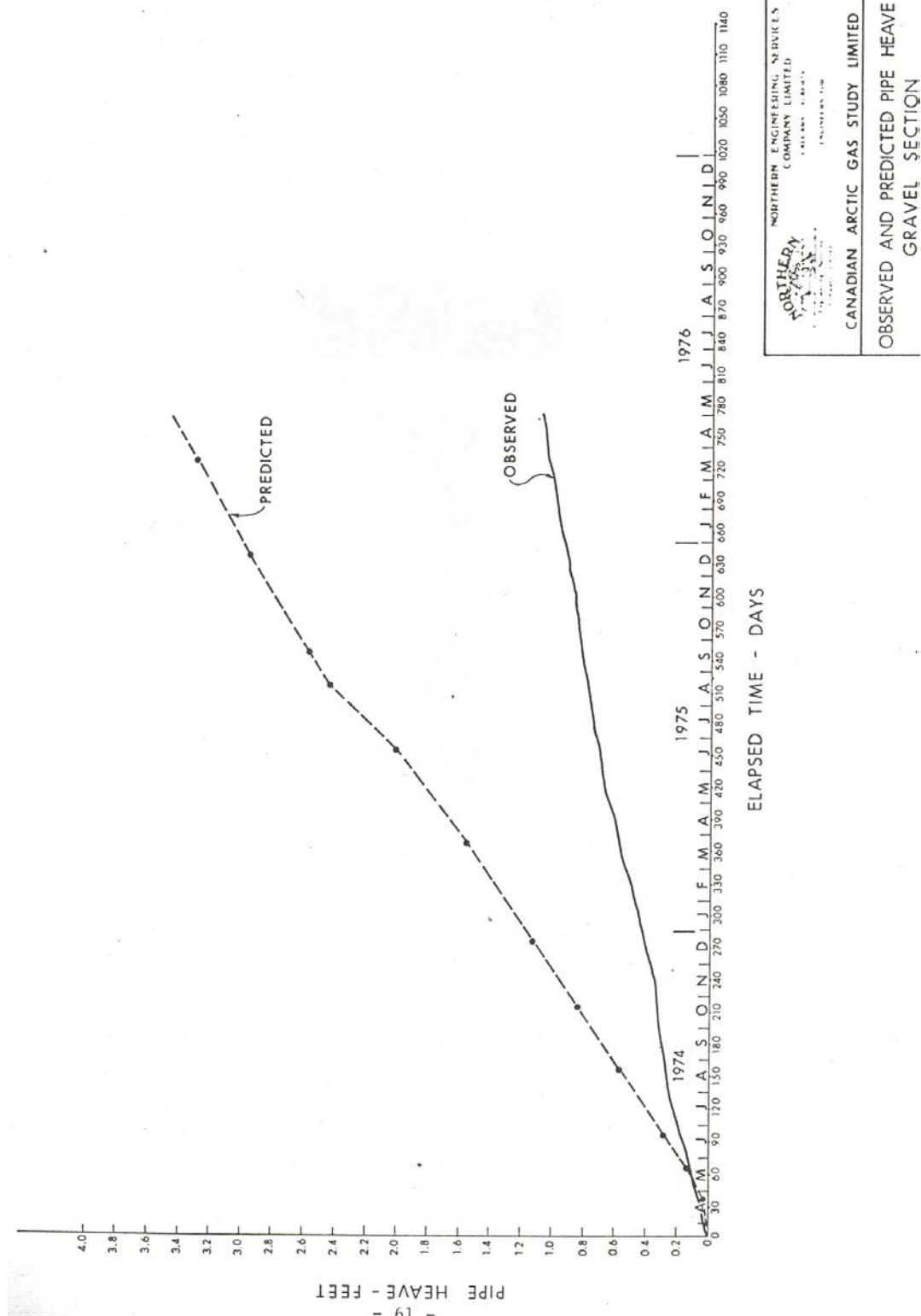
Figure 3 Calgary frost heave test facility — observed pipe heave and depth of frost below bottom of pipe



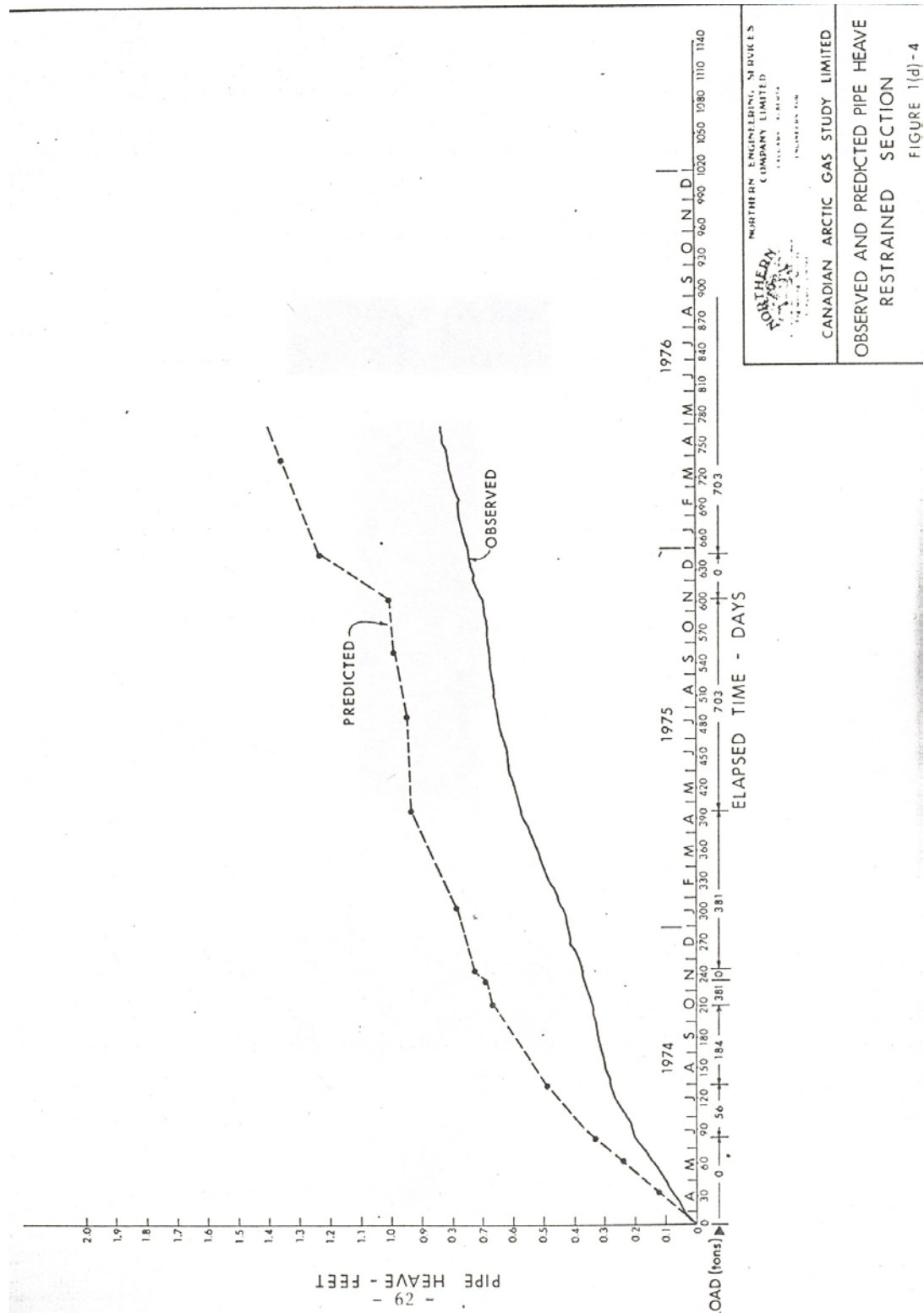
Pipe Heave – Control Section (After NES 1976)



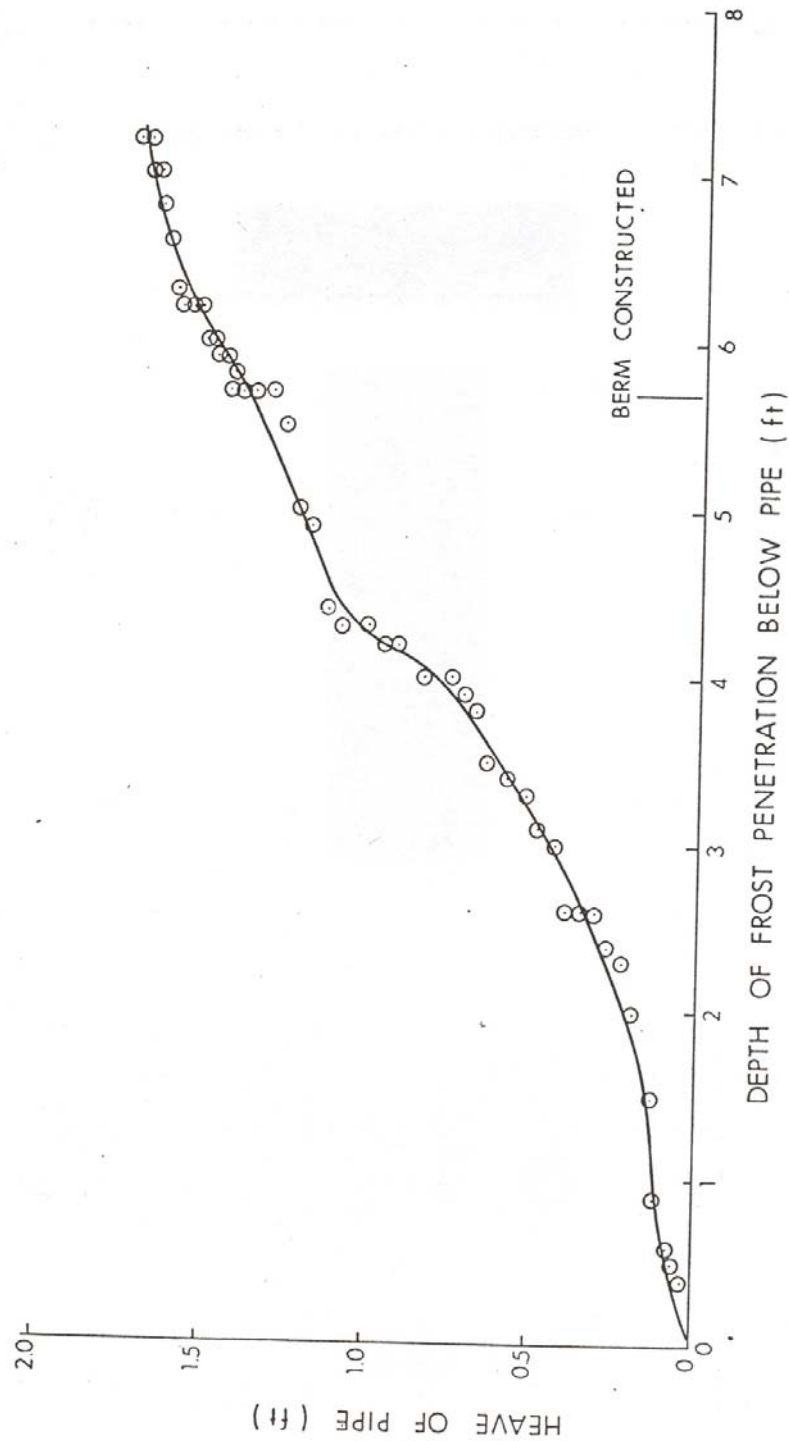
Pipe Heave – Deep Burial Section (After NES 1976)



Pipe Heave – Gravel Section (After NES 1976)

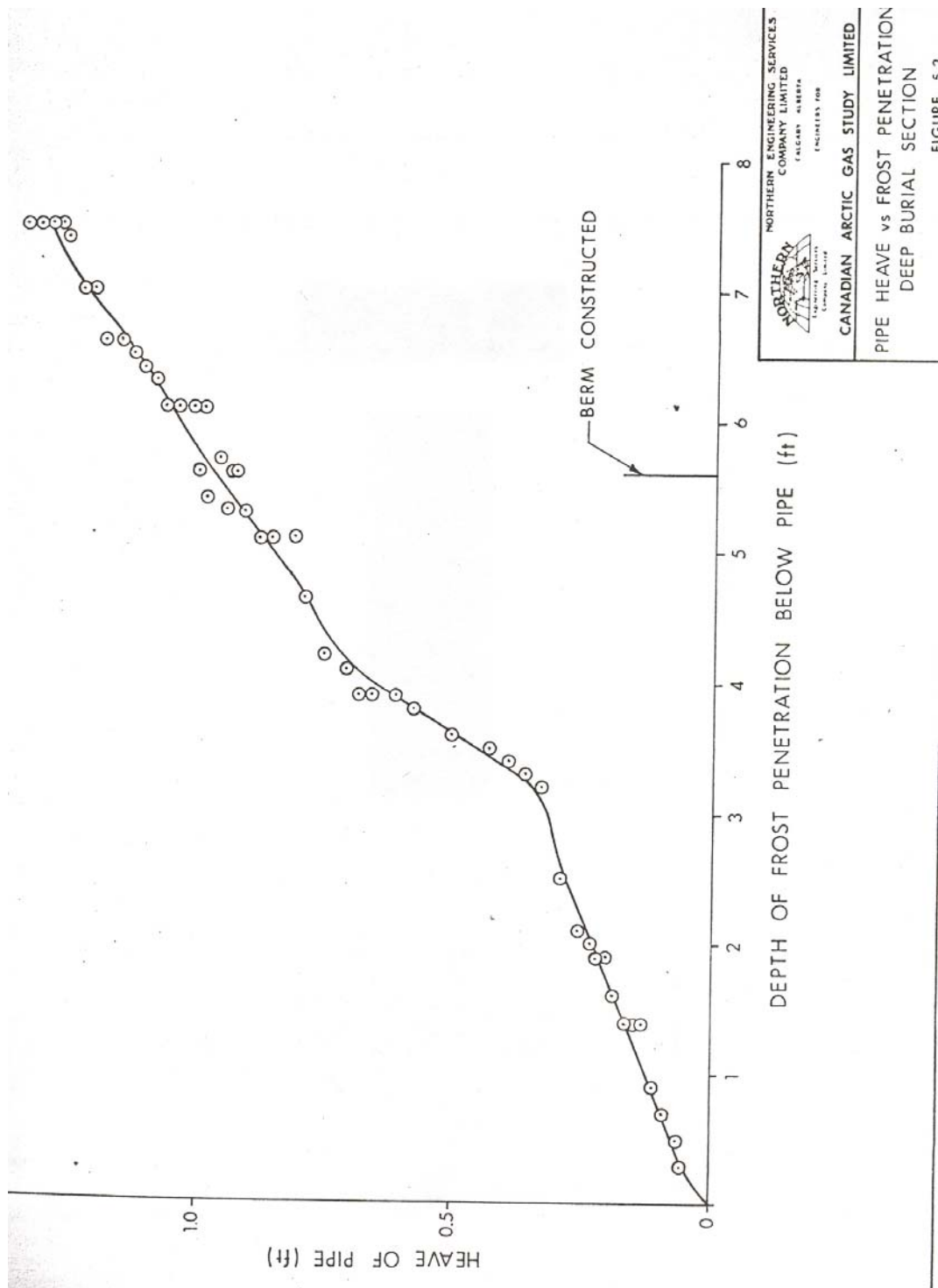


Pipe Heave – Restrained Section (After NES 1976)

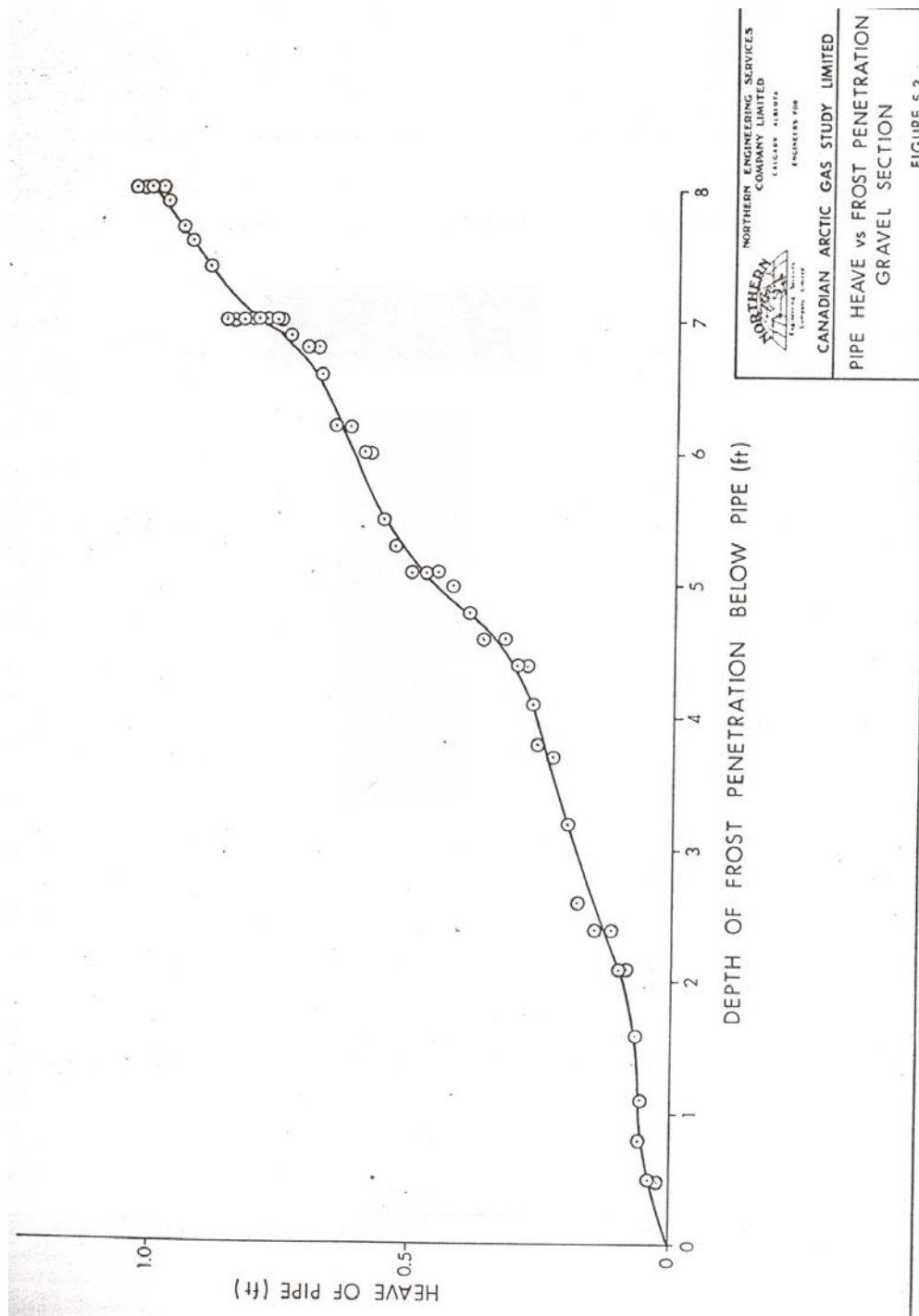


NORTHERN ENGINEERING SERVICES
 COMPANY LIMITED
 CALGARY ALBERTA
 ENGINEERS FOR
 CANADIAN ARCTIC GAS STUDY LIMITED
 PIPE HEAVE vs FROST PENETRATION
 CONTROL SECTION
 FIGURE 2-1

Pipe Heave vs. Frost Penetration – Control Section (After NES 1976)



Pipe Heave vs. Frost penetration – Deep Burial Section (After NES 1976)



Pipe Heave vs. Frost Penetration – Gravel Section (After NES 1976)



Surface Effects Due to Pipe Heave (From JICA Library)

Fairbanks 1 Frost Heave Test Facility

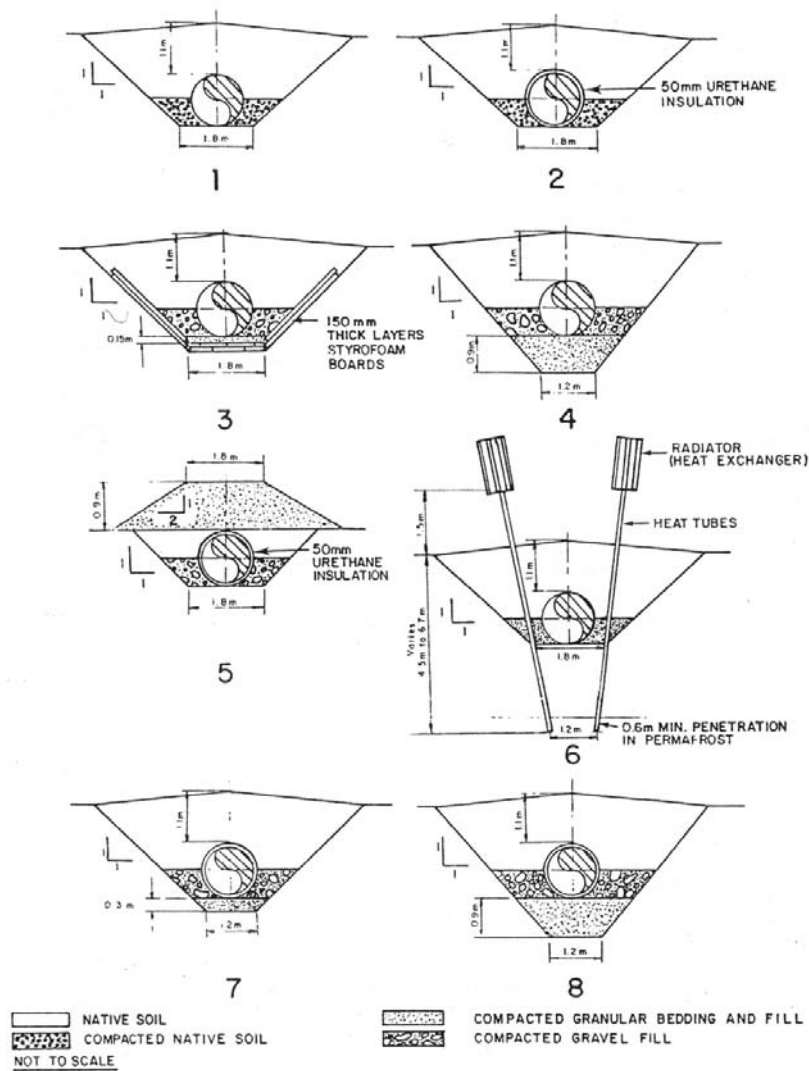
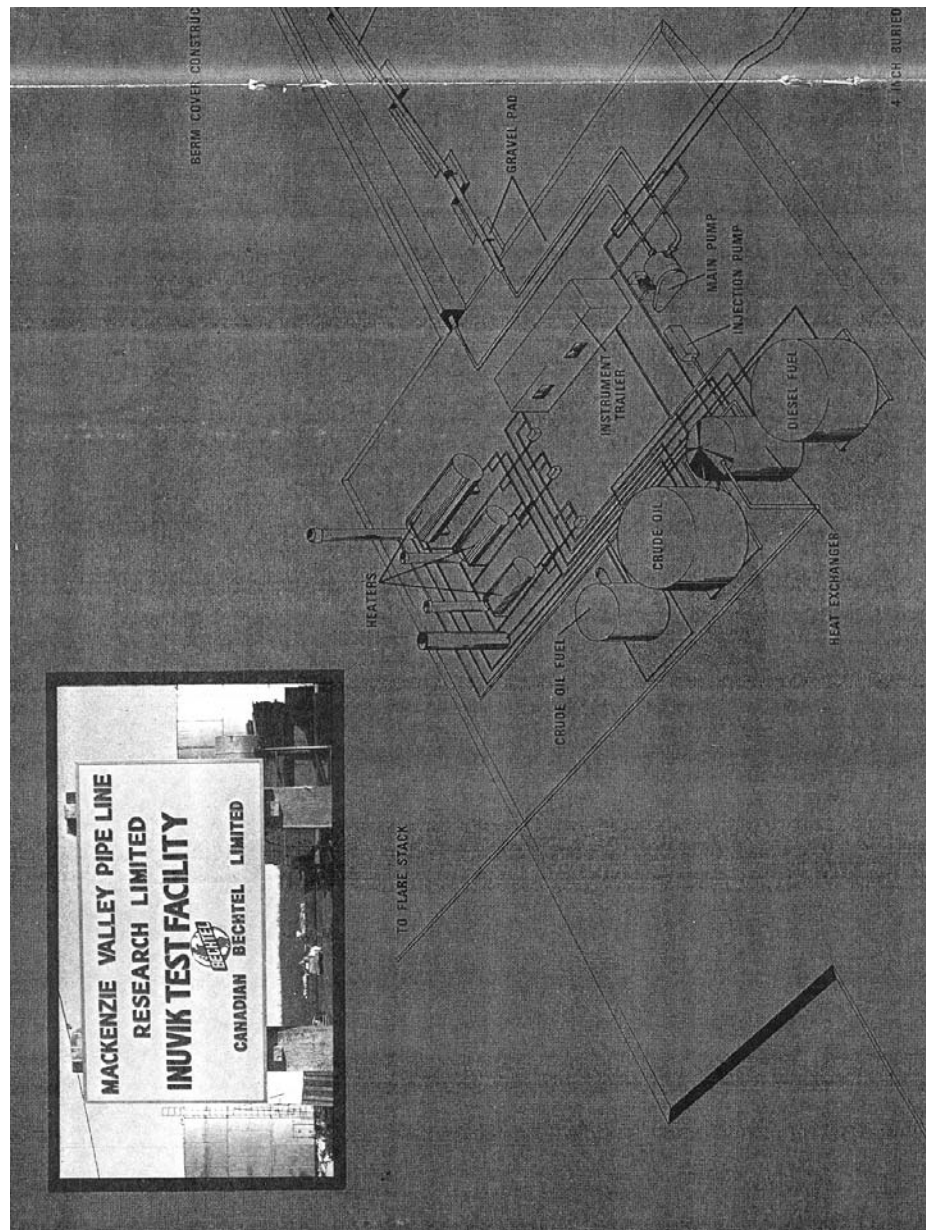


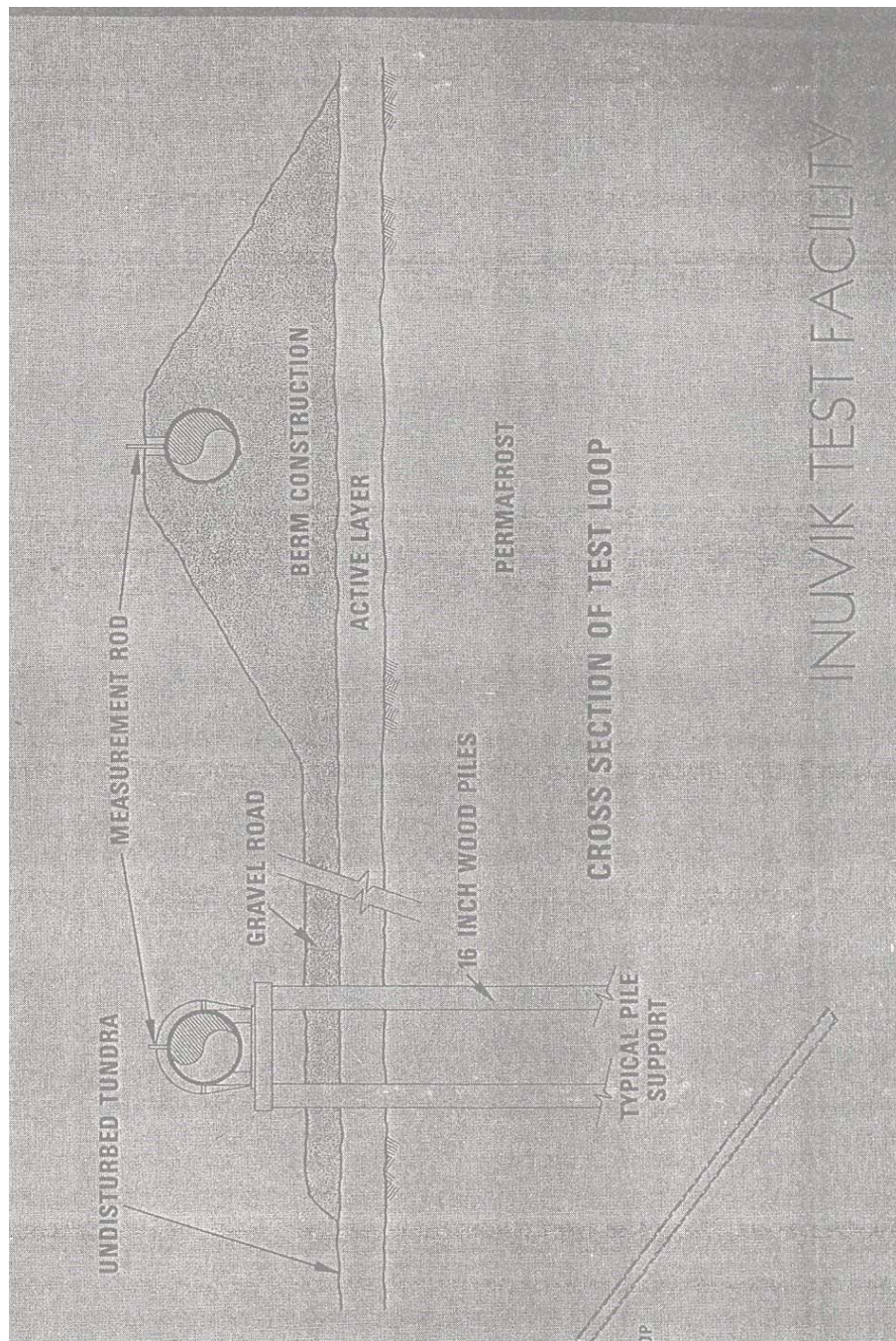
Figure 4 Ditch configurations, Fairbanks frost heave test facility

Test Pipe Burial Configurations (After Carlson 1985)

Inuvik Hot Oil Test Facility

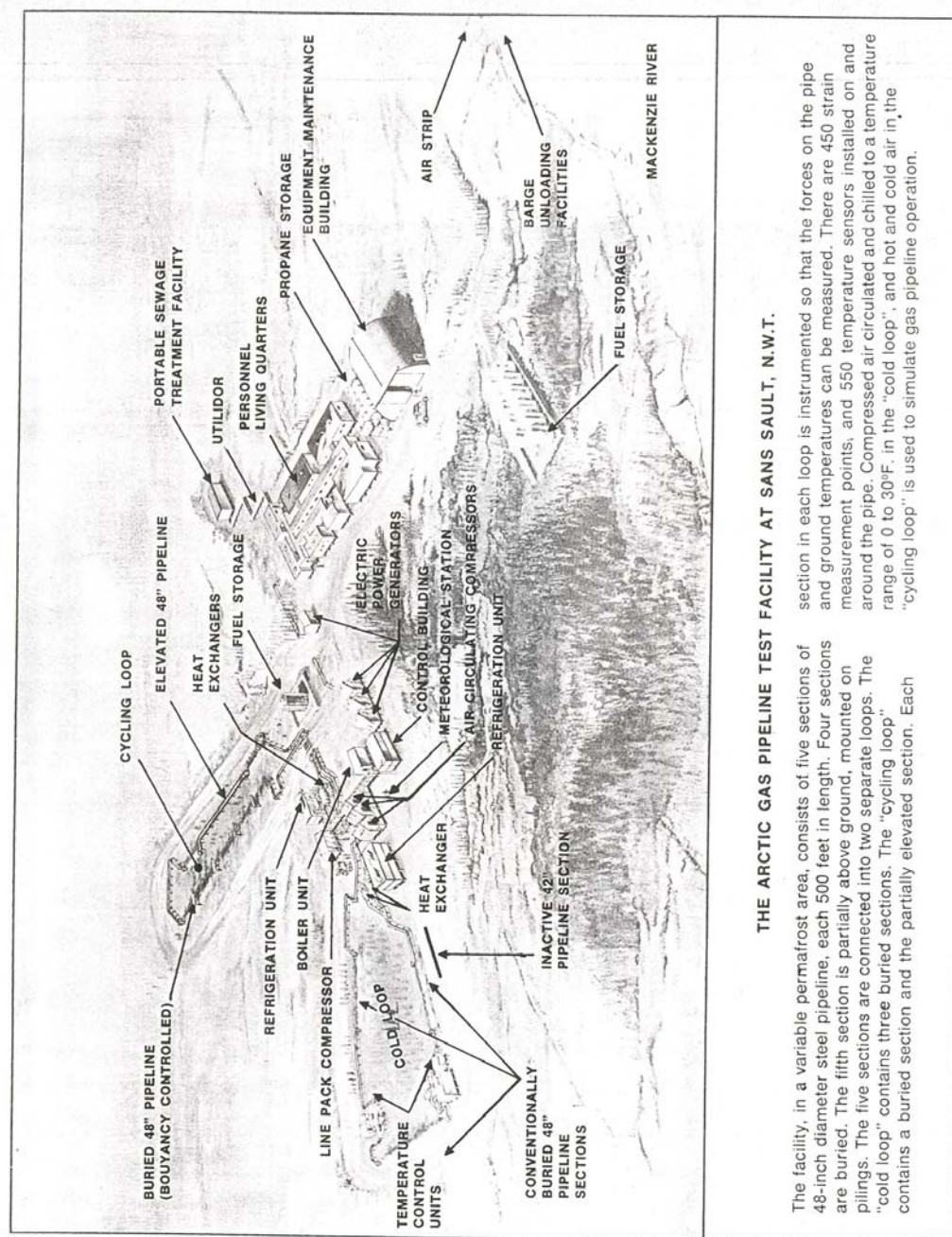


Test Facility Layout (After Research at Inuvik 1970)



Test Pipe Arrangement (After Research at Inuvik 1970)

Mountain River / Sans Sault Rapids Frost Heave Test Facility



Test Facility General Layout (After Walker 1973)

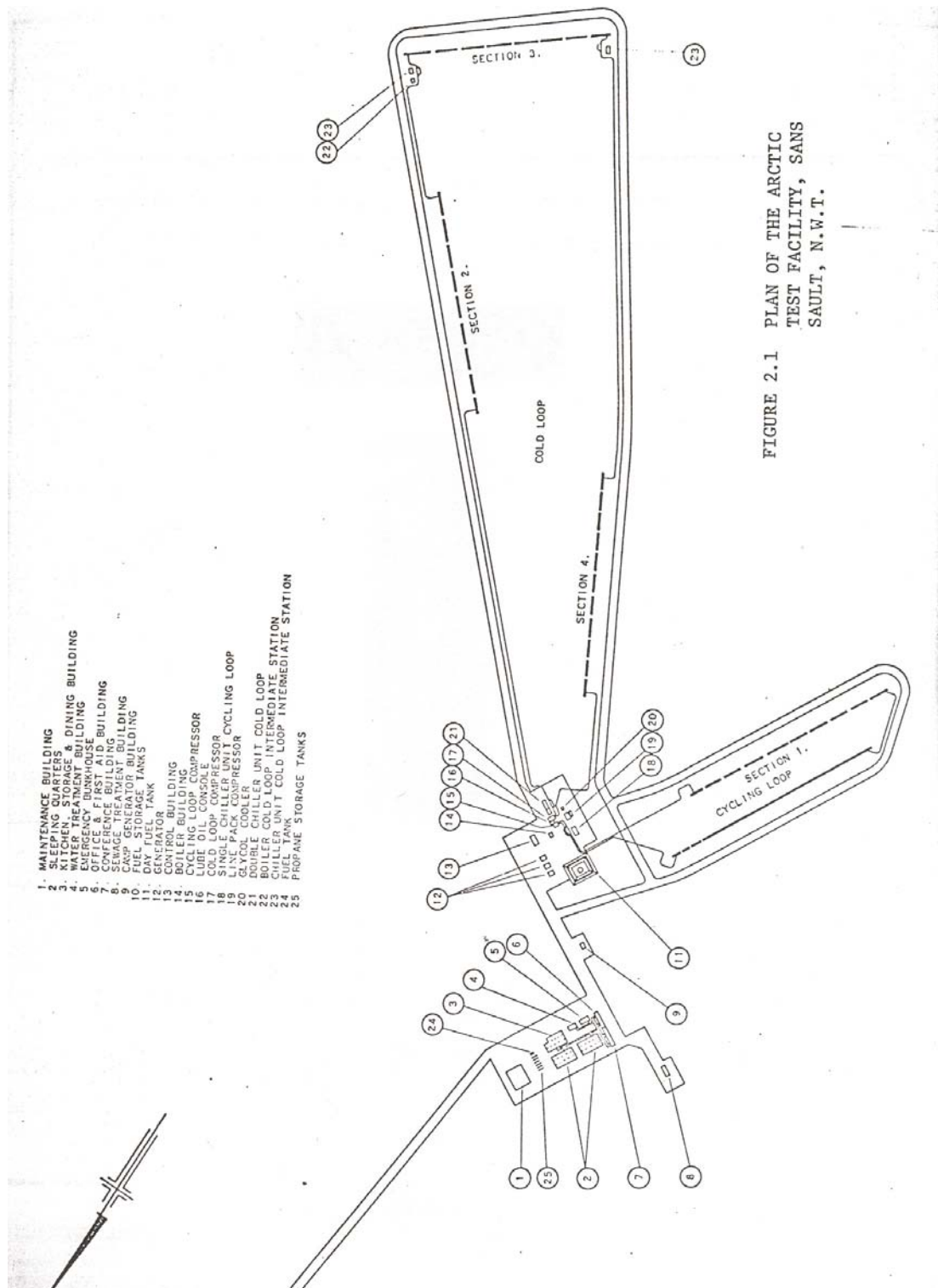
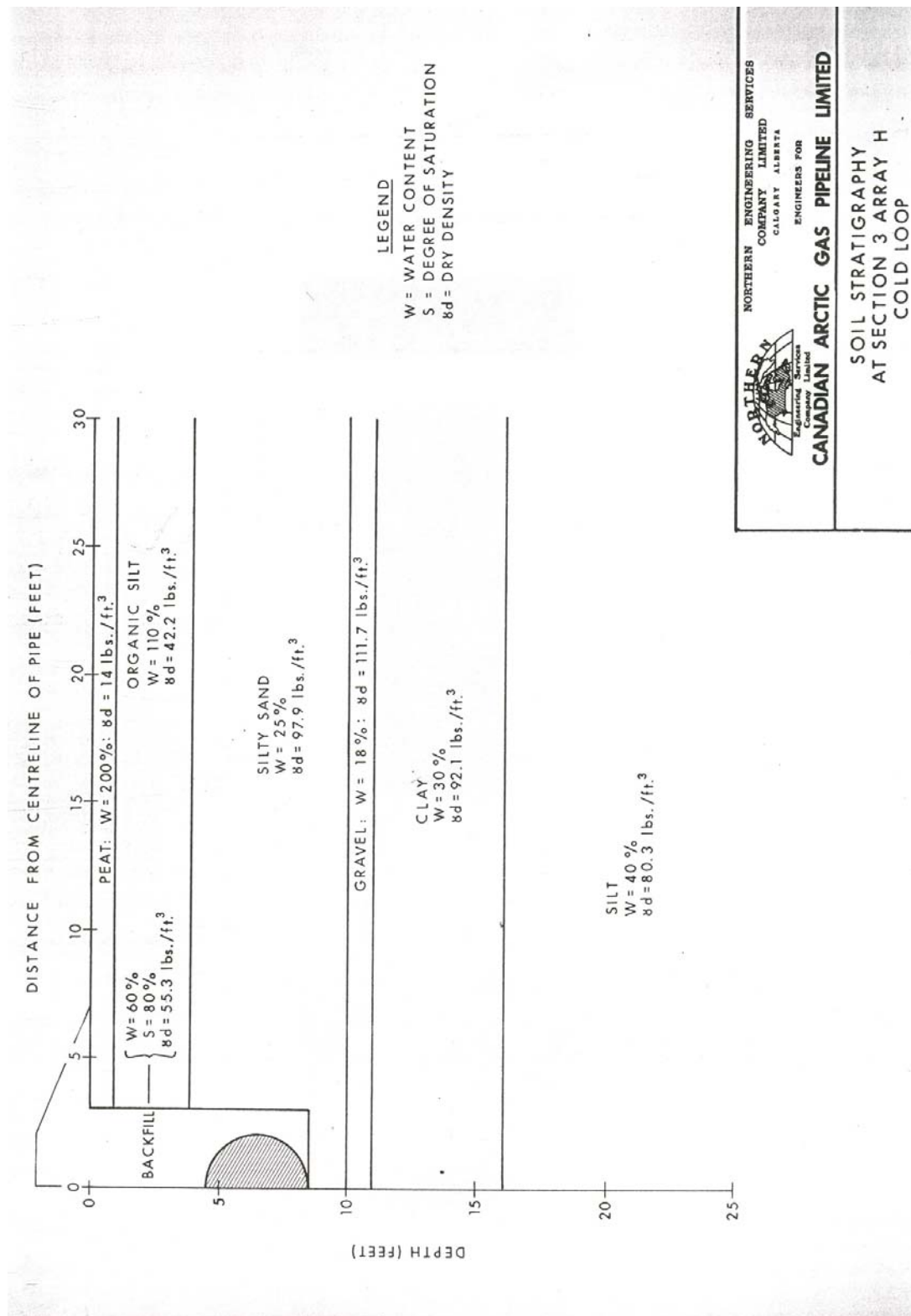
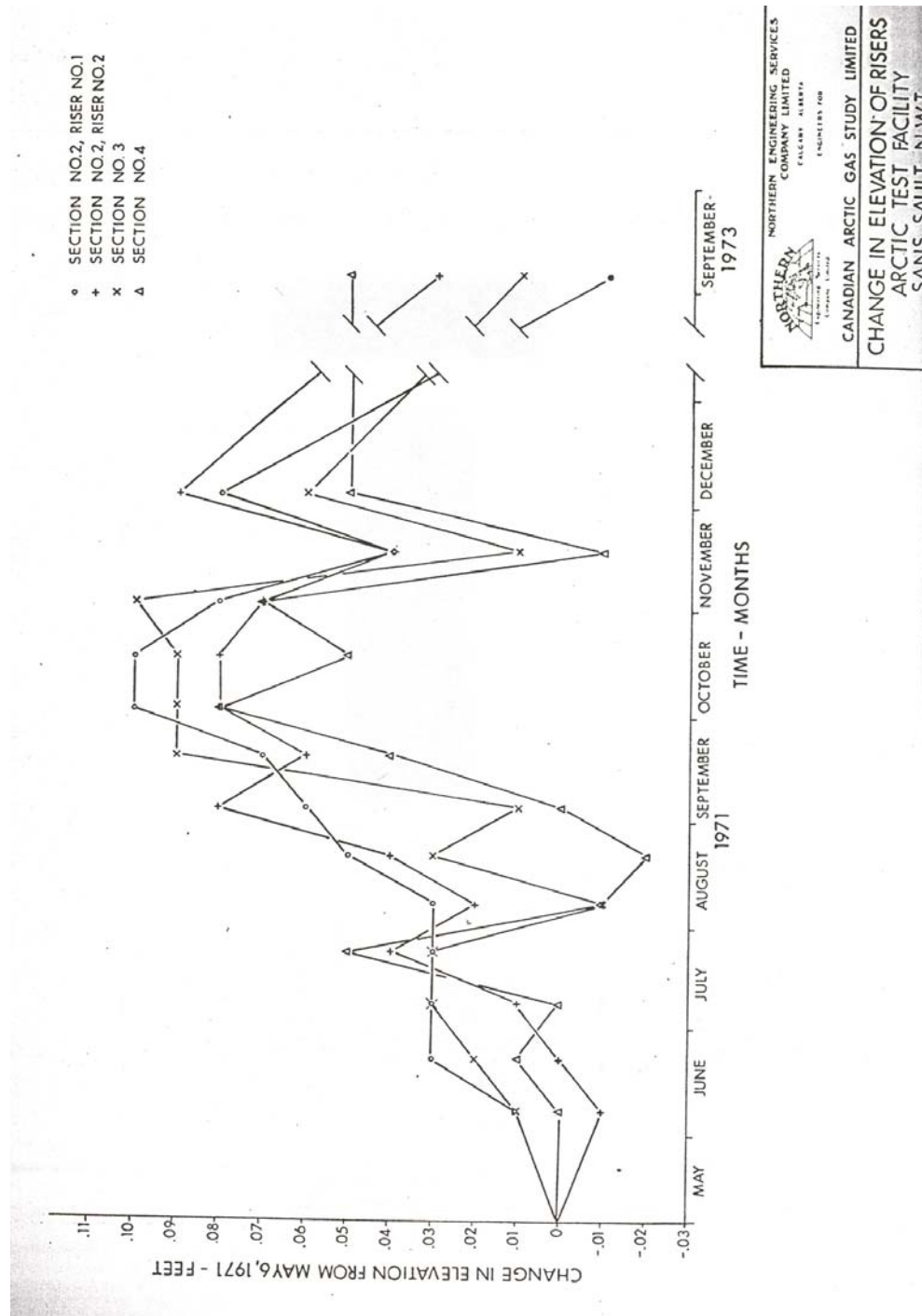


FIGURE 2.1 PLAN OF THE ARCTIC
TEST FACILITY, SAULT,
SAULT, N.W.T.

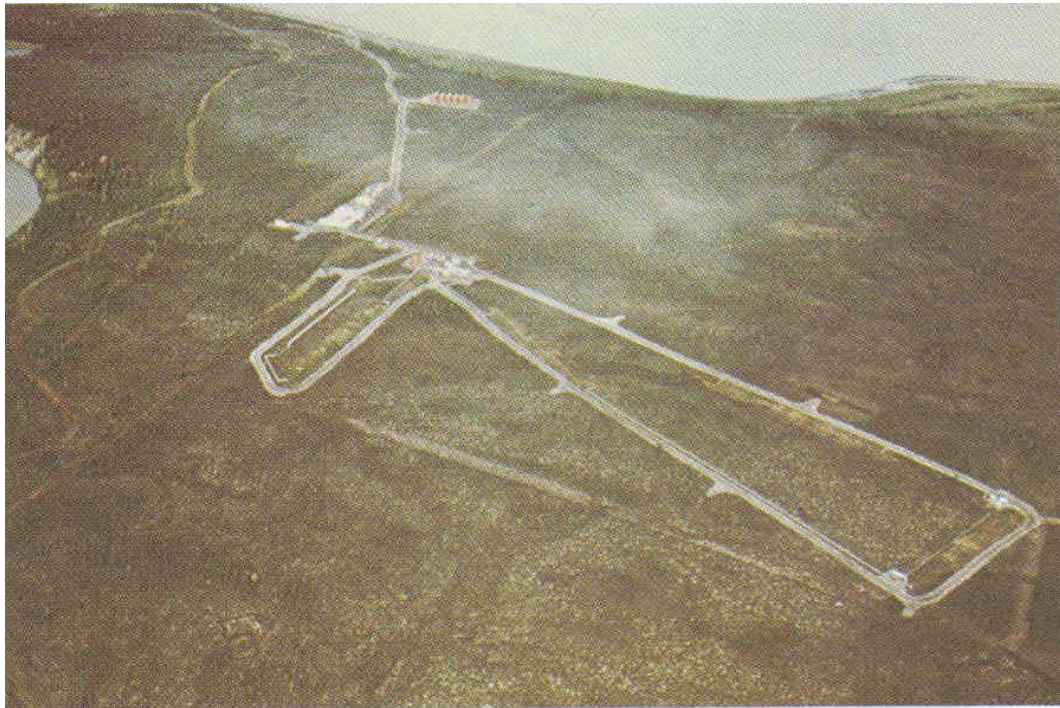
Test Facility Schematic Layout (After NES 1976)



Pipe Burial Arrangement – Cold Loop (After NES 1974)



Pipe Movement Measurements (After NES 1976)



1. Aerial view of Sans Sault Arctic Test Facility. September 1973.

Arial View of Facility (From JICA Library)



Ditcher Tests (From JICA Library)



7. North end of Inactive Section No. 4, August 1971. Note subsidence along ditch line.



9. Inactive Section No. 5, August 1971. View from south end of site. Area around the test section is flooded each summer.

General Surface Conditions at Inactive Sections (From JICA Library)

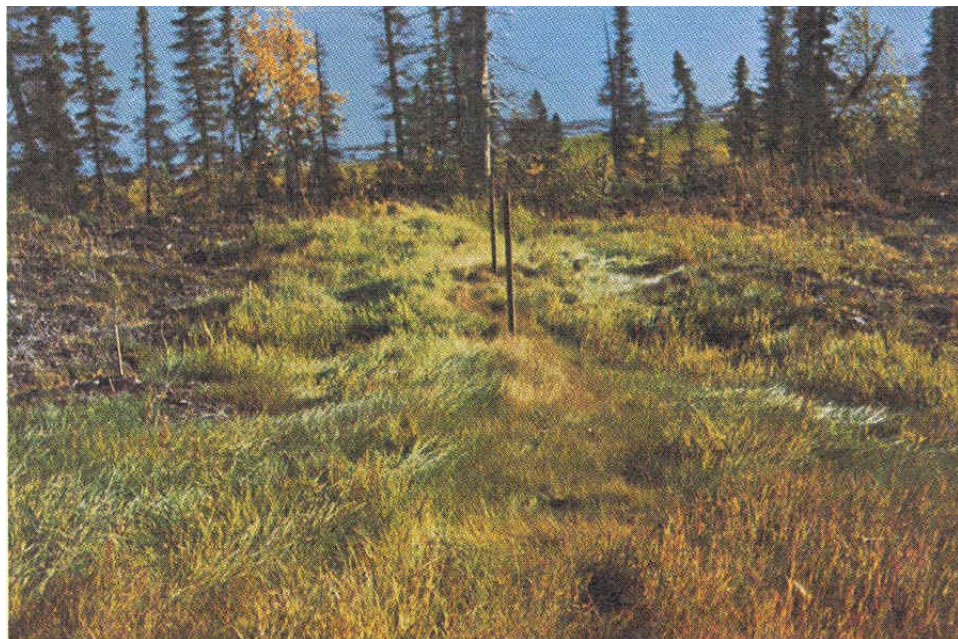


8. Inactive Section No. 4, September 1973. View from south end showing settlement along ditch line.



20. Aerial view of Inactive Section No. 5, September 1973.

General Surface Conditions at Inactive Sections (From JICA Library)



General Surface Conditions at Inactive Sections (From JICA Library)

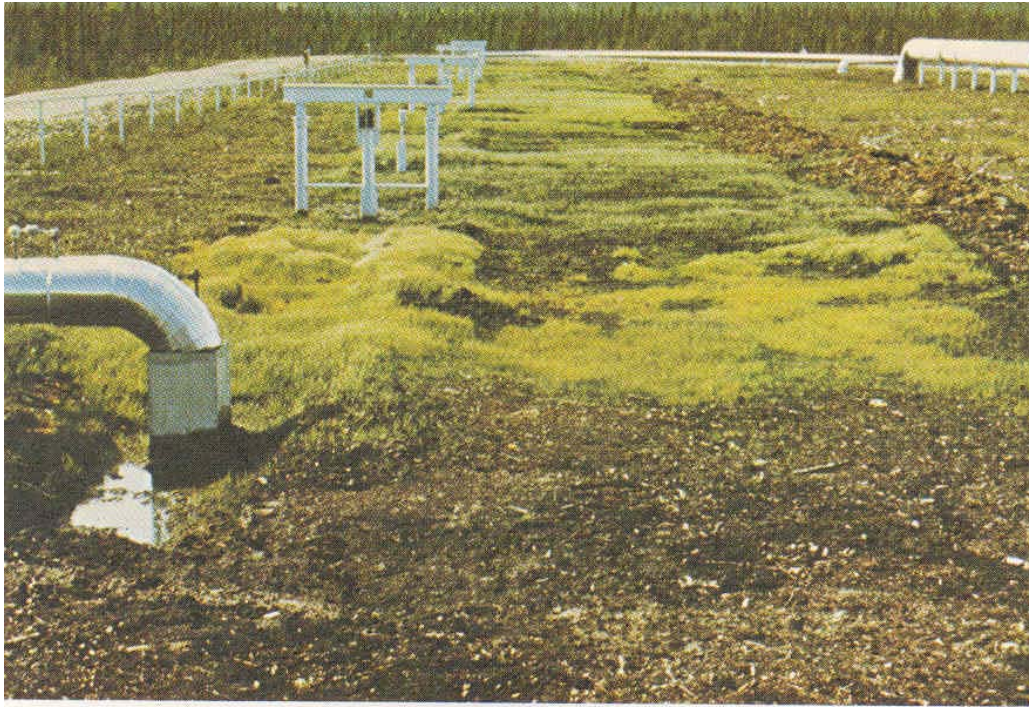


7. Cold Loop. View of Section 3 from west end, July 1971.

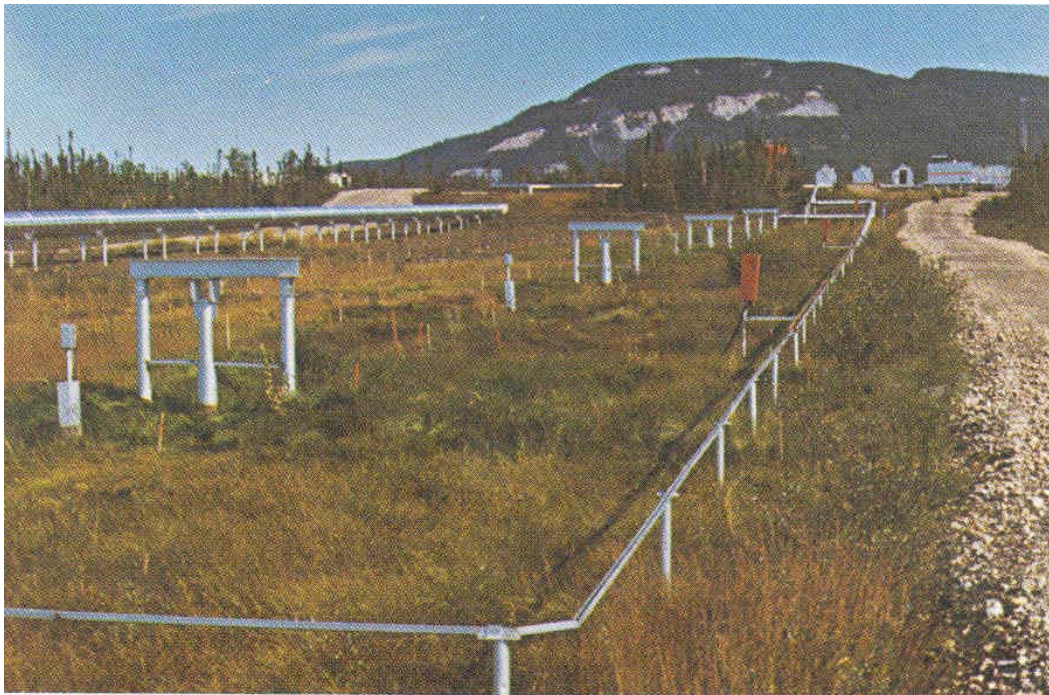


8. Cold Loop. View of Section 3 from east end, August 1973. Ground settlement evident from unpainted portion at the base of the strain gauge boxes.

Surface Conditions at Cold Loop (From JICA Library)



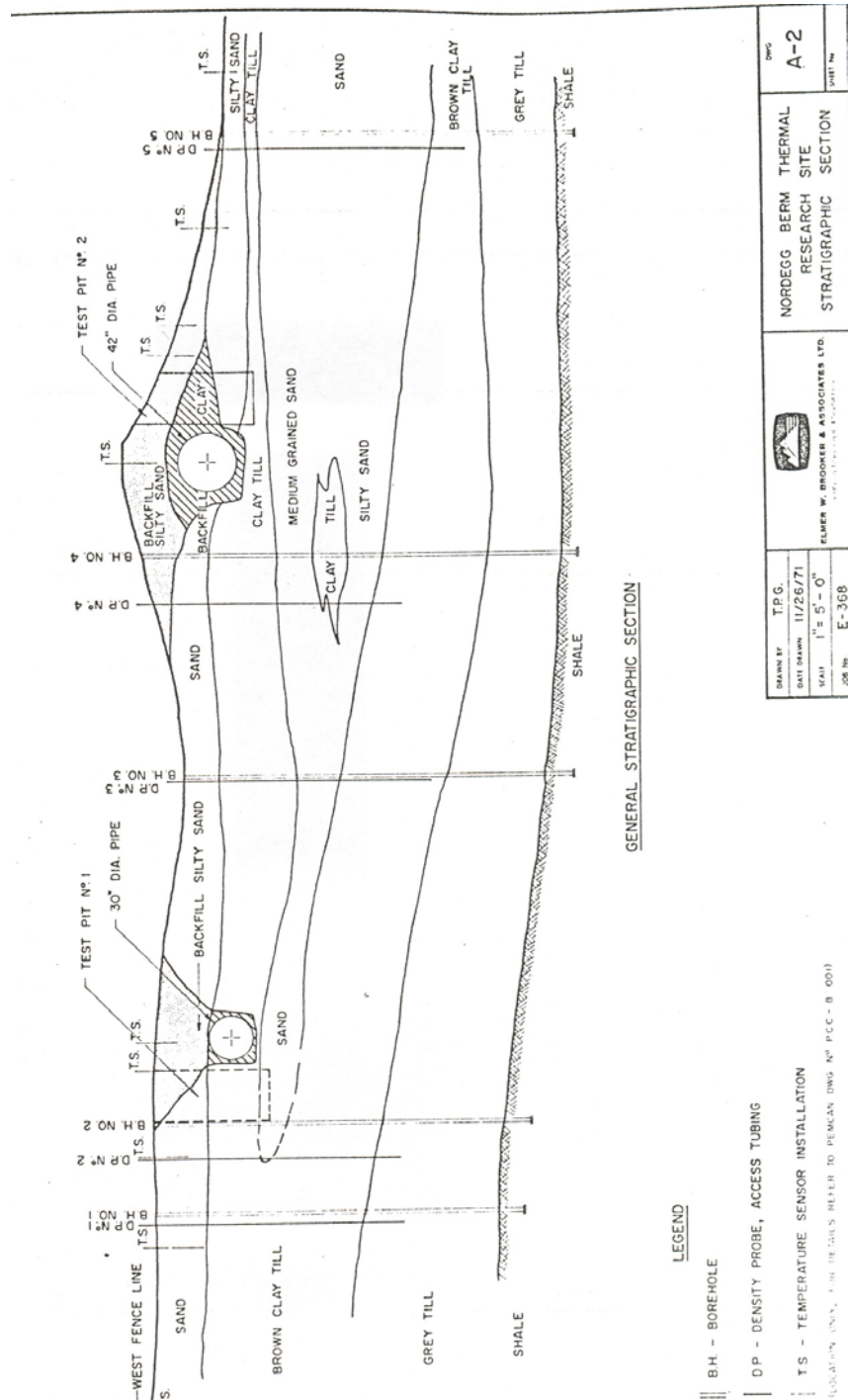
3. Cycling Loop. View from east end of Section 1, July 1971. Section 5 on the extreme right.



4. Cycling Loop. View from west end of Section 1, August 1973. Section 5 to the left.

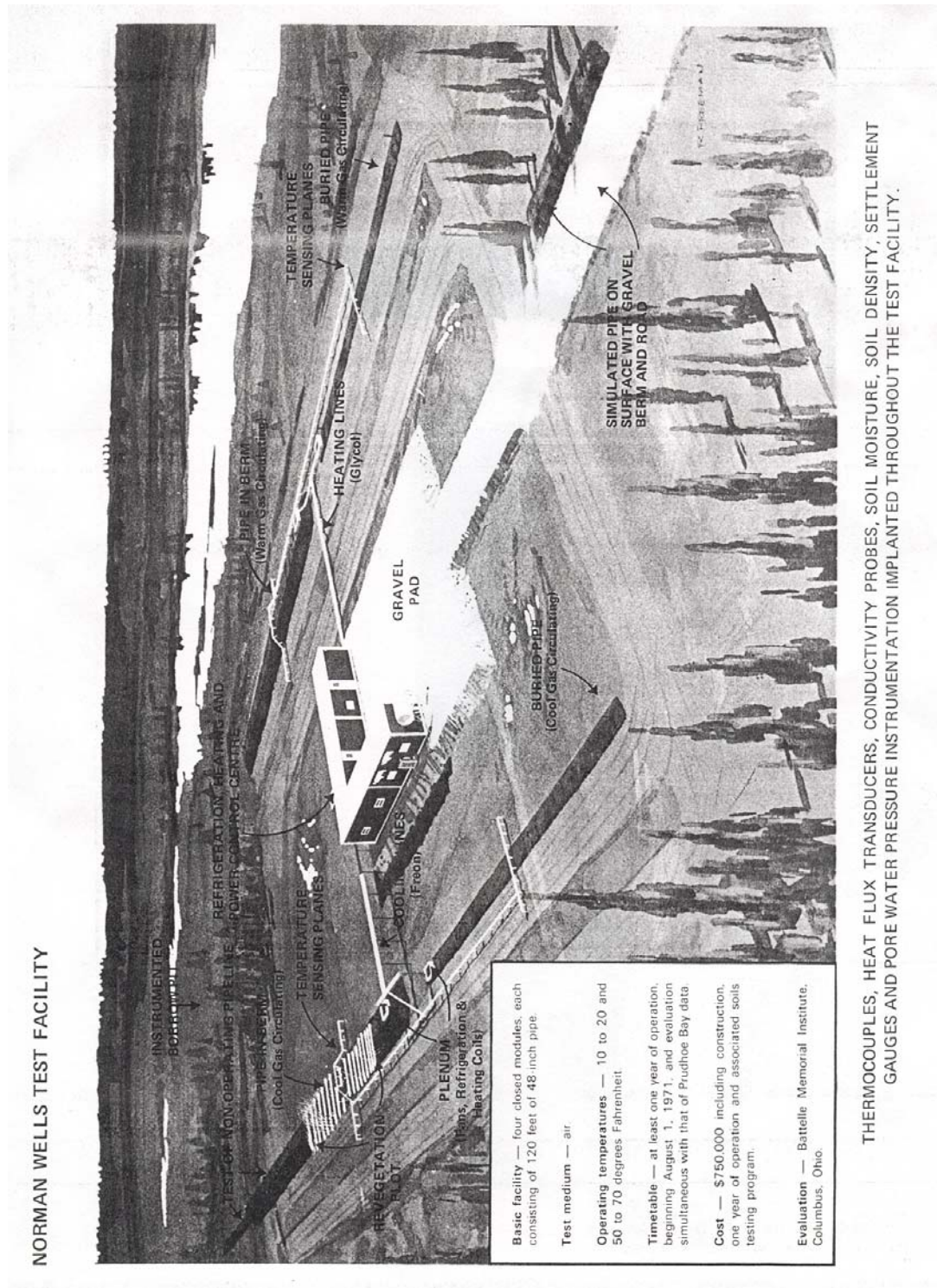
Surface Conditions at Cycling Loop (From JICA Library)

Nordegg Chilled Gas Test Facility



Pipe Burial Arrangement (After E W Booker & Associates 1971)

Norman Wells Chilled Gas Test Facility



General Layout of Test Facility (After Walker 1973)

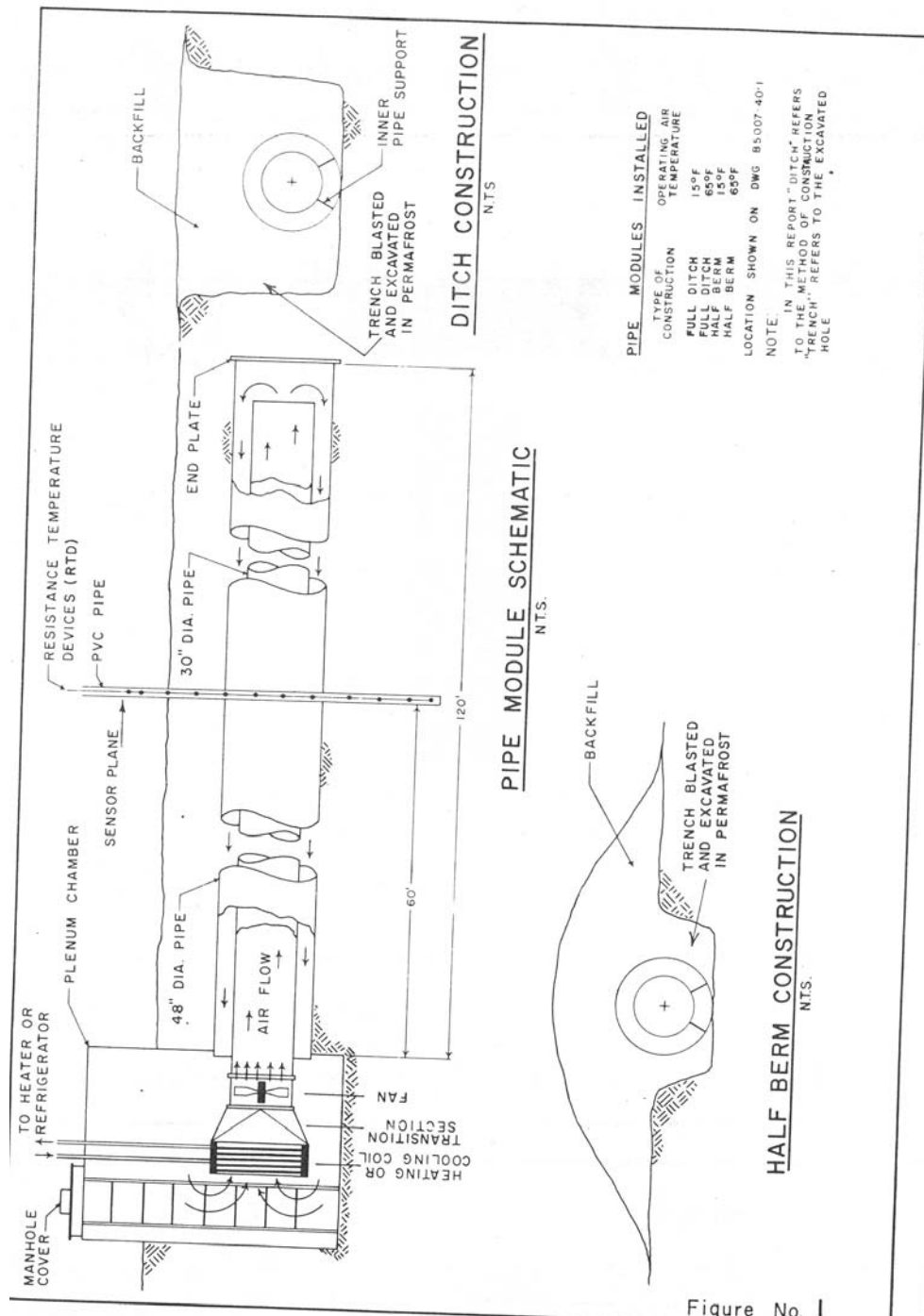
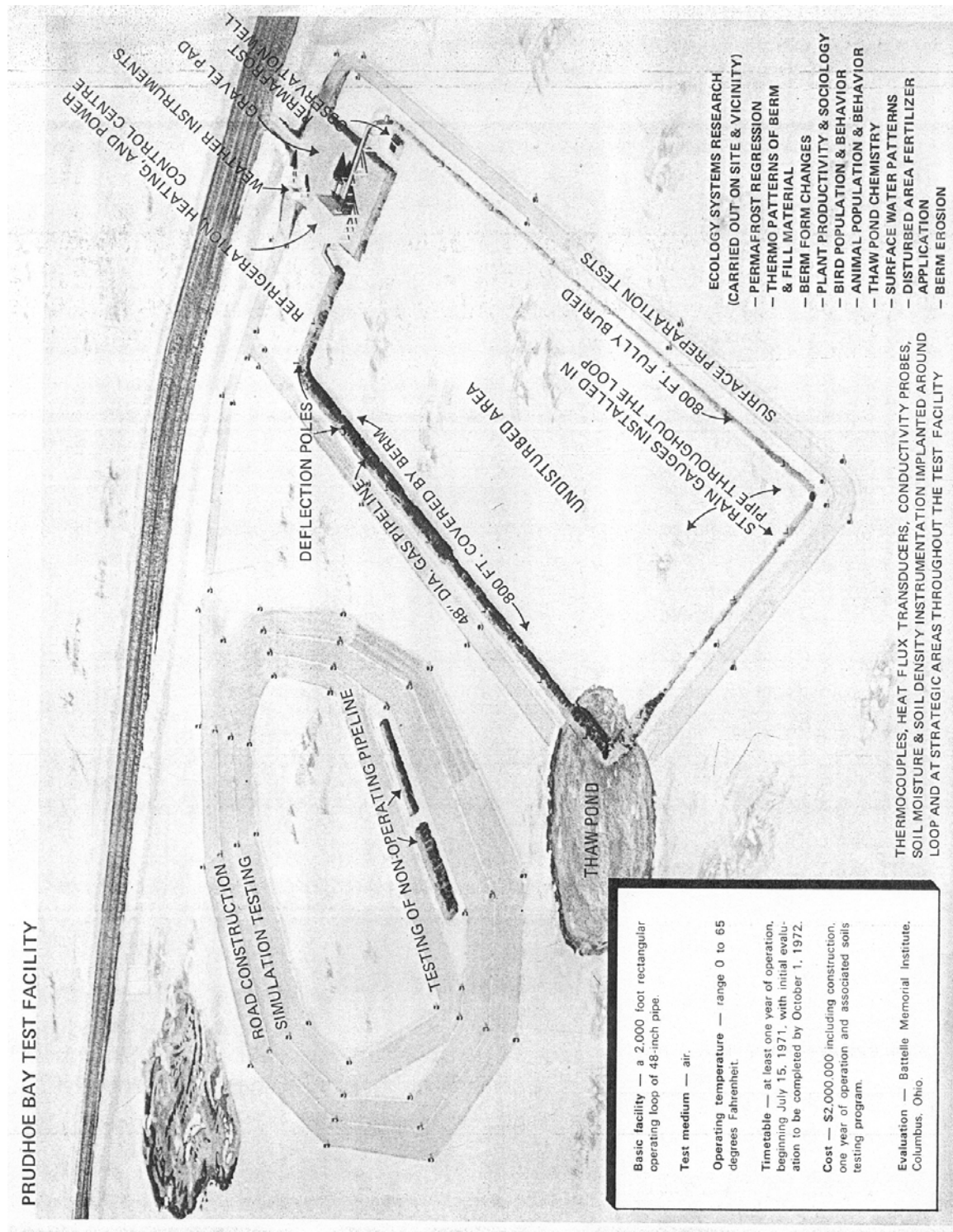


Figure No. 1

Pipe Burial Arrangement (After Pemcan Services 1972)

Prudhoe Bay Test Facility



Test Facility Layout (After Walker 1973)

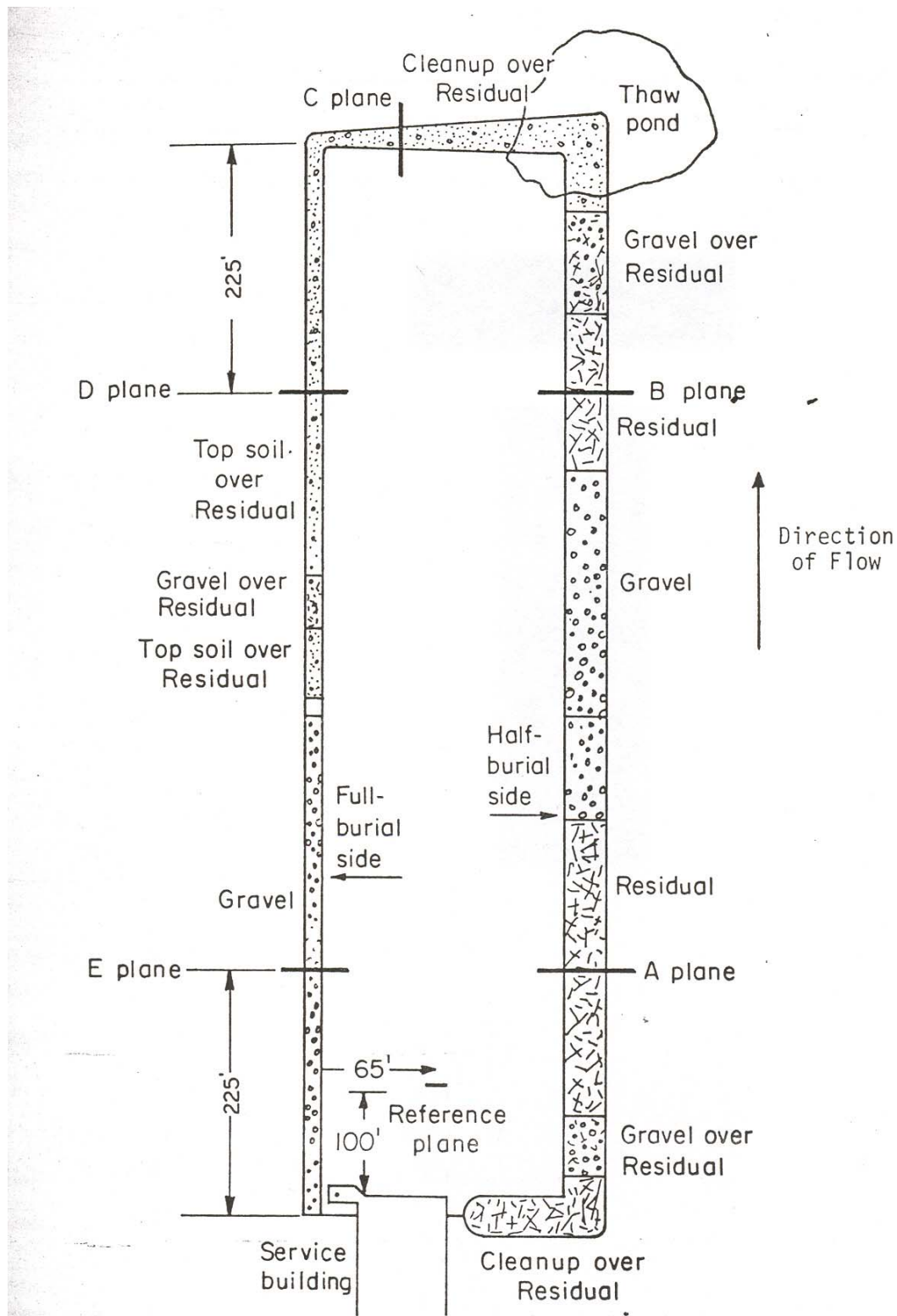
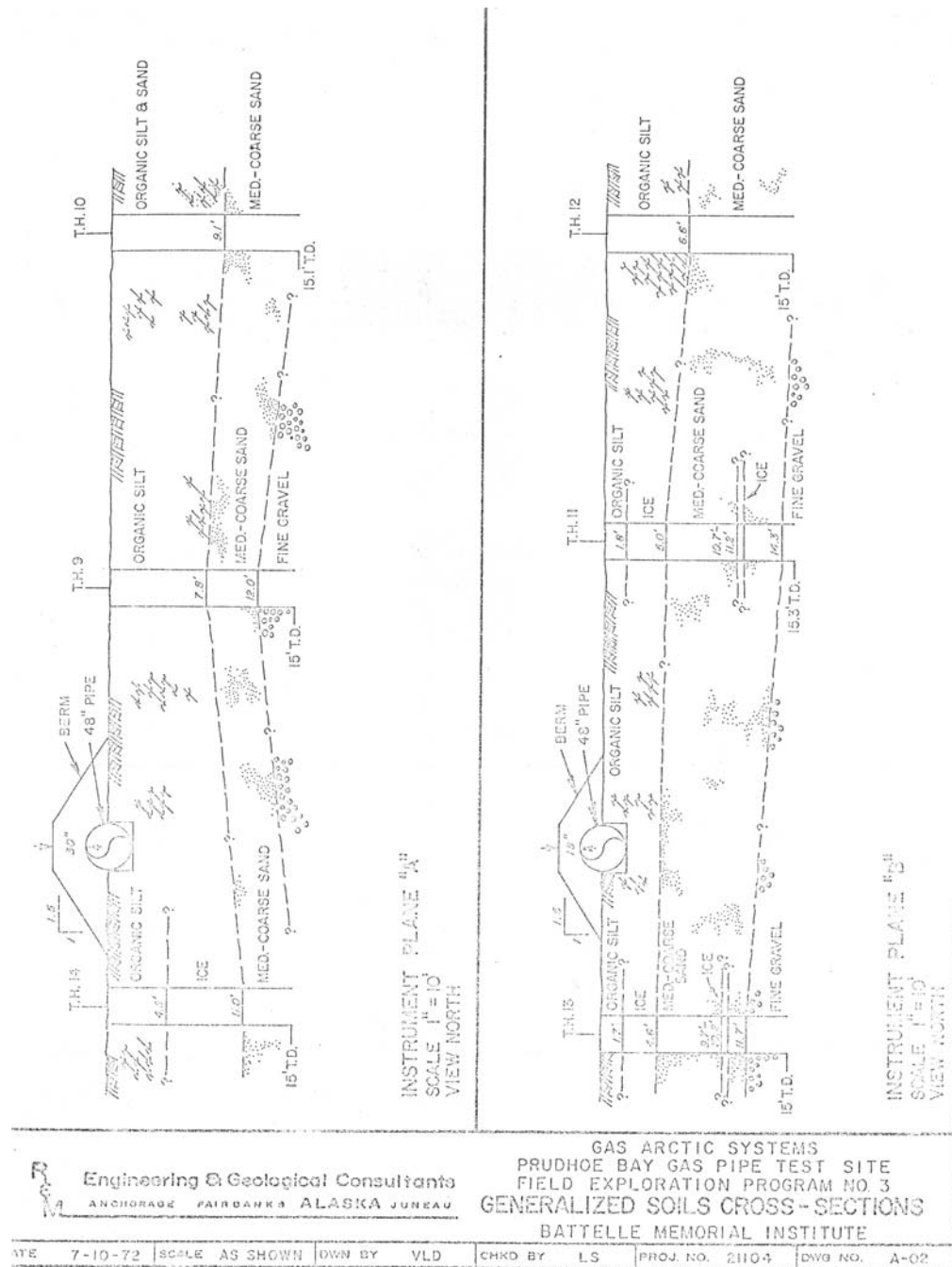


FIGURE 10. LOCATION OF THERMAL INSTRUMENTATION PLANES

Test Facility Layout (After Battelle Engineering 1972)



Soil Stratigraphy (After R&M Engineering 1972)



Surface Subsidence due to Partial Chilling Failure (From JICA Library)



Pipe Flotation due to Chilling Failure (From JICA Library)



Void Formation above Bermed Pipe Section (From JICA Library)

Quill Creek Test Facility

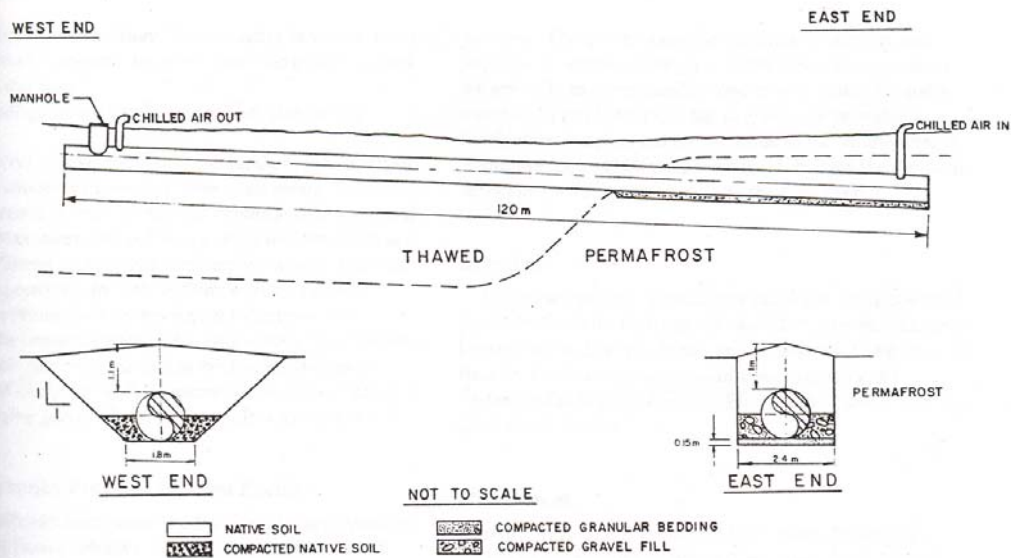


Figure 5 Interface test pipe, Fairbanks frost heave test facility

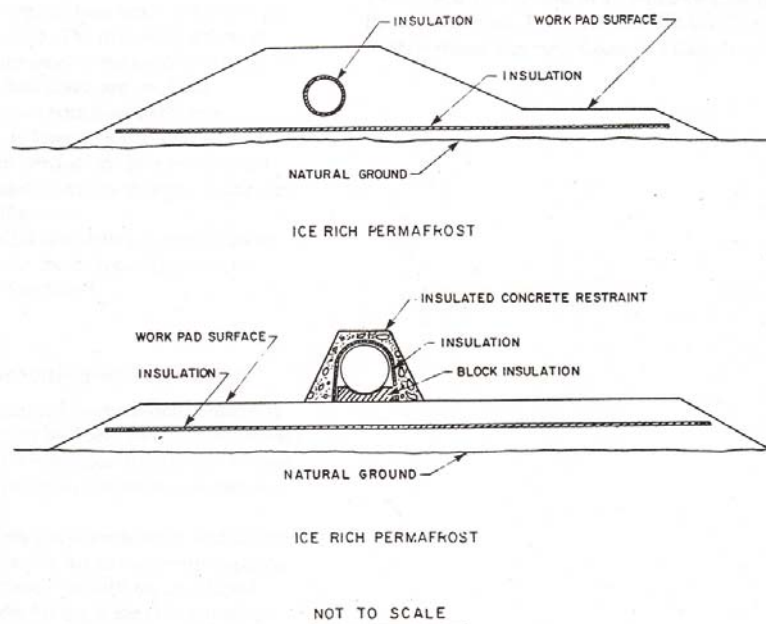


Figure 6 Thaw settlement design modes, Quill Creek test facility

Test Pipe Arrangement (After Carlson 1985)

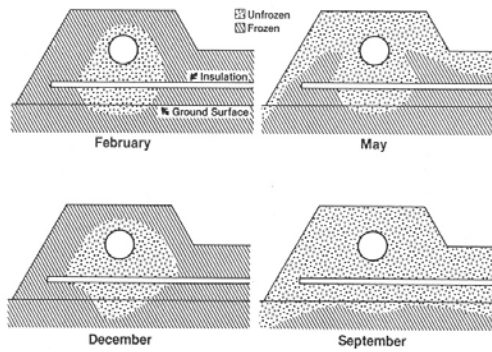


FIGURE 4 Thermal History. Uninsulated pipe in insulated embankment.

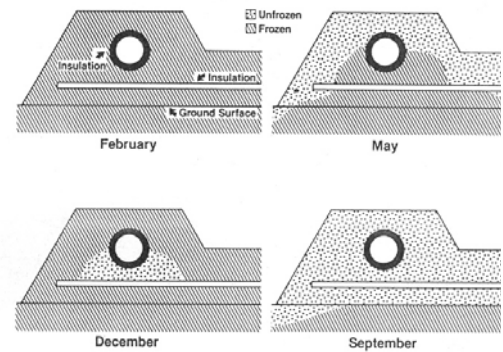


FIGURE 5 Thermal History - Insulated pipe in insulated embankment.

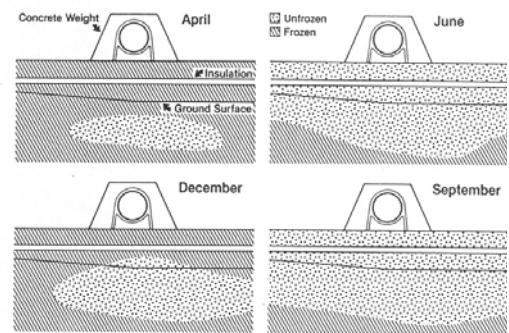


FIGURE 6 Thermal History. Concrete covered pipe on insulated gravel pad.

Pipe Sections – Thermal Effects (After Carlson & Butterwick 1983)