Introduction

Insulated log drains were constructed in several locations across the Alaska Highway in the Blueberry Flats area near Tok, Alaska. The intent of the drains was to provide a pathway for water to flow through the road embankment in winter, thus preventing the formation of aufeis over the roadway which had previously been a serious maintenance problem.

This report is a compilation of information regarding the design concept, the construction, and the performance of this experimental feature. It also includes information about insulated rock underdrains which were installed in the same vicinity for a similar purpose.

Chapter 1 provides background information about the problem and the experimental design concept intended to solve the problem. This chapter originally appeared in a DOT&PF memorandum from Engineering Geologist Gary Brazo to Experimental Features Coordinator Matt Reckard.

Chapter 2 includes details of the plans, specifications, and costs of the log and rock drains. This information was taken from the construction contract and from the final estimate review report for the project.

Chapter 3 describes the construction of the log drains and their performance during the construction of the remainder of the roadway built under the same contract. It was written by Rod Anderson, DOT&PF's project engineer for the contract, and appeared originally in the project history contained in the final estimate review report.

Chapter 4 reports on the performance of the log and rock drains in preventing aufeis problems during the first three winter/spring periods after installation (January to May of 1982, 1983, and 1984). It also includes the conclusions reached regarding the log and rock drains and the possible future use of the experimental feature. This chapter is a slightly modified form of parts of the memorandum from Brazo to Reckard referred to above.

Matthew Reckard
Experimental Features Coordinator
Alaska DOT&PF
Icing or aufeis along the Alaska Highway across Blueberry Flats near Tok was an annual affair ever since the highway was realigned across the swamp in the late 1940's. Ice clearing and control efforts were required from January thru April with the degree of effort being directly proportional to the severity of the icing. The maintenance efforts included fire pots at the culverts, steaming the culverts, and ripping and blading the ice from the roadway. Such activities required the diversion of men and equipment from other activities during the icing period.

Controlling, or at least mitigating the aufeis on Blueberry Flats was a major concern for the Maintenance and Operations (M&O) Section. The Geology Section was requested to study the problem and to recommend possible design alternatives, as part of the recent reconstruction project for the reach between Tok and Yerrick Creek.

The boring logs from the centerline soils investigation revealed several interesting features of the icing area. The foundation soils in the swamps included a one to five foot thick, surface layer of organic silt over sandy gravel throughout the icing area. Both of these soils are perennially frozen except for three areas where the surface silt may be frozen and the sandy gravels are saturated (an aquifer) to at least 20 feet in depth (33 feet deep at the creek). The primary aquifer is located at the creek crossing. The bottom one to two feet of the embankment is below the ground surface and during the summer transmits water through the roadway itself, (basal fill water). At that early stage in the investigation, it was felt that the icing was caused when the basal fill water froze and the water was forced to the surface to become aufeis.

Two ideas were suggested to mitigate the icing. The first one was to raise the grade five feet in the area of the creek and create a higher dam that could store more ice. The second idea was to install a number of insulated log drains through the embankment at ground level in an effort to intercept the offending water and direct it through the roadway. A bit later in the investigation, it was suggested that two insulated log and rock drains be installed on either side of the culvert at the creek. The rock drain material beneath the logs would replace the five feet of silt that is sandwiched between the embankment and the aquifer below and create
two "windows" through the silt through which additional groundwater could be transmitted beneath the roadway. The basis for this design was that the source of the icing was the basal fill water and that it did not manifest itself as surface water flow. Further, when this basal fill water was frozen down to the silt, the (summer) window was shut and the only conduits for the water were the aquifers beneath the silt. Virtually none of the basal fill water could be forced down five to seven feet to beneath the silt.
Chapter 2: Plans, Specifications, and Costs

Sixteen log drains were installed on the project at a total cost of $105,968.00, which included both materials and construction. The original contract price of $6,700 each was reduced to $6,623 by Extra Work Order #2, which also relaxed the compressive strength specification for the insulation board. The changes were made at the request of the contractor.

The plans and specifications for the log drains are reproduced below. Extra Work Order #17 is also reproduced below, along with some of the backup documentation for it. This extra work order was made to pay for the two additional rock underdrains which were added to the contract in 1982.
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
& PUBLIC FACILITIES

PLAN AND PROFILE
PROPOSED HIGHWAY PROJECT
FR-F-062-2(13)
TOK TO YERRICK CREEK
&
FR-F-046-2(12)
TOK SOUTH 1.5 MILES
GRADING, DRAINAGE & PAVING

The following standard drawings apply to this project:

A-1, C-00-04, C-10-04, C-11-04,
D-00-00, D-05-00, D-04-00, D-05-02
I-00-00, I-00-11, I-00-00, I-10-05, I-10-03
T-21-03, T-22-00

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<th>SHEET NO.</th>
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<tr>
<td>1</td>
<td>TITLE SHEET</td>
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<tr>
<td>2</td>
<td>TYPICAL SECTION</td>
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</table>
| 3-4       | APPROACH TYP.
| 5         | SUMMARY OF APPROPRIATIONS |
| 6-7       | HIGHWAY SUMMARY |
| 8         | COAL CITY TYPICALS |
| 9-02      | B-DETAILS |
| 13-03     | P-L & PROFILE |
| 50        | SITE FURNISH & MATERIAL SOURCES |

Planned Developed by

Under the Supervision of

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
& PUBLIC FACILITIES

APPROVED
SECTION 605.
UNDERDRAINS

605-1.01 Description. Add the following: This work shall also consist of the construction of log drain systems which includes furnishing and placement of spruce logs, filter fabric, riprap, and insulation in accordance with the plans and as directed by the Engineer.

605-2.01 Materials. To the materials list add the following:

Insulation Board

635-2.01

Add the following: The filter fabric shall be Typar 3401, Mirafi 500X or equivalent. The Contractor shall submit the manufacturer's specifications and a sample of the proposed fabric, one (1) square foot in size, two weeks before the installation to secure the approval of the Engineer.

Logs shall be spruce and shall have all limbs removed.

CONSTRUCTION REQUIREMENTS

605-3.04 Log Drains. Log drains shall be constructed in accordance with the details and at the locations shown on Sheet 11 of the plans.

The filter fabric shall be unrolled directly onto the surface to be covered. Any material which might cause punctures in the fabric shall be removed from the surface to be covered. No other special preparation of the surface is required. Fabric sections shall be joined by overlapping the fabric a minimum of two (2) feet. No fastening techniques are necessary. In case of damage to the fabric, the torn or punctured section shall be repaired by meeting the above two (2) foot overlap guideline, and the fabric patch shall be laid directly on top of the damaged sections. At no time shall traffic be allowed on the exposed fabric.

Spruce logs, that conform to the sizes shown on the plans, from within the clearing limits for the embankment or material sources, may be used in the log drains. The Contractor shall supply spruce logs from other sources, if a sufficient amount is not available within clearing limits. Logs shall be placed in the drains in as compact a manner as practical. Care shall be taken to place logs such that shifting or consolidation of the logs will not occur after completion of the drain.

605-4.01 Method of Measurement. Delete in its entirety and substitute the following: The quantity of work to be paid under this section shall be the actual number of log drains constructed and accepted as shown on the plans or as directed by the Engineer.

SPECIAL PROVISIONS
Project No. FR-F-062-2(13) and FR-F-046-2(12)
TOK TO YERRICK CREEK AND
TOK-SOUTH 1.5 MILES
605-5.01 Basis of Payment. Delete in its entirety and substitute the following: The accepted quantity, determined as provided above, shall be paid at the contract price per unit of measurement, complete in place.

Payment will be made under:

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<tr>
<td>605(1)</td>
<td>Log Drain</td>
<td>Each</td>
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All work and equipment and all materials not shown in the bid schedule required for the construction of log drains shall be considered incidental to other pay items. Work and materials shown in the bid schedule shall be paid for under their respective pay items.

SPECIAL PROVISIONS
Project No. FR-F-062-2(13) and FR-F-046-2(12)
TOK TO YERRICK CREEK AND
TOK-SOUTH 1.5 MILES
EXTRA WORK ORDER NO. 17

Interior Region
FR-F-062-2(13) & FR-F-046-2(12)

Contractor Mat-Su/Blackard J.V.

Tok to Yerrick Creek &

Address 1705 Ship Avenue

Tok South 1.5 Miles

Anchorage, Alaska 99502

The above designated Contract is hereby modified in the manner described below. This order is supplemental to the above Contract, which is, by reference made a part hereof. All terms, conditions and provisions of the Contract, except as specifically modified herein, remain unchanged and in full force and effect.

Acceptance of this Extra Work Order constitutes agreement to the terms, conditions, and prices stated.

ACCEPTED:
Mat-Su/Blackard J.V.

Recommended:

Robert W. Finney

Issued:


Andy Zahare, Interior Regional Engineer

Date 10/27/83

DESCRIPTION

In accordance with Sub-sections 104-1.02 and 104-1.04 of the Standard Specifications, the following changes are hereby made:

Establish New Item 109(3), Insulated Rock Underdrain

Description: The insulated rock underdrains at Station "L" 307+00 and Station "L" 315+00 have been constructed by Force Account.

Construction and Materials: The labor, equipment and materials were provided to construct the underdrains in accordance with Work Order "I" which is attached and made a part of this order.

Measurement: This item was measured in accordance with Sub-section 109-1.05 Extra and Force Account Work.

Payment: Item 109(3) Insulated Rock Underdrains will be paid at the agreed lump sum price of $17,034.29.

Items 114(1), 115(1) and contract time will not be affected as a result of this order.

PLEASE INDICATE YOUR AGREEMENT BY SIGNING, DATING AND RETURNING THE ORIGINAL OF THIS DOCUMENT.

Use form 25D-065 for continuation, if required
## COMPARISON OF COST DUE TO CHANGE

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<th>UNIT</th>
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<th>QUANTITY (+ or -)</th>
<th>AMOUNT (+ or -)</th>
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<td>6201</td>
<td>Insulated Rock Underdrains</td>
<td>L.S.</td>
<td>L.S.</td>
<td>All Req'd.</td>
<td>+17,034.29</td>
<td>New Item</td>
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**NET CHANGE THIS ORDER**: +17,034.29  +0.247

**TOTAL PREVIOUS CHANGES**: +424,785.15  +6.142

**ACCUMULATIVE CHANGE**: +441,819.44  +6.389

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### DESCRIPTION AND REASON FOR CHANGE

Item 109(3) was established to provide payment to the contractor for the construction of the insulated rock underdrains at Stas. "L" 307+00 and "L" 315+00 by Force Account. This work was initiated by Work Order "1".

These underdrains were requested by the Engineering Geologist in his memo dated July 1, 1982, which is attached.

Only those underdrains which were located over thawed aquifers were installed. It was felt the others would freeze back in one season.

The Daily Force Account Summary Sheets are attached and made a part of this back-up.
INSULATED ROCK UNDERDRAIN GENERAL NOTES:

Construction
The 36"x62' CMP will be installed under Item 603(22-36") Pipe Culvert.
The Thaw Pipe will be installed under Item 616(1) Culvert Thaw Pipe.
The Insulation Board will be installed in accordance with Item 635(1)
Insulation Board. This Item will only be installed under the highway
embankment and all joints shall be staggered.
The waste excavation will be wasted in MS-622-011-5.
Borrow Rock Backfill will be hauled from the Gun Club Pit, or
MS-622-171-2 as directed by the Engineer.
The excavation shall cut through the frozen silt to the clean
underlaying gravels.
This work will be accomplished while the Contractor's forces are
working in the area on Culvert repairs.

Equipment
Cat 245 Backhoe
Scaper or Bellydumps (Push-Pull Scrapers)
Front end Loader or Loaders (Loaders only if required)

Manpower
Foreman with pick-up
Flagman
2 ea. Haul Unit Operators or Teamsters
Operator or Operators for Loader (if required)
Operator for Backhoe

Materials Required
One set Culvert Marker Posts
Thaw Pipe installation for 62' CMP
36"x62' Culvert Pipe
Insulation Board

Note: Manpower, Equipment, or Method of Construction may be changed by
the Engineer.
ULATED ROCK UNDERDRAIN PLAN AND TYPICAL SECTIONS:

TO POE

PLAN VIEW
STA. 307+00 & STA 315+00

SECTION B-B STATION 307+00

SECTION A-A STATION 315+00

PROFILE GRADE

Rock Backfill

4" INSULATION BOARD

O.G.

-8'

PROFILE GRADE

36" x 62" CMP WITH WIRE

Bedding Material

4" OF INSULATIONS BOARD

Rock Backfill

-8'

DEPTH IS 8' OR TO CLEAN FREE DRAINING GRAVEL AS DIRECTED BY THE ENGINEER
Chapter 3: Construction

The log drains were constructed as an experimental feature on this project. The timbers for the construction of the log drains were spruce cut from the highway right-of-way, M.S. 622-007-5 and M.S. 622-013-5.

Construction began on October 16, 1981 with the construction of the log drain at Station "L" 320+00 and was completed on October 30, 1981 with the construction of the log drain at 346+60. During this period the temperature varied from a low of 0°F on October 16, 1981 to a high of 48° on October 22, 1981. Geo-Foam was used for the insulation board at a $1,232.00 price reduction. The Geo-Foam has a compressive strength of 30 P.S.I. which is 5 P.S.I. less than the 35 P.S.I. required. All other requirements were in conformance with the specification. The filter fabric used on log drains 320+00, 326+10, 349+00, 351+00, 353+00, 355+00, 333+00, 335+39, 335+67, 338+00, 340+00 was Propex 2002. Mirafi 500X was used on the log drains at 341+45, 341+73, 344+00, 346+22 and 346+60. While the culvert and rock underdrain were being installed at Station "L" 346+50 the flow from Fish Creek was diverted through the log drain at Station 346+22 with outstanding success. The log drains were inspected in April 1982, finding the ice on Blueberry Flats higher than the inlets. The glaciering on the lower or north side of the road was evident at Fish Creek indicating winter flow; however, there were no glaciers downstream of the log drains indicating that no winter flow had taken place. The roadway was shaped with a small cat adjacent to the log drain during the 1982 construction season. Slope material was deposited over the log drains during this operation. The cleaning of the log drains and the replacement of the brush cover was completed on October 22, 1982. Three construction photos are shown here; others are on file in the project photo album.
Placement of logs, station 341 (October 20, 1981)

Placement of insulation and backfill, station 326+10 (October 17, 1981)
Outlet end of completed installation at Fish Creek, station 346+50
(May 5, 1982)
Chapter 4: Evaluation and Conclusions

The insulated log drains and the rock drains were installed during the initial phase of construction in 1981. Dale Probert, M&O Foreman at Tok, and Rod Anderson, P.E., Tok to Yerrick, observed the drains over the winter of 1981-1982. That winter was a low to moderate icing season in the Interior and no maintenance effort was required for icing on "Blueberry Flats". In late March, fresh aufeis was observed on the south (uphill) side of the embankment with movement of the water towards the west (towards Delta Junction). The aufeis extended for approximately three quarters of a mile and nearly topped the road.

In the opinions of Dale and Rod, the rock drains functioned quite well until late March when, the flow of ground water apparently exceeded the capacity of the drains and when the culvert at the creek was temporarily frozen shut. Other than this short period, the creek culvert carried water the entire winter. It was not clear whether the log drains performed any useful function. Dale was reluctant to disturb the snow and brush covered inlets and outlets of the drains on the chance of disrupting any flow that might be in them. Fresh aufeis was noted on the north (downhill) side of the road and near several of the log drains during this "break-out". Because a culvert is located near each drain, it was difficult to determine which conduit may have transmitted the water. At the very most, several of the log drains and/or culverts west of the creek acted as "safety-valves" during the "break-out".

Based upon these observations and the test borings, the Geology Section recommended that two additional insulated rock drains without logs, be installed at two known aquifer locations approximately three-quarters of a mile west of the creek. This location, incidently, is the area where the "break-out" terminated. These drains were installed in the summer of 1982.

The winter of 1982-1983 was nearly a repetition of the previous winter. It, too, was a low to moderate icing season in the Interior. Again, no ice clearing was necessary on Blueberry Flats. In late March and early April, the aufeis again "broke-out" from the area of the creek. This time, however, the aufeis went to the southwest and then to the northwest in a loop south of the highway to reach the area of the new rock drains. There it terminated.
The most recent winter of 1983-1984 has been a high icing season in the Interior. The residents of Goldstream Creek valley north of Fox (Fox is about 10 miles north of Fairbanks) have experienced considerable distress due to aufeis. The access road into Denali National Park had considerable icing over it and Sears Creek near Mile 1374.5 of the Alaska Highway had severely iced and has required considerable effort by M&O.

Icing on Blueberry Flats has also been high. The brush south of the road and in the area of the creek was nearly level with the roadway surface. The total embankment height here is ten to eleven feet above the summer ground elevation of the swamp. Once again there was a "Break-out" and aufeis moved west on the south side of the highway to the area of the two "added" rock drains where it terminated. Fresh aufeis was observed here with ice surface being approximately three feet below the roadway surface. No ice clearing efforts were necessary in 1984.
Conclusions

1. The five foot grade raise at the creek provides "Freeboard" above the afeis particularly during the critical March/April "break-out" period when the capacity of the rock drains at the creek can be exceeded.

2. The log drains appear to contribute minimally to the mitigation of the general icing conditions. These drains (or the culverts associated with them) may act as "safety-valves" at selected locations during the critical March/April period.

3. The log drains probably become plugged with ice despite the insulation over them and the brush cover on each end. This would account for their poor performance. Logs used in below grade drain systems might perform adequately, as did the rock in the underdrains on this project.

4. The insulated rock drains have performed well, particularly in the area of the creek. By opening the windows beneath the road, ground water flow has been maintained through-out the winter. The one to two feet of basal fill water in the embankment is a substantial amount of water that has only four drains through which to move beneath the roadway during the winter.

5. Our experience with the rock drains has shown that increased drain capacity would be desireable. This could be accomplished by the installation of rock drains at two locations west of the creek where there is basal fill water and perennially frozen gravels beneath. Increasing the capacity of the drains at the creek would be desireable. These drains were designed to transmit 2 times the amount of basal fill water in the area of the creek. It would be preferable to have 3 to 5:1 capacity versus volume. Lastly, the insulated log drains could be placed into the base of the fill in areas of basal fill saturation to provide conduits for the water.

It would appear that a major M&O expense has been eliminated on Blueberry Flats.