NATIONAL PETROLEUM RESERVE IN ALASKA

DESIGN & CONSTRUCTION OF THE LISBURNE WELLSITE

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For the

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INTRODUCTION

Naval Petroleum Reserve No. 4 was established by Executive order of President Harding in 1923 in order to protect a source of strategic petroleum products for the Federal Government. The Reserve covers 23,000,000 acres in northern Alaska and spans south from the Beaufort and Chukchi Seas to the Brooks Range and west from the Colville River to Icy Cape (Figure No. 1). During the period between 1944 and 1953, the Navy carried out a large scale exploration program in the Reserve and identified several small gas and/or oil fields.

In 1974, the U. S. Congress authorized and funded a new program to perform geophysical work and drill exploratory wells in the Reserve. This program was initially under the jurisdiction of the U. S. Navy, but was transferred to the Department of the Interior in June 1977. Responsibility for the program was assigned to the U. S. Geological Survey (USGS). Concurrently with this transfer, the Reserve was renamed the National Petroleum Reserve in Alaska (NPRA).

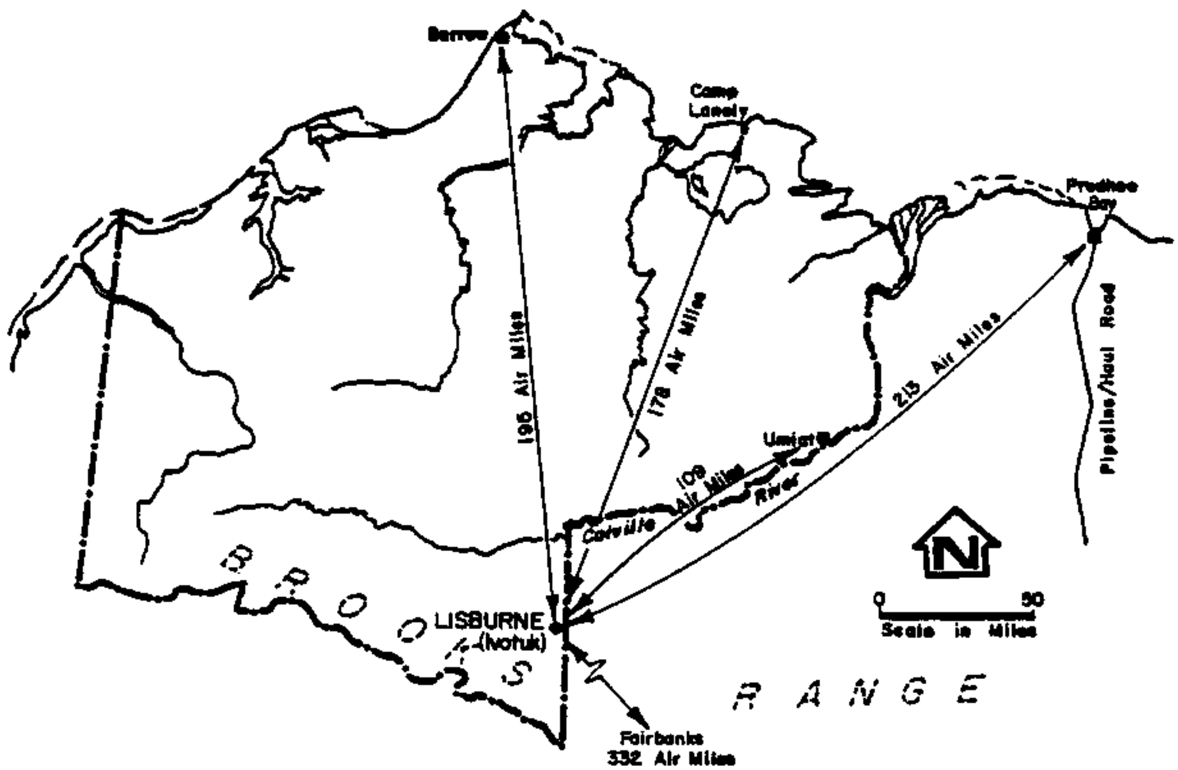

FIGURE NO. 1. LOCATION OF LISBURNE

The Navy contracted the management of the exploratory operation to Husky Oil NPR Operations, Inc., which acted as prime contractor for the Navy and then the USGS. Between 1976 and 1981, Husky and its subcontractors drilled 27 exploratory oil wells at locations scattered throughout the Reserve. Most were drilled to depths of 10,000 feet or less, although three wells were drilled to depths between 15,000 feet and 17,000 feet and two wells were completed to depths exceeding 20,000 feet. The Lisburne Test Well No. 1 was completed to a depth of 17,000 feet. The design and construction of the wellsite facilities at the Lisburne location is the subject of this paper.

LOCATION AND DRILLING REQUIREMENTS

In the spring of 1978, the USGS directed Husky to begin preparations to drill five exploratory wells during the following winter. One of these wells was Lisburne Test Well No. 1 with a projected depth of between 15,000 and 17,000 feet. The selected well location was at latitude 68°29'05'N and longitude 155°41'36'W in the northern foothills of the Brooks Range (Figure No. 1). The location is approximately 213 miles southwest of Prudhoe Bay and 195 miles south of Barrow. The nearest permanent airstrip is at Umiat, about 109 miles northeast of the site, and the nearest portion of the Alaskan road system is approximately 160 miles east of the site.

It was estimated that about 1 year would be required to complete the well. Approximately 200 days of drilling would be required. Prior to the actual drilling, it would be necessary to mobilize a construction crew to the site, construct airfield, road and drilling facilities, mobilize the drilling rig and its associated camp and support equipment, and to assemble and prepare the drilling rig. After the conclusion of the actual drilling, it would be necessary to disassemble the rig (commonly called rigging down) and prepare it, the camp and the equipment for transport out of the site and, finally, complete the demobilization of the drilling rig and equipment.

SITE CONDITIONS

As previously stated, Lisburne is located in the northern foothills of the Brooks Range. The area is characterized by small streams flowing northward and cutting through a series of east-west trending ridges. Vegetation is predominantly tussock tundra. The site is continuously underlain by permafrost. A few small lakes are scattered within 6 miles of the Lisburne wellsite. However, the nearest lake capable of supporting heavy aircraft (C-130 Hercules) ice-airstrip operations is Lake Betty, 25 air miles to the west.

Helicopter supported soils sampling and survey crews were working in this area in July/August, 1978. The surficial soils were found to be predominantly ice-rich silts with occasional sands, broken soft rocks and some cobbles. Soil moisture contents varied widely, with some test holes showing predominantly ice. Typical soils logs are shown in Appendix I. Deposits of coarse gravel, overlain by silts and sandy silts, were located along the nearby streams. The gravel typically contained about 10% to 12% silt and clay. Boulders up to 12 inches in diameter were also present.

The survey crews established horizontal and vertical control points at the site based on the nearest USGS survey monuments and performed some topographic surveying. Based on the control points set by the ground survey crews and pairs of stereographic aerial photographs, topographic maps were prepared covering potential locations for the wellsite facilities. The results of the soils investigation were added to the detailed topographic maps and the maps became the primary tool used for layout of the facilities.

The site subsurface temperature was measured at 22°F by setting a thermocouple at a depth of 50 feet.

Helicopter supported environmental surveys were also performed. These environmental surveys had three significant impacts. First, nesting raptors were located in the area. This resulted in restrictions on runway alignments and aircraft operations. Second, archeologically significant items were discovered in some proposed borrow areas, resulting in excavations by an archeological team. Other, more suitable, borrow areas were later located and the excavated sites were not used. Finally, minimization of the borrow quantities mined along streams was identified as an important environmental goal.

SELECTION OF OVERALL DESIGN

The three basic factors which affect the overall construction design philosophy at a remote exploratory wellsite are the length of the proposed drilling program, environmental considerations, and cost.

If a well can be completed in roughly 5-months time, or less, it is preferred for environmental and cost reasons to complete the well in a single winter season. For these purposes, winter is considered to begin in the fall when the tundra is both frozen and snow covered and end in the spring when the ice begins to melt. Although variable within the NPRA from year to year, these occurences usually correspond to late November and either late April or early May.

The primary advantages of winter-only operations are environmental. Overland mobilization of site construction equipment is much less damaging to the tundra when it is both frozen and snow covered. In addition, the drilling pad can be constructed solely of material removed during excavation of the reserve pit, without regard as to whether the material is thaw-stable or not. It is therefore not necessary to disturb additional areas through development of borrow sites containing thaw-stable material. The use of thaw-stable material is required only if the pad is to be used for drilling operations during the summer. The third environmental advantage of winter operation is that the airstrip, and the road which connects it to the pad, can both be constructed on, or of, ice. These facilities melt and disappear in the spring, leaving no permanent effect on the environment. Finally, because much of the wildlife found within the Reserve is migratory and leaves the North Slope during the winters, wildlife disturbance which might otherwise occur is minimized.

The cost of completing a well during the winter season is also less than that of completing the same well during the summer. While the actual drilling costs are not significantly affected by the seasons, the cost of constructing facilities suitable for winter-only use is considerably less than the cost of constructing facilities capable of supporting summer operations. The cost of developing borrow sites, and excavating, hauling, and placing thaw-stable fill is eliminated entirely.

If a well cannot be completed in a single winter season, as was the case for the Lisburne well, two options exist. Either operations can be limited to winter only and two or more winters used to complete the well, or, operations can be carried on year-round on an all-season basis.

From an environmental standpoint, multiwinter drilling is usually preferred to all-season drilling. At multiwinter sites, the roads and airfields can be constructed of ice, and although they must be rebuilt each winter, they have no long term effect on the environment. At all-season sites, however, large quantities of thaw-stable borrow material are necessary for the construction of roads and airfields. In addition, multiwinter drilling pads must only be sufficiently stable during the summers to support the storage of equipment and materials whereas all-season pads must also support daily operations. Less thaw-stable borrow and/or synthetic insulation is therefore required for multiwinter pads than for all-season pads. Finally, multiwinter activities have a minimum effect on the local summer wildlife population while summer drilling has a slightly more pronounced negative impact.

The primary advantage of all-season drilling is the saving of time. It has been Husky's experience that at least two winters are required to complete a 15,000 foot deep well, which means that the drilling rig is committed for up to 2 years. By drilling year-round, the rig can reach equivalent depths in roughly 1 year and then be released from contract or moved to another location.

For the Lisburne well, consideration was given to both multiwinter and all-season drilling. First, large quantities of thaw-stable granular material were available in the area. It was decided that, by taking proper precautions, it could be extracted and used without significantly degrading the environment. In addition, tt was realized that it would be necessary to construct a completely thaw-stable drilling pad at this location for either multiwinter or all-season operations. This was needed because the designated well location was immediately uphill of a small stream in an area with a natural ground slope of 7%. It would be unacceptable to construct a non-thaw-stable pad at such a location as it would slump and flow into the creek during the summer thaw.

These factors sufficiently mitigated the normal advantages of multiwinter drilling that it was decided to proceed with the Lisburne well on an all-season basis. Attention was then turned to the development of detailed designs for an all-season airstrip, road and drilling pad.

Airstrip dimensional requirements are primarily established by the aircraft operators. The runway was required to be 5,150 feet long by 150 feet wide. A taxiway and parking apron were also needed. Gravel was selected as a cost effective wearing surface meeting the bearing capacities specified by the operators.

The location of the airstrip alignment was a primary design consideration. Arctic subsurface soils are frequently highly ice rich and are heavily influenced by thermal criteria. Thaw-stable structural embankments must insulate any lower thaw-unstable soils or massive thaw settlements can result. Typically, embankment thicknesses are 5 to 6 feet on the North Slope. However, if a site with thaw-stable in situ soils can be found, a lesser thickness of structural gravel is required. Constructing the final grade of the airstrip at least 2 feet above the existing terrain also helps the runway blow clear of snow in the winter, simplifying maintenance.

The Lisburne area did not offer a suitable airstrip site with thaw-stable soils. The selected airstrip location is shown in Figure No. 2. Primary considerations were the local mountainous topography and presence of nesting raptors along the creek. The alignment was chosen to utilize the smoothest grade available and to direct the aircraft as far from the nesting areas as possible while avoiding topographic barriers in the aircraft approach zones.

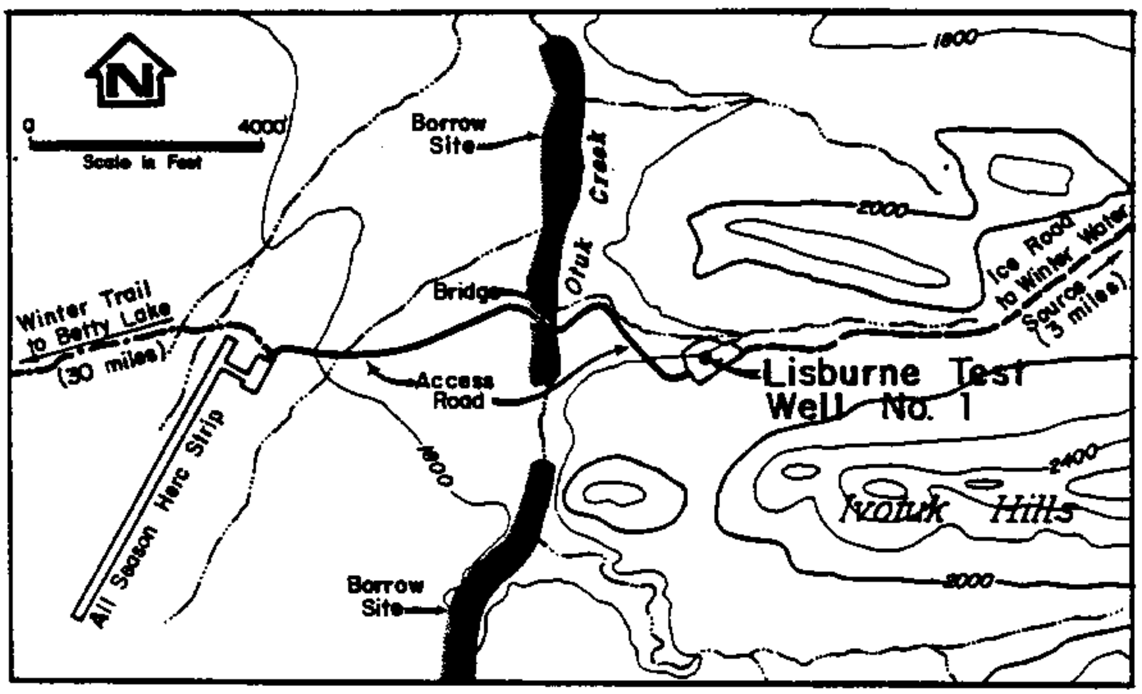

FIGURE NO. 2. LAYOUT OF LISBURNE LOCATION

Thermal criteria was the controlling factor in determining the airstrip thickness and two basic types of gravel airstrips were considered. The first was a typical arctic gravel runway. Construction of such a runway is accomplished by placing gravel over the tundra until the required thickness is developed. At Lisburne, an average of 6 feet of gravel is required for thermal insulation of the underlying tundra.

The second type considered and finally selected was a fully insulated runway. The design concept chosen is shown in Figure No. 3. The lowest portion of the cross section consisted of a minimal gravel leveling course. At Lisburne, the leveling course was iced over and utilized as a temporary airstrip. The ice was then bladed down and grooved, and insulation was placed over the icy leveling course. The insulation was covered, in turn, by a plastic membrane, then by the gravel courses. The thickness of the gravel courses was selected to prevent crushing of the insulation by the anticipated wheel loadings. The thickness of the insulation layer was designed so that the gravel/insulation thermal system would prevent any thaw beneath the insulation and preserve the bearing integrity of the ice/gravel leveling course and in situ subsoils. Plans called for installation of termocouples beneath the insulation so that the performance of the insulating system could be monitored.

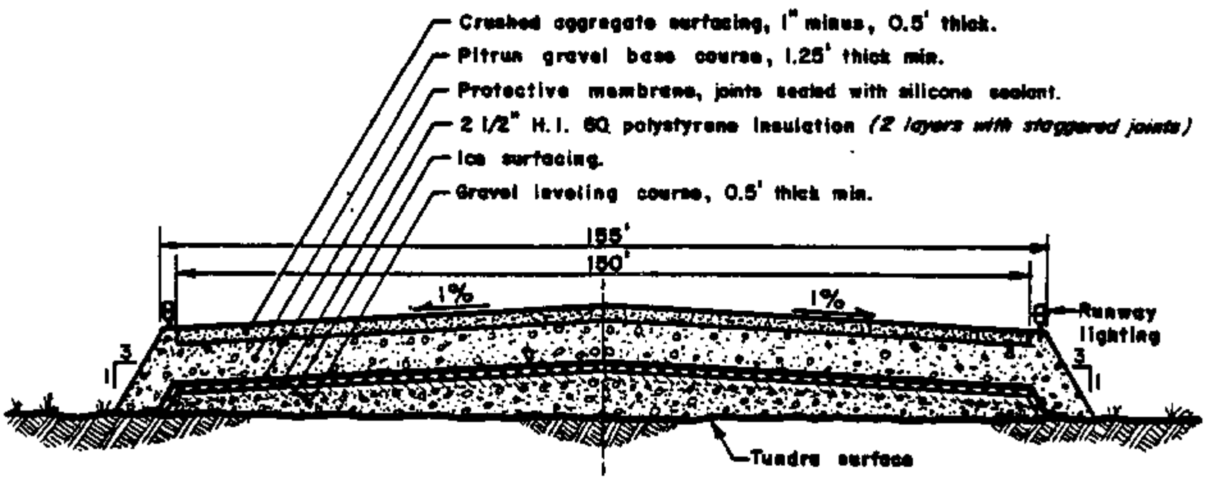

FIGURE NO. 3. TYPICAL INSULATED RUNWAY SECTION

Selection of the insulated design was justified by a combination of economic and environmental reasons. The two designs were first compared economically. The actual cost comparisons were more detailed than the following analysis, but these simplified comparisons provide the fundamental economic assumptions. Gravel costs (unburdened labor and equipment charges) were estimated at $7.50 per cubic yard. In place insulation costs were estimated at $0.60/board foot. Comparison of the design cross sections showed that the 2-1/2-inch insulated design required approximately 3.5 feet less gravel than the all gravel design. Considering the runway alone, the comparison computations are:

Gravel = (5,150' x 155' x 3.5' ÷ 27) x $7.50	$ 776,000
Insulation = 5,150' x 150' x 2.5" x $0.60	1,159,000
Difference	$ 383,000

However, the insulated design was estimated to provide significant savings in other areas. These included:

Mobilization/Demobilization	$ 120,000	
Fuel on Site	60,000	
Maintenance	250,000	
		430,000
Net Difference (Savings with Insulation)		$ 47,000

Mobilization/demobilization and fuel costs were saved by reductions in construction equipment inventory. Equipment was flown into the site from Prudhoe Bay, Fairbanks, or other NPRA remote sites. Fuel was flown in from Fairbanks.

Maintenance savings resulted from the unique thermal decoupling between the gravel course and the subgrade that was provided by the insulation. Because the insulation cuts off the cooling effect of the subgrade, the spring thaw progresses more rapidly through the gravel above the insulation. The winter-placed gravels can then be compacted and stabilized more quickly. After this occurs, further maintenance is minimal. A full-section, winter-constructed gravel airstrip would require much more attention through its first summer due to the slow progression of thaw through the embankment.

Although the insulated design was selected over the full thickness design for economic reasons, it was also superior in other ways. These were centered in three areas - operational, cost escalation and environmental.

The rig for the Lisburne well had to move onto the location in late April and early May. This was necessary because the rig was completing another well on a location with an ice airstrip and the move had to be accomplished before the airstrip melted. Thus, Husky estimated the rig move would occur when the Lisburne airstrip surface course would be thawing. If so, the increased stability of the insulated design at breakup could provide a considerable cost savings. Rig moves are very expensive, typically estimated at $50,000 per day. If the Lisburne airstrip became unserviceable to heavy aircraft for a day or two, these costs would continue. If the airstrip at Lisburne failed to perform for an extended period, the rig could be stranded at the previous location due to thaw of its ice airstrip. This could cost up to several million dollars.

The cost escalation consideration was also important. The in-place insulation cost of $0.60 per board foot included acquisition, packaging, transportation to the site and site costs. Site costs were only about 10% of the total. The remaining 90% of the estimated costs occurred in areas where the pricing was relatively fixed. Thus, the $0.60 per board foot estimate was treated with confidence. On the other hand, the costs for gravel work are incurred entirely on site. Experience has shown that these estimated costs, no matter how carefully derived, can be considerably in error. This proved to be the case at Lisburne when the actual raw price for gravel was about $11.50, not $7.50 as was estimated. Actual insulation costs were slightly below the estimated costs.

Finally, the environmental benefits which resulted from mining reduced quantities of gravel were important. It was highly desirous to reduce borrow quantities and thus lessen overall environmental impact of the construction of the wellsite. Gravel savings were estimated at 135,000 cubic yards for the airstrip, taxiway and apron. Additional savings were realized through reductions in stripping of overburden and reductions in rehabilitation costs. Total gravel excavation for the site was about 300,000 cubic yards.

The drilling pad location also posed significant design problems. The well location was fixed by the geologists, placing it on a 7% side slope. Meeting the reserve pit containment criteria and providing relatively level working areas became the initial design objectives.

The reserve pit containment volume was specified by Husky's Drilling Department. The project stipulations dictated that this fluid volume had to be contained below the lowest original ground elevation around the pit per imeter. Dikes formed only contingency storage. Because of the 7% natural ground slope, excavation of a large cut slope on the uphill side was necessary. The cut volume was somewhat minimized by elongating the reserve pit along the contour lines (Figure No. 4). Unfortunately, the reserve pit cut quantity remained high, at 76,000 cubic yards. The material was ice-rich silt with pure ice layers (see Appendix I).

The required pad area for the rig, rig working areas, storage and camp areas was provided most economically by utilizing two levels. This greatly reduced the required fill quantities. The lower pad provided the rig area and working area, while the upper pad provided storage areas and a camp area. Both levels were elongated along the contour lines to minimize fills.

A road was designed to connect the pad and airstrip. Unlike the airstrip, an uninsulated design was selected rather than an insulated one. This less conservative design was selected because the stability of the road was not as critical as the stability of the airstrip. The road section thickness was not sufficient to prevent thaw beneath it, but the drainage was expected to be much better than the airstrip due to the narrow width. Differential settlements could be graded out easily, causing only minor traffic delays. This thinner section was estimated to be more economical than an insulated design. In any case, heavy hauling all-terrain vehicles would be available on site to traverse the road if it became impassable to conventional rig trucks.

A crossing structure was required at Otuk Creek creating a considerable design problem due to the lack of hydrological data. A bridge design was selected over culverts because the bridge offered greater protection against possible high flood waters. Gabions were used to protect the west abutment, while the east abutment was protected by both gabions and an insulated piling/retaining wall system. The bridge itself was protected by designing the decking to be higher than one of the roadway approaches. Thus, if high floods occured, the road approach to the bridge would wash out and could easily be rebuilt when the flood waters receded. In addition

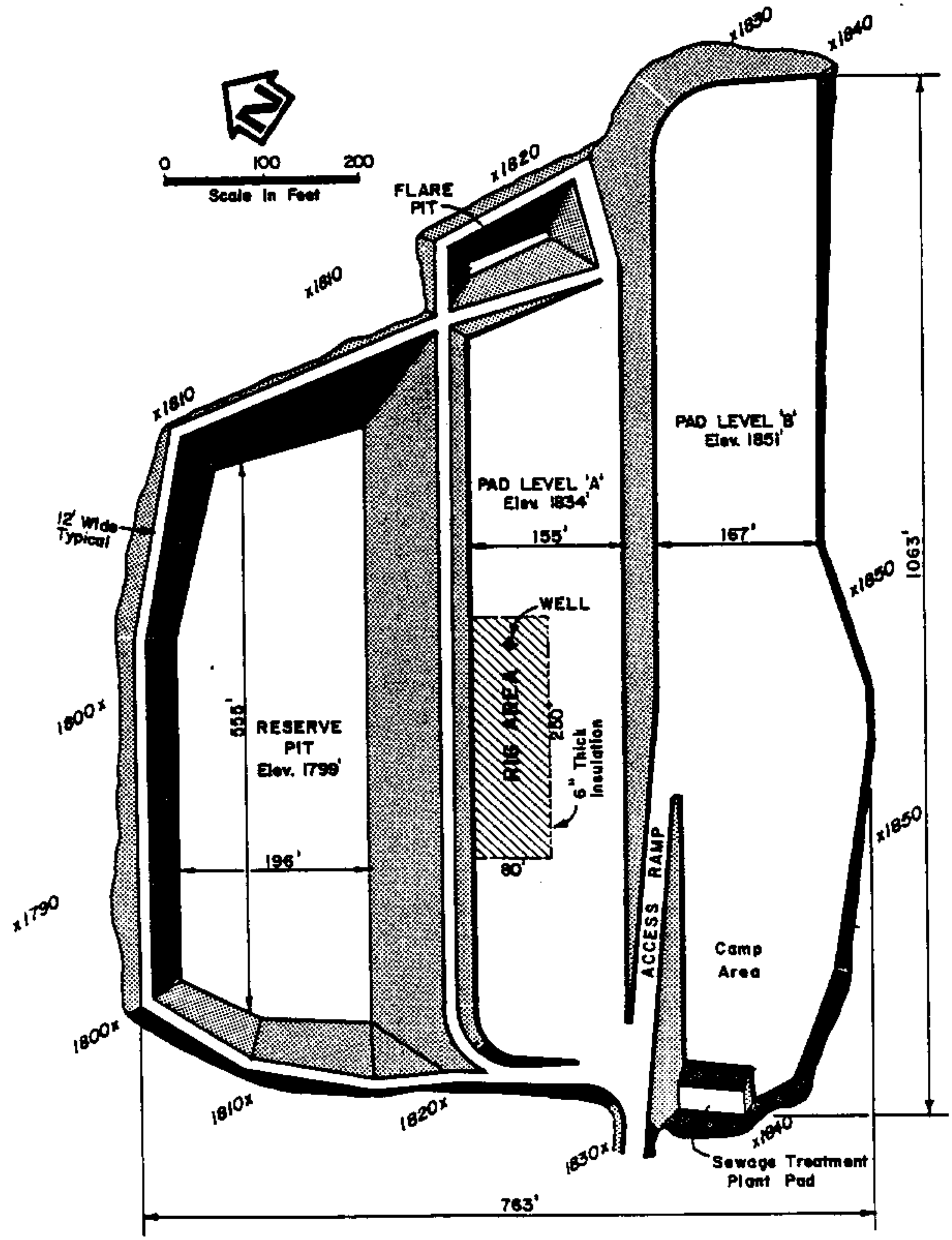

FIGURE NO. 4. LISBURNE PAD LAYOUT

use of a bridge allowed the natural flow lines and velocities of Otuk Creek to be more nearly maintained than was possible with a culvert design.

A 100-foot-long glulam timber bridge, composed of two spans of equal length was used. Piling were installed to support the spans. In all cases, low cost, airlift capability and ease of construction with existing site tools were used as design criteria.

The last major consideration in the Lisburne design was the mining plan for the borrow site. The desired gravels were deposited along the narrow Otuk Creek flood plain. At working depths greater than about 5 feet, the gravels were saturated and contained visible ice. This deeper material contained considerable amount of ice and would be almost impossible to rip economically in winter. Thus, the excavations were extended along Otuk Creek in long narrow strips. These extensions provided more effective restoration and revegetation potential, and maintained the original flowline of the stream. The borrow areas are shown in Figure No. 2.

In order to minimize the environmental impact of the borrow sites and to provide for their environmental restoration, three design criteria were established. First, a 25 foot wide strip of undisturbed vegetation was to be left between the active creek channel and any borrow excavation. Second, excavation was not permitted lower than 6 inches above Otuk Creek water levels. Third, some of the ice-rich silts from the reserve pit excavations were backhauled, spread over the disturbed areas in the borrow sites, and contour graded. This provided good seedbed material for summertime seeding.

DESIGN DETAILS - AIRSTRIP

One of the key components of the airstrip design was the insulation. Its purpose was to prevent thaw of the icy subgrade during the summer. The required insulation thickness was calculated by the Cold Regions Research and Engineering Laboratory (CRREL) who acted as a consultant to the USGS. An insulation thickness of 2-1/2 inches or 3 inches was recommended, depending upon the degree of confidence desired.

Two and one-half inches of insulation was used at Lisburne. Cost estimates for an additional 1/2 inch of thickness were about $232,000 for the airstrip alone. This cost was weighed against the possible consequences if thaw did occur beneath the insulation. It was estimated that if thaw did occur, it would be very late in an unusually warm summer season. The effect on airstrip serviceability was judged to be marginal. The ice immediately beneath the insulation might melt, but small amounts of melt water could travel into the gravel leveling course with only small settlements resulting. It was considered very unlikely that these thaw settlements would be detrimental to the airstrip operations. Removal of all airstrip ice surfacing prior to insulation placement was also considered, but was discarded for several reasons. First, because the runway was iced to produce a mobilization airstrip, the leveling course need only be pit run and rough graded. Removal of all ice would require intensive grading of the leveling course, thus greater cost and additional time. Second, the high heat input required to melt the ice would limit the rate of thaw penetration. However, the ice was bladed and scarified down to the top of the gravel with longitudinal 1-inch wide grooves to provide local pockets for slight amounts of sub-insulation water.

The insulation at the Lisburne airstrip was placed in two layers. The lower layer was 1-1/2 inches thick, and the upper layer was 1 inch thick. The 2 foot x 8 foot insulation boards were staggered so that the joints between the boards did not align through the insulation cross section. This helped to prevent "leaks" in the thermal protection. Also, if thaw were to occur beneath the insulation, the joint stagger would make it difficult for the water to pump up and down through the insulation and increase the heat penetration and thaw.

The type of insulation selected for use at this wellsite was a high density, closed cell, extruded polystyrene manufactured by Dow Chemical Corporation under the brand name Styrofoam. Previous use by Husky at other sites in the NPRA and use by others in various arctic areas had demonstrated the suitability of this material for use within gravel embankments. Both laboratory tests and long term field tests had shown that Styrofoam would maintain its thermal properties and structural strength for many years.

Styrofoam is manufactured in three standard grades which have essentially the same thermal properties but differ in their rated compressive strengths. The two stronger grades, called HI-60 and HI-35, are crushed to 90% of their original thickness under loads of 60 psi and 35 psi, respectively. A weaker grade, manufactured for use as house insulation, is similarly crushed under loads corresponding to 25 psi. The airstrip design called for use of the HI-60 Styrofoam.

One disadvantage associated with the use of Styrofoam is that it is dissolved by most types of hydrocarbon fuels. To protect the insulation from any spilled fuel, a strong cross-laminated polyethylene sheeting was placed over the insulation.

The proper thickness of gravel over the insulation was very important. It was desirable to keep the layer as thin as possible for economic reasons. However, the gravel had to be sufficiently thick to prevent insulation crushing under actual wheel loadings. To determine these thickness requirements, a study by the Waterways Experimental Station in Vicksburg, Mississippi, was commissioned by the USGS. This study demonstrated that the design Hercules (C-130) aircraft wheel loads would cause crushing if less than 15 inches of cover was utilized over 60 psi rated insulation (see Reference 6).

It was decided to utilize a 15-inch base course plus a 6-inch crushed surface course at Lisburne. The base course would protect the insulation from the gravel truck wheel loadings during construction. The construction schedule dictated that both courses had to be placed in winter at very cold temperatures, when compactive efforts produce little benefit. Recompaction after spring thaw was expected to reduce the cross section thickness by about 10% to 15%, leaving a net thickness of about 18 inches.

This left a 3-inch allowance for improper grading or rutting from aircraft wheel loadings during thaw periods.

Final airstrip layout was then developed. It is shown in Figure No. 5. The apron was located as close to the drilling pad as possible to limit road construction. Uninsulated overruns were added. A full complement of runway lighting equipment was specified, including vertical angle slope indicator (VASI) lights, runway end indicator lights (REIL), a non-directional beacon (NDB), an elevated operations room and weather station, and a diesel generator module. The uninsulated equipment storage apron shown in Figure No. 5 was added during construction. This provided space for the construction contractor and a seismic contractor to "stack out" for the summer.

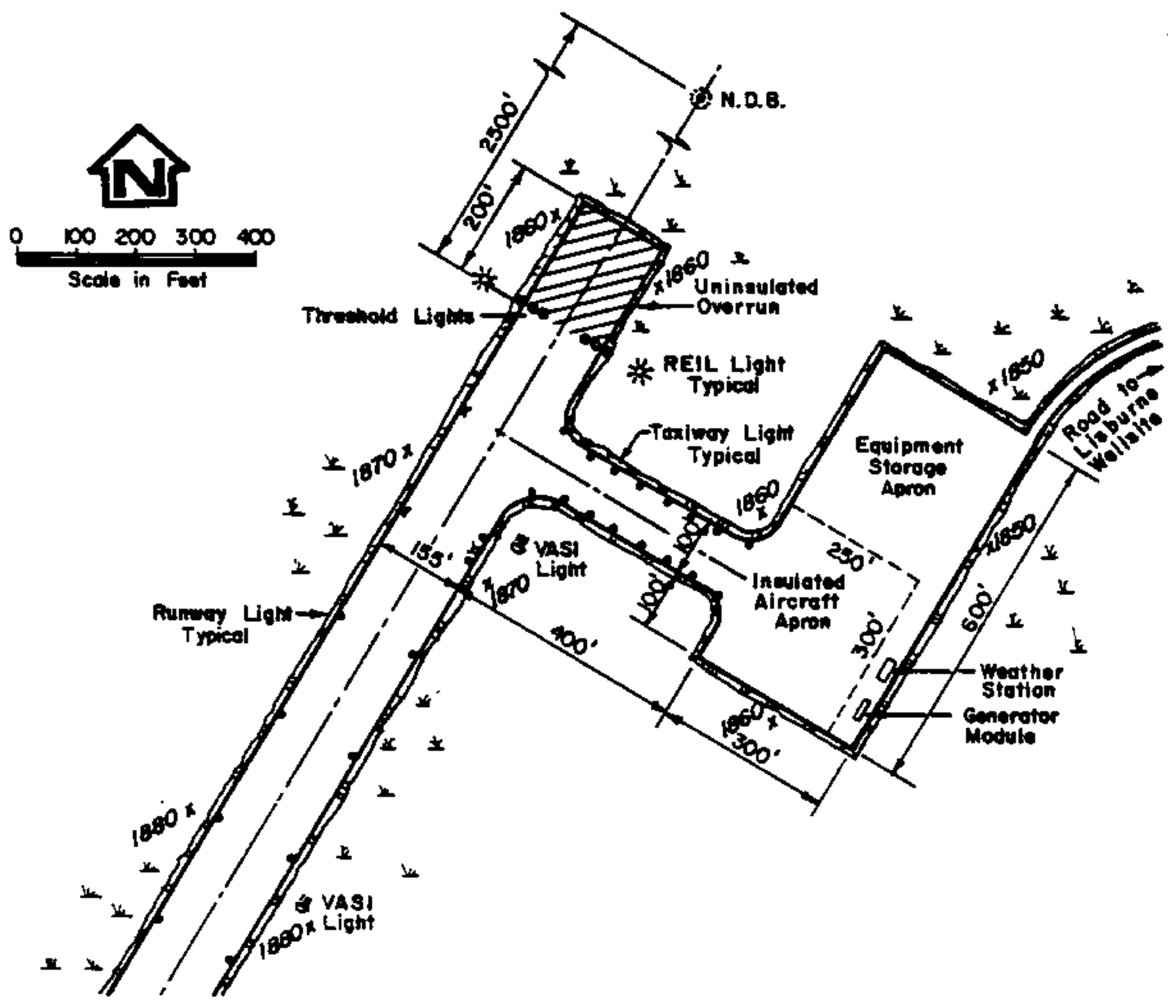

FIGURE NO. 5. NORTH END OF RUNWAY & APRON LAYOUT

DESIGN DETAILS - PAD

Once the drilling pad layout was established, the approximate reserve-pit-cut and pad-fill quantities were considered. The reserve pit excavation was computed to be 76,000 cubic yards consisting of ice and ice-rich silt with some sand. Total pad fill was computed to be 135,000 cubic yards.

The use of the reserve pit material was a problem. As much as 30,000 cubic yards of the material could be used for borrow site rehabilitation. The remaining material was not readily useable for embankments because of its thaw instabilities. However, if kept frozen, the material could be satisfactory structural fill.

Stabilizing the ice-rich reserve pit excavation material with insulation was the plan considered and finally adopted. This material could then be utilized in the core of the drilling pad, except in the rig area where drilling operations would produce additional heat input to the pad. This material would be covered by 2-1/2 inches of insulation to preserve its frozen state. A 24-inch gravel covering would protect the insulation and serve as the pad's bearing surface. This design provided a good quantity balance. The pad could accept about 49,000 cubic yards of reserve pit material, leaving an estimated 27,000 cubic yards for borrow site rehabilitation. This solution also had two environmentally desirable effects. First, it provided use for reserve pit excavation material, eliminating a disposal problem. Second, it reduced total gravel borrow excavations.

Details of this concept are shown in Figure No. 6. Note that a gravel dike is shown separating the two pad levels. This dike was designed to be sufficiently thick to prevent thaw from penetrating back into the ice rich material beyond the gravel.

Pad level "A" had a very similar design except in the rig area. This area received pit run gravel to promote thaw stability. The drilling operation was expected to generate a large amount of heat and warm water. The downward flow of heat was retarded by placing a 6-inch insulation layer underneath the rig. Gravel was placed under the insulation between the rig and the original ground surface. This design is shown in Figure No. 7.

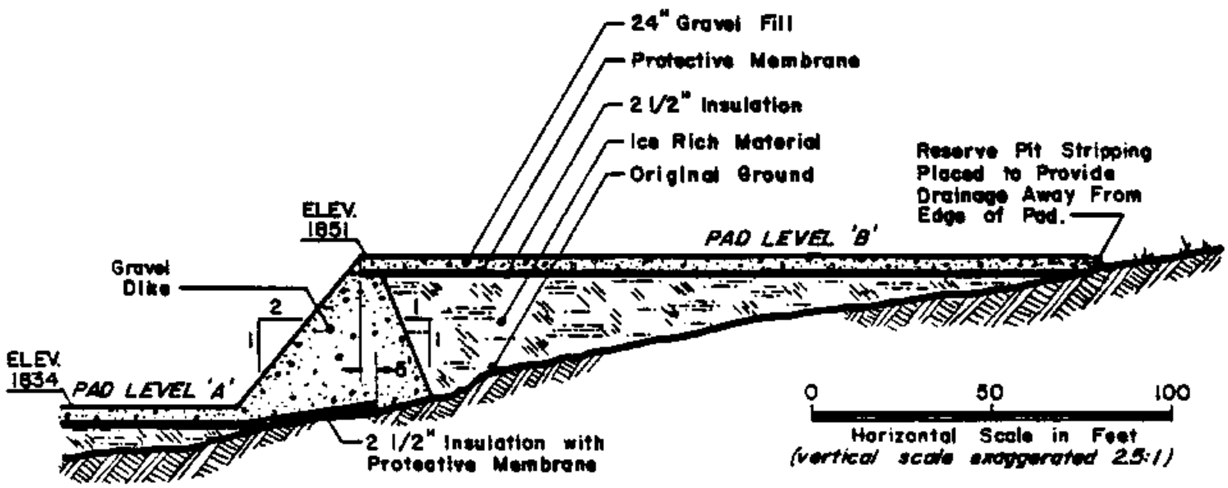

FIGURE NO. 6. PAD LEVEL B, CAMP & STORAGE AREAS

16.

The last major concern was the large exposed area of the reserve pit cut slope. It was decided to insulate the cut slope and provide a sufficient gravel cover to the insulation to hold it in place. This system was designed to preserve the stability of the pit slope over an extended period of time. A 12-foot wide ledge was constructed along the length of the stabilized slope 10 feet below the pad elevation to provide access for a bulldozer to remove any accumulation of drill cuttings.

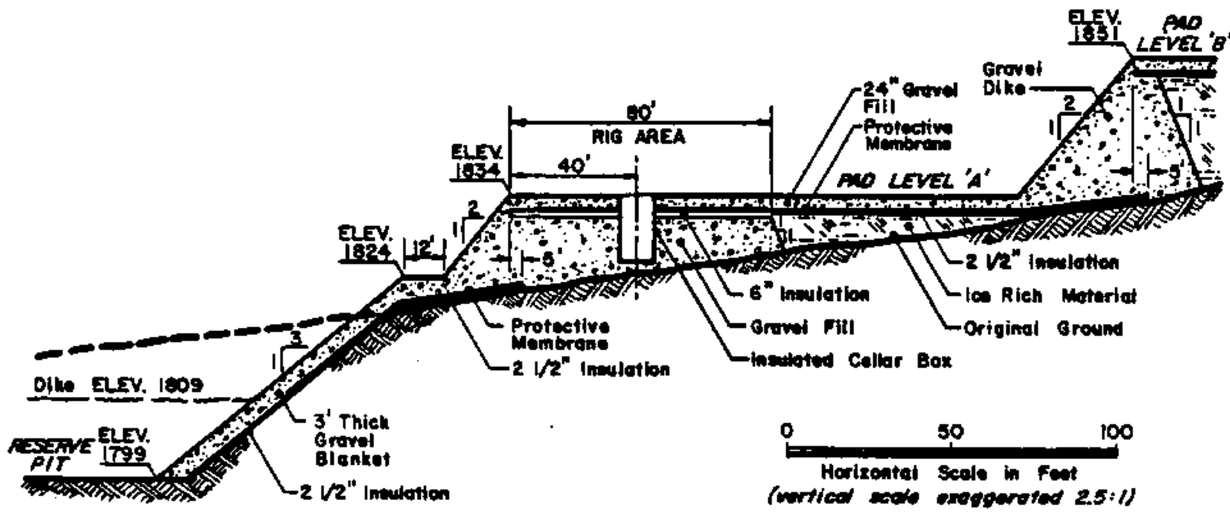

FIGURE NO. 7. PAD LEVEL A, RIG & WORKING AREAS

DESIGN DETAILS - BRIDGE

No hydrological data was available for use in the design of an all-season crossing for Otuk Creek. In spite of this deficiency, it was necessary to develop a design which would provide both reliable access between the airstrip and drilling pad and also minimize alteration of the flow characteristics of Otuk Creek. Two options were considered. The first was to construct a crossing utilizing culverts and fill. The second was to construct a bridge over the creek.

The use of culverts and fill would have been less expensive than a bridge, but would also have several disadvantages. The disadvantages included encroachment on the stream and the lack of data on which to base the size, number, and location of required culverts. In addition, it is difficult to adequately place and compact backfill during the winter to support culverts and prevent seepage through the embankment itself.

Evaluation of possible bridge designs identified the advantages and disadvantages compared to the use of culverts. The primary advantage of a bridge was environmental, as disturbance to Otuk Creek could be minimized. Additionally, a bridge was less likely to be affected by spring run-off. Among the disadvantages which were identified in the preliminary analysis was the fact that a bridge would be more costly than a culvert crossing from a materials purchase standpoint. A bridge would also require more time to install and more exacting construction techniques.

Because of the environmental advantages, it was decided to purchase and install a bridge crossing and a prefabricated glulam timber bridge was selected. The bridge was 100 feet long and composed of two 50 foot long spans. A center pier, consisting of 5 timber piles set to a depth of 20 feet below the natural ground elevation and a steel ice raker was designed using 12-inch deep I-beam steel, 50-pounds per foot.

The designs developed for the east and west abutments differed from each other considerably. Each was based on the terrain at the abutment, and designed to provide additional safety factors.

The eastern abutment consisted of timber and pile wing walls and a typical pile and timber bulkhead supporting the bridge. This was appropriate for the steep eastern bank of the creek. Provision was made for minor field adjustments of the bridge alignment to achieve a best-fit design. The design included the use of insulation between the abutment and in-site natural permafrost soils to maintain the soil in a frozen state. Insulation was also placed between the natural soil and the granular fill of the roadway approach for the same purpose. A field design change added rock-filled gabions to extend the upstream wing wall. This was necessary to fully confine the toe of the approach fill adjacent to the creek.

Development of a more complicated design was necessary for the western abutment. Initially, it was planned to construct an abutment similar to that designed for the eastern end and connect the bridge to the normal road fill with an approximately 10-foot-thick gravel causeway. It was decided to construct the causeway in such a way that the low point in the gravel surface would be sufficiently lower than the bridge so that the very high water levels which possibly could occur during breakup would wash out the causeway leaving the bridge intact. To assure the stability of the western abutment during a causeway washout, it was designed as a 16-foot square rock-filled timber and piling box. The box was protected from normal erosion by rock-filled gabions placed at normal creek level.

A photograph of the completed structure is presented in Figure No. 8.

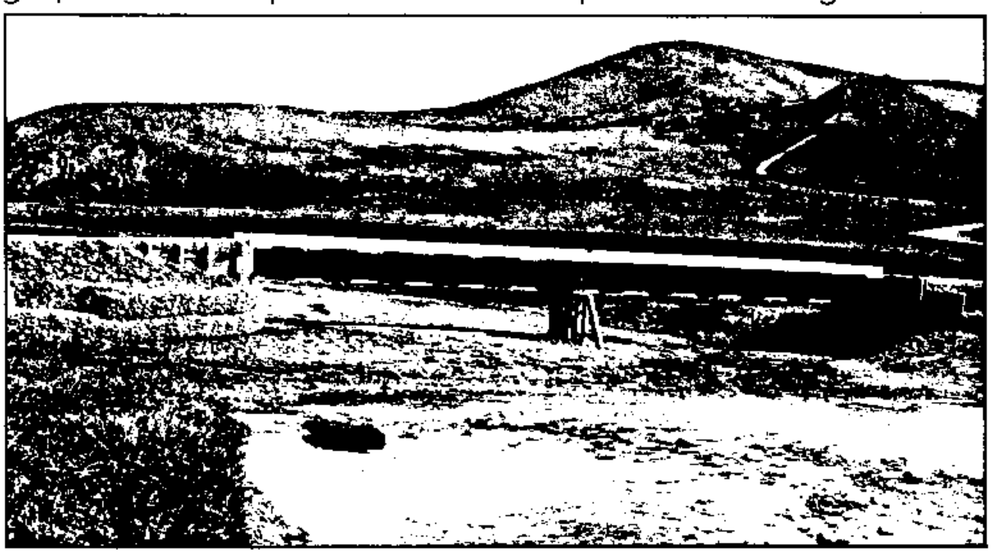

FIGURE NO. 8. OTUK CREEK BRIDGE

13.

CONSTRUCTION OF LISBURNE WELLSITE

After Husky was directed to proceed with the construction of the Lisburne wellsite in the spring of 1978, the first major challenge was deciding how to best gain access to such a remote area. The nearest large airstrip, at Umiat, was 109 air miles northeast of Lisburne. It was estimated that 140 trail miles would be required to move equipment overland from Umiat to Lisburne. In addition, the equipment which Husky preferred to use at Lisburne was then located at the Tunalik test well, located 220 air miles northeast of Umiat and approximately 230 trail miles from Lisburne. Both mobilizing overland directly from Tunalik and mobilizing first by air to Umiat and then overland to Lisburne would be time consuming and expensive. However, during April 1978, Husky's seismic subcontractor was working in the Lisburne area and it was decided, to request the contractor to clear a 5,000-foot long ice airstrip on Lake Betty, about 25 air miles west of the Lisburne site.

The ice airstrip was quickly cleared a minimum amount of equipment was mobilized and stored on the tundra adjacent to the lake. The purpose of this advance mobilization was twofold. First, the equipment would be available at Lake Betty in the fall of the year to construct another ice airstrip on the lake for use in mobilizing additional equipment. Second, the small camp would provide a base of operations to efficiently support summer surveying activities in the Lisburne area. A listing of the equipment stored at Lake Betty during the summer is presented in Appendix II.

During late September, when the summer program was completed, the Lake Betty camp was temporarily closed. The camp was reopened on December 21, 1978, beginning the winter wellsite construction program. The construction schedule is shown in Figure No. 8. In addition, Appendix III contains a summary of the daily weather conditions and progress reports. Temperatures during the construction period ranged as low as -55° F with most construction occurring in temperatures from -10° F to -30° F.

Under the initial construction plan, all heavy airlift for the Lisburne construction would fly into Lake Betty. This ice airstrip would be connected to the wellsite via a 30-mile-long winter trail. However, as the materials list grew, it became obvious that the amount of traffic would necessitate construction of an ice road rather than a winter trail. The ice road and the additional trucking support, etc., began to look logistically complicated and very expensive.

Several alternative methods of completing the mobilization were considered. One alternative to the Lake Betty support concept was to construct a 5,000-foot ice airstrip at the Lisburne location. However, there were no suitably sized lakes in the immediate vicinity. Construction of a 12-inch thickness of ice over the tundra to make an airstrip was considered, but there was not a sufficient quantity of water in the nearby lakes at that time of year. The alternative chosen was to ice down the leveling course of the all-season airstrip.

Utilizing the airstrip leveling course as a mobilization airstrip offered many advantages. It minimized the amount of equipment and materials mobilized into Lake Betty for overland transport to the Lisburne wellsite. Only enough equipment for opening the borrow pits, laying the leveling course, and icing the runway surface needed to be mobilized overland. Once the mobilization strip was complete, all additional equipment could be flown directly to the location. The traffic over the Lake Betty/Lisburne winter trail was minimized, providing important environmental benefits and cost savings.

The principal disadvantage of the plan was the heavy airlift logistics. It would be necessary to move large amounts of construction equipment, fuel and materials to the location in the short period that the mobilization strip would be open (Figure No. 8). If weather or aircraft availability problems occurred, the opening of the completed airstrip could be delayed. This was very undesirable as the rig move to Lisburne was planned from an ice airstrip. This disadvantage was considered carefully. The aircraft availability for mobilization was programmed without other conflicts and thus guaranteed.

A small crew was flown to the Lake Betty camp on December 21, 1978 in a single engine Beaver aircraft on skis. The crew was able to start the camp generators and spent the first night on location. These personnel were quickly supplemented with others and snow clearing began along the Lake Betty ice airstrip alignment. Initial ice borings showed 36 to 40 inches of ice, short of the 48 inches required for the Hercules aircraft. The two water trucks were used to flood the lake surface to build up the ice thickness. These efforts were slow due to unseasonably warm temperatures. Airstrip completion was delayed until January 25, somewhat later than planned.

When the Lake Betty airstrip became operational, additional construction equipment and fuel were flown onto the airstrip. This equipment was assembled into an overland train. Camp units were mounted on skis and all equipment prepared to travel the winter trail to the Lisburne wellsite.

The overland mobilization began on February 20, about 2 weeks behind schedule. One night was spent on the trail and the train arrived at Lisburne on February 21. From this point forward, the job was double shifted. Two 10-shifts were used 7 days per week. The 2-hour breaks between shifts were used to service equipment.

Work began immediately to open the nearest borrow site aliquot. Work was begun on the trail to the water-source lake, with water being applied to build up to the eventual ice road.

The next day enough borrow material was available to begin hauling for a thin gravel running surface along the road alignment from the bridge area to the airstrip. More trucks and drivers were added as increasing amounts of borrow became available. The haul rapidly progressed through the apron and onto the actual airstrip alignment.

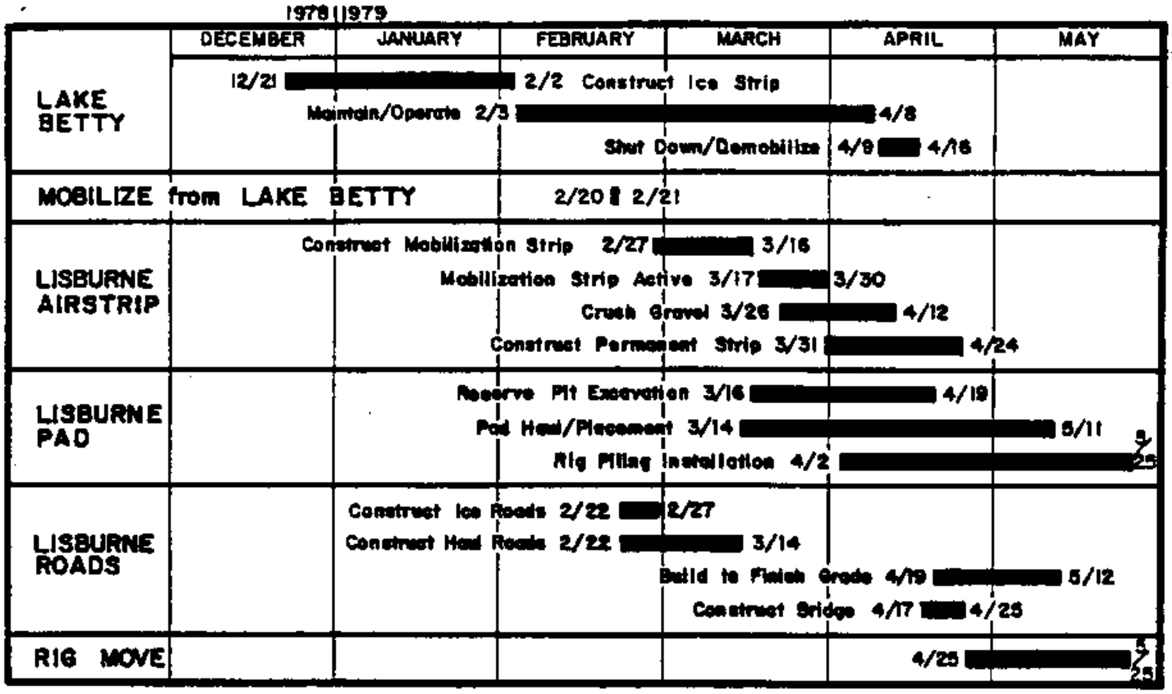

FIGURE NO. 9
CONSTRUCTION SCHEDULE FOR LISBURNE WELLSITE

As the trucks proceeded with the gravel haul to the airstrip alignment, water was hauled over the ice road from the water-source lake. This water was sprinkled onto the airstrip leveling course to bind the gravel and eliminate all loose spots. A 1 to 2-inch lift of ice was built up over the rough graded gravel leveling course to stabilize and smooth the loose surface.

Temporary runway lights were then installed and the airstrip was pilot checked on March 16. The mobilization airstrip remained open through March 30. During this period over 200 heavy aircraft landings were made, with a peak of 26 in one day. The airlift logistics are summarized in Table I. A list of the construction equipment on site during the peak construction period is presented in Appendix II.

When the trucks had completed the airstrip leveling course, they began hauling material for a thin running surface on the road alignment to the pad. When this was completed, trucks hauled steadily to the dike areas in pad levels "A" and "B".

The reserve pit excavation was begun in mid-March utilizing a single D-8 ripper Cat. As additional equipment was mobilized to the site, this Cat was supplemented with blasting gear and the majority of the reserve pit was loosened with explosives. Husky's estimates had shown that this procedure would be less expensive than mobilizing and ripping with additional D-8 Cats, and actual cost analysis substantiated this forecast.

TABLE I.

NUMBER OF HEAVY AIRLIFT OPERATIONS* ONTO LISBURNE MOBILIZATION AIRSTRIP

Date	Materials	Equipment	Fuel	Insulation	Total
3/17	0	4	0	3	7
3/18	4	6	0	14	24
3/19	3	6	3	12	24
3/20	3	2	2	13	20
3/21	1	6	0	8	15
3/22	7	3	4	12	26
3/23	0	0	2	16	18
3/24	1	0	4	9	14
3/25	1	2	4	0	7
3/26	1	0	3	0	4
3/27	0	2	0	3	5
3/28	3	0	0	5	8
3/29	2	5	4	10	21
3/30	3	5	0	2	10
TOTAL	29	41	26	107	203

* One operation is a landing and a takeoff.

The material from the reserve pit excavation was hauled to the designated areas of the pad concurrently with the haul of gravel from the borrow sources. Close monitoring of the pad fill placement was necessary to insure that the material was placed as specified. The ice-rich material in excess of that specified for the pit was stockpiled in the reserve pit for later use in rehabilitation and revegetation of the borrow area. The rig area was filled and leveled at the insulation subgrade line with gravel and the installation of piling subsequently began in early April.

Installation of the timber piling began with augering of 22-inch diameter holes. The truck-mounted auger used to drill these holes and the ice-rich material which was encountered are shown in Figure No. 10. Most holes were drilled to a depth of 20 feet. The piles, typically 14 to18 inches in diameter, were then set in the holes, plumbed and wedged in place. The annular space between each pile and its hole wall was then filled with a slurry comprised of some of the finer-grained granular borrow material and water. The slurry, which froze in place, provided the required support strength by bonding to both the pile itself and the natural soils on the perimeter of the hole. The holes closest to the wellbore were drilled to depths of approximately 45 feet, where bedrock was encountered. This provided an additional margin of safety should the frozen bonds supporting the piles be weakened by heat radiating from the wellbore.

After the heavy airlift was completed on March 30, the airstrip was then closed to heavy aircraft and the final construction effort was started. The ice mobilization airstrip was scarified and the loose ice was bladed off the airstrip alignment. Placement of insulation and its covering membrane proceeded quite rapidly. Trucks were soon able to begin hauling and back dumping the 15-inch thick base gravel course. The back-dumped material was pushed out over the insulation with a D-7 Cat. This process is shown in Figure No. 11.

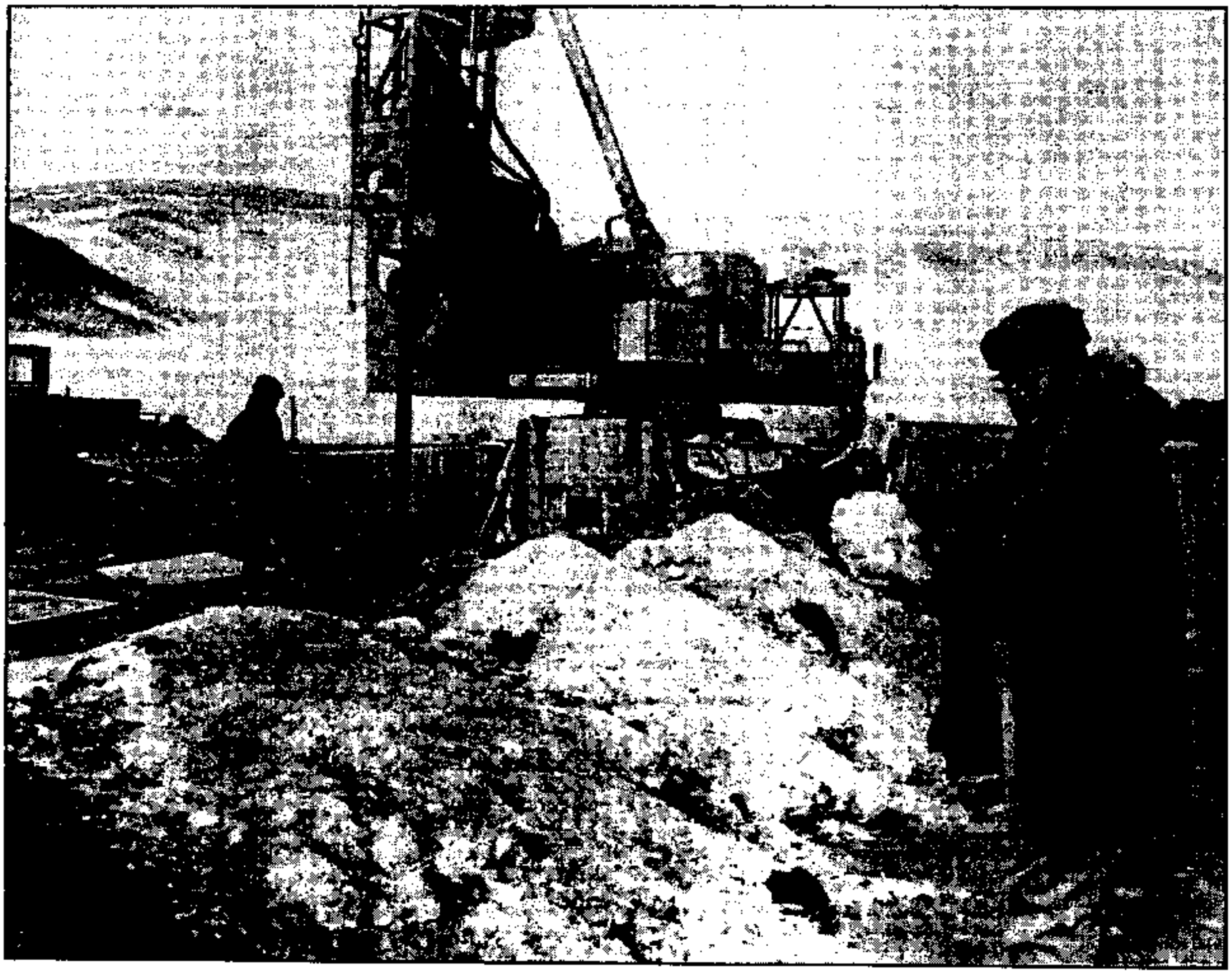

FIGURE NO. 10
AUGERING OF PILING HOLES IN ICE-RICH SOIL AT PAD

After placing the base course, a 6-inch-thick crushed gravel surface course was placed. Use of crushed material was necessary because the rounded pit run gravel was not considered suitable to support aircraft wheel loads without rutting.

Construction proceeded from the north to the south. One half of the total airstrip length was completed before work on the other half began. This allowed a 2,000-foot light aircraft strip to be active on the "quiet" half at all times. These aircraft brought personnel, food and miscellaneous cargo directly to the location. This arrangement worked quite well.

Early compactive efforts, applied to both the base course and the crushed course were ineffective for two reasons. First, the material's frozen state prevented attainment of the design compactions. Second, the compactors did not perform well in the extreme cold. Breakdowns were frequent and machine availability poor. However, as the weather warmed up and the granular material above the insulation began to thaw, these compactors became very important.

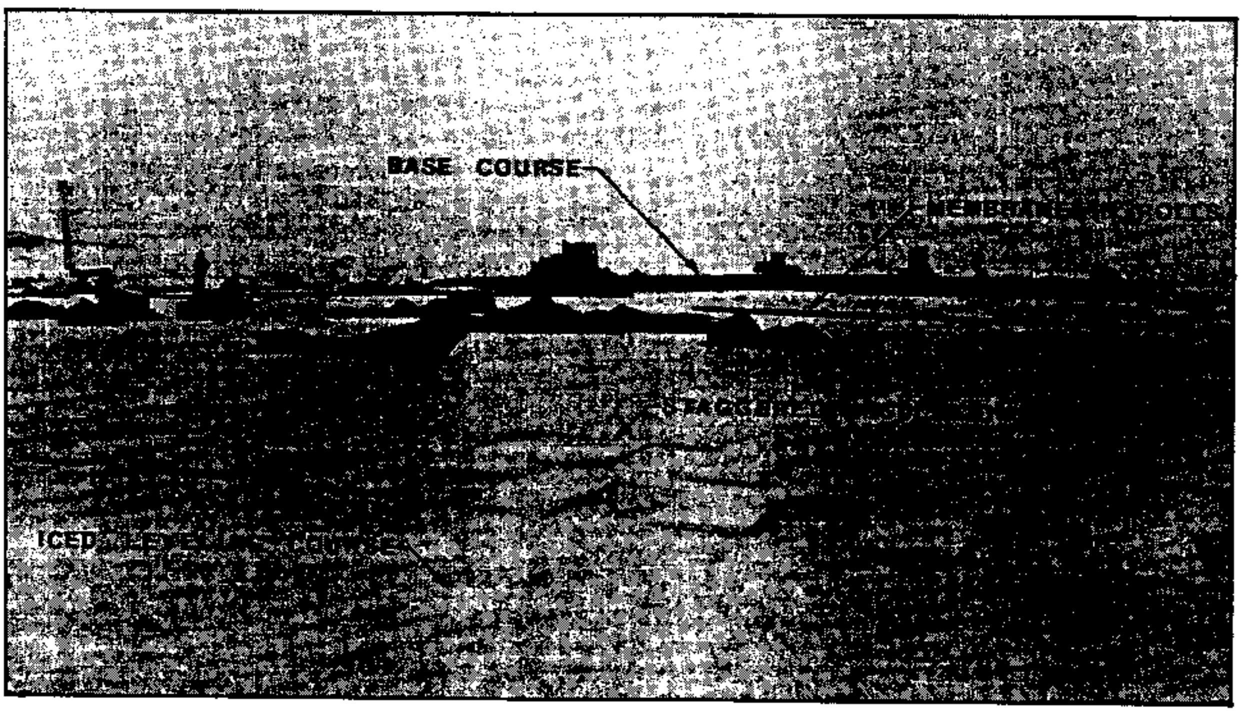

FIGURE NO. 11. PLACEMENT OF INSULATION, MEMBRANE, AND BASE COURSE OVER ICY SUBGRADE

Figure No. 12 shows an overview of the wellsite at the peak of construction. The placement of the insulation, membrane, and gravel courses is nearing completion. Note the borrow areas along Otuk Creek and the pad in the valley above the borrow sites. Please refer to Figure No. 2.

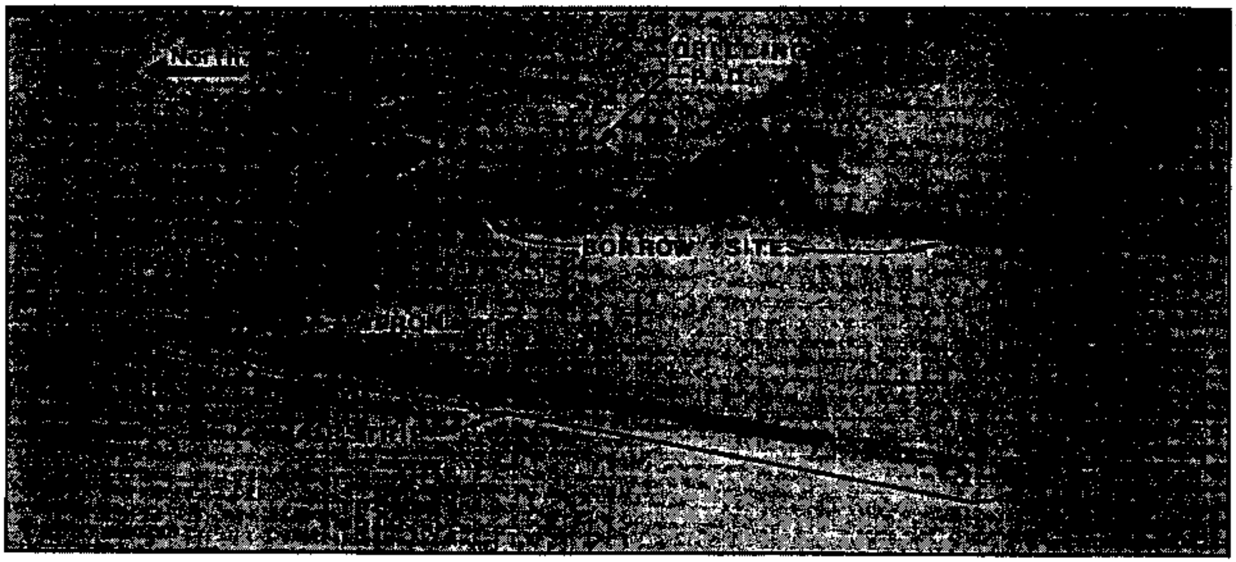

FIGURE NO. 12. OVERVIEW OF AIRSTRIP IN MID-APRIL 1979, LOOKING NORTHEAST

When the airstrip gravel haul was completed, the trucks returned to hauling gravel from the borrow site to the pad. By late April, the trucks were able to backhaul the reserve pit material to the borrow sites for revegetation.

The bridge over Otuk Creek was constructed in late April. Most of the effort was required for the piling and abutments. Carpenters easily assembled the glulam beams and bridge decking. It was completed just before the creek began to flow and melted the ice crossing which the trucks used.

The pad area was completed by May 11. The responsibility for pad and road maintenance was then turned over to the Drilling Department. Figure No. 13 shows the pad later in the summer with the rig in place and the drilling camp in the foreground.

The construction contractor continued to maintain the airstrip through May and June. Although the airstrip remained operational, a number of soft spots developed, some as large as 50 feet in diameter. Both the pit run base course and the crushed surface course contained two troublesome elements: a relatively high content of plastic soil particles and a water content above optimum. As the thaw progressed, the released water was held by the plastic material. This slowed the rate of drying and hampered drainage severely. Test excavations showed that ice had formed just above the insulation in some areas. Water had apparently percolated down from the thawing front and refrozen against the membrane.

Heavy vibratory compaction was necessary to consolidate the gravel and move water upward through the section for better evaporation. A Raygo 400 compactor began the work and was supplemented with a larger Raygo 600 after the thaw began. The larger compactor caused some concern for insulation crushing, so a test section was run on the apron insulation. This test showed that there was no significant damage to the insulation.

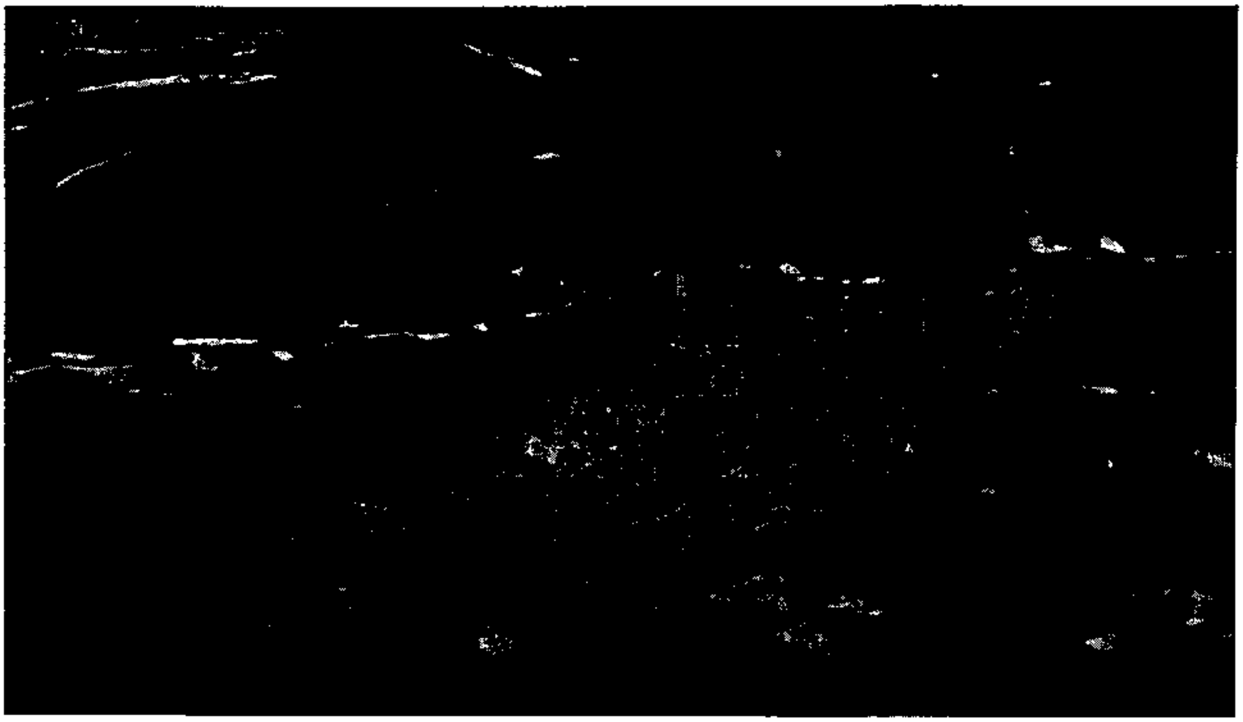

FIGURE NO. 13
LISBURNE PAD IN EARLY SUMMER, LOOKING NORTH

Table 2 shows the number of heavy airlift operations into Lisburne during the 60-day thaw and consolidation period of the runway and apron. Hercules (C-130) aircraft were able to operate through the period, although Electra (L-188) aircraft were not able to land from April 29 to June 28. The Electra's nose wheel was prone to "punching through" and burying itself in soft areas while taxiing. Fortunately this was not a problem during takeoff and landing. The Hercules, which was originally designed for tactical logistics, has a much lighter wheel loading and operates with lower tire pressures. Even so, the Hercules aircraft would cause ruts as deep as 6 inches in some soft spots. When this occurred, restricted operations were placed on the airstrip. Restrictions took two forms. The airstrip might be closed for several hours for heavier maintenance work or the aircraft operator limited the payload of the Hercules occasionally to as low as 50% of rated capacity.

A few of the soft spots were excavated and at the direction of the on-site engineer the material was either manipulated over the runway surface to dry or replaced with dry material. Compactive efforts started along the airstrip centerline and proceeded outward as the centerline consolidated. Gradually, adequate compaction was achieved and airstrip maintenance responsibility was assumed by the Drilling Department in early July.

TABLE 2.
NUMBER OF HEAVY AIRLIFT OPERATIONS* INTO LISBURNE FOR TWO MONTHS AFTER AIRSTRIP COMPLETION

Date	No. of Operations	Comments	Date	No. of Operations	Comments
4/24	5	Start rig move	5/25	10	
4/25	1		5/26	10	
4/26	19		5/27	2	
4/27	27		5/28	3	Poor weather, fog
4/28	3		5/29	0	Snow and fog
4/29	7		5/30	9	Poor weather, fog
4/30	7		5/31	15	
5/1	0	Bad weather, fog	6/1	6	
5/2	6		6/2	5	Poor weather
5/3	36		6/3	12	
5/4	1	Bad weather, fog	6/4	8	Airstrip very soft
5/5	9		6/5	2	Restricted operations
5/6	4	Poor weather	6/6	4	Restricted operations
5/7	4	Poor weather, fog	6/7	3	Restricted operations
5/8	0	Bad weather	6/8	3	Restricted operations
5/9	0	Bad weather, fog	6/9	1	
5/10	0	Bad weather, fog	6/10	6	
5/11	5	Poor weather, fog	6/11	2	Poor weather
5/12	20		6/12	1	Bad weather
5/13	12		6/13	2	
5/14	12		6/14	4	Poor weather
5/15	11		6/15	10	Airstrip excellent
5/16	2	Bad weather, fog	6/16	5	
5/17	0	Bad weather, fog	6/17	6	
5/18	3	Poor weather, fog	6/18	2	Heavy rain
5/19	10		6/19	0	Heavy rain
5/20	8	Poor weather	6/20	0	Heavy rain
5/21	4	Bad weather, fog	6/21	0	Heavy rain
5/22	0	Bad weather, fog	6/22	3	
5/23	7	Poor weather, fog	6/23	4	Restricted operations
5/24	8	Rig move completed	6/24	2	
	Total for Period			371	

* One operation is a landing and a takeoff.

DESIGN PERFORMANCE

The Lisburne wellsite performed very well and no settlement problems were encountered. The rig remained on location until February 1981, although drilling activities ceased in June 1980. The well was drilled to a depth of 17,000 feet.

The airstrip was quite stable after the initial compaction and was relatively maintenance free. The thermal regime was closely monitored by CRREL and thermocouple readings (Figure No. 14) demonstrated that the thaw never penetrated significantly below the insulation. As a further check, a small test pit was dug in the runway on September 9, 1979. A 15 inch square section of insulation was removed. The lower layer was chipped out as the insulation was frozen to the subgrade ice. This would indicate some minor thaw had occurred and later refrozen. The airstrip has since been monitored for two summers and has shown no distress.

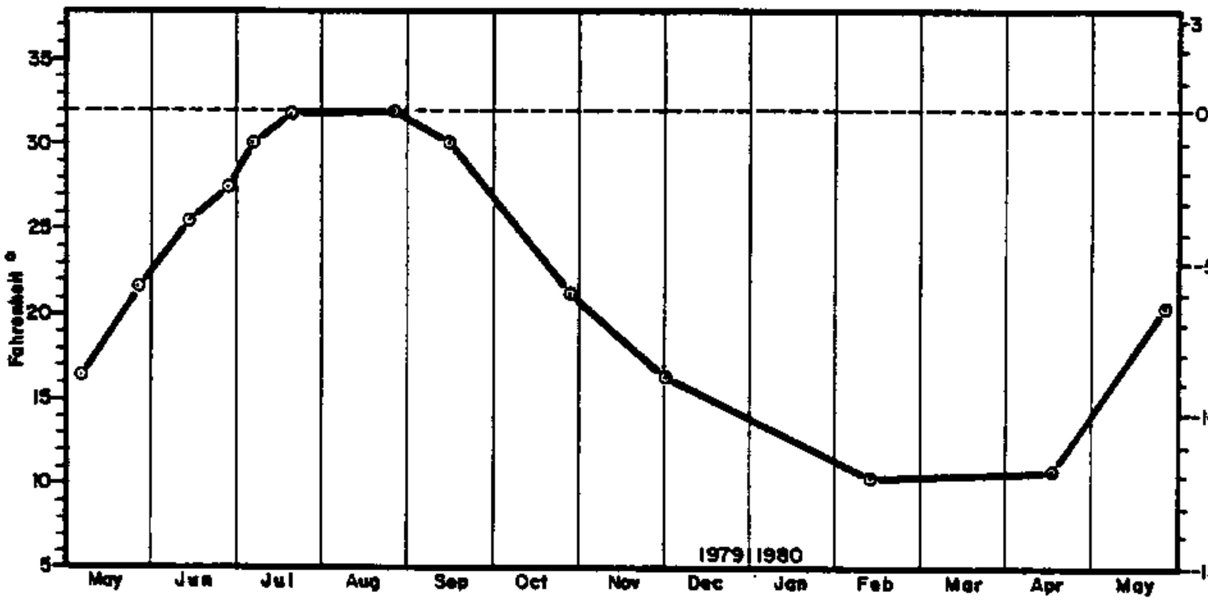

FIGURE NO. 14
TEMPERATURE READINGS AT BOTTOM OF INSULATION

The pad itself also performed well. The surface was loose during the first thaw, but drilling operations were never impaired. A small drainage channel did develop along the exterior toe of the dike on the west edge of the reserve pit. Flowing water penetrated the reserve pit dike near the pad, by piping through an ice wedge, and entered the reserve pit. This condition was corrected by excavating the dike, backfilling with competent soil, and compacting.

Borrow site environmental rehabilitation and revegetation was very successful. During June of 1979, all borrow areas were fertilized and seeded. Inspections during the summer of 1980 showed that the revegetation effort was particularly successful in borrow areas where material from the reserve pit excavation had been spread.

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Other References

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4. Alaska Department of Highways, Control of Permafrost Degradation Beneath a Roadway by Subgrade Insulation, November, 1972.

5. Berg, Richard L., Thermoinsulating Media within Embankments on Perennially Frozen Soil, CRREL Special Report 76-3, Cold Regions Research and Environmental Laboratory, Hanover, New Hampshire, 1976.

6. Burns, Cecil D., Traffic Tests of Expedient Airfield Construction Concepts for Possible Application in the National Petroleum Reserve Alaska (NPRA), Technical Report GL-79-2, Waterways Experiment Station, Vicksburg, Mississippi, March, 1979.

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9. U. S. Department of the Interior, U. S. Geological Survey, Bureau of Land Management, Environmental Assessment, Lisburne Test Well No. 1, Anchorage, Alaska, 1979.

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HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA
SHALLOW EXPLORATION LOG

PROJECT: Lisburne	SHEET 1 OF 1
LOCATION (Coordinates or Station): N. Final Airstrip ℄ Alignment	
DRILLING AGENCY ☐	☐ OTHER
HOLE NO. FIELD 7-79-47-64 PERMANENT Same	NAME OF DRILLER: G. Gould
WEATHER: Windy Clear, 55 °F	
TYPE OF HOLE: TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐ Air Rotary	DEPTH TO:
DEPTH DRILLED INTO:	TOTAL DEPTH OF HOLE: 8'
SIZE AND TYPE OF BIT: 3 7/8" Rock Bit	DATUM FOR ELEVATION SHOWN: ☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT: Mayhew 200	
TYPE OF SAMPLES: Grab/Drive	TOTAL NO. OF SAMPLES: 2
DEPTH TO GROUND-WATER:	STARTED: 8/15/78
DATE HOLE COMPLETED: 8/15/78	
EL. TOP OF HOLE: 1886.5	LOGGED BY: B. Nidowicz
APPROVED BY:	Approved by: HUSKY OIL N P R Ops. Inc. Date

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0				Pt		Dark Brown Fibrous Organics
				OL		Brown to Black Organic Silt
1	73.2	X		12.8% OLI		
2				OL, Vx	2 mm	
3	39.6	X		ML, Vx	2mm	Gray Brown Gravelly w/ trace clay
4						
5						
6					6"	Gray Sandy Silt w/ Occasional Cobbles
7						
8						

31

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA

SHALLOW EXPLORATION LOG

PROJECT: LISBURNE			SHEET 1 OF 1
LOCATION (Coordinates or Station): N. FINAL AIRSTRIP ALIGNMENT			
DRILLING AGENCY: ☐	☐ OTHER		
HOLE NO.: FIELD 7-79-47-62 PERMANENT SAME	NAME OF DRILLER: G. GOULD	WEATHER: CLEAR, WINDY, 35°F	
TYPE OF HOLE: AIR ROTARY — TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐	DEPTH TO	DEPTH DRILLED INTO	TOTAL DEPTH OF HOLE: 7.5'
SIZE AND TYPE OF BIT: 3 7/8" ROCK BIT	DATUM FOR ELEVATION SHOWN: ☐ TBM. ☐ MSL.	TYPE OF EQUIPMENT: MAYHEW 200	
TYPE OF SAMPLES: GRAB	TOTAL NO. OF SAMPLES: 3	DEPTH TO GROUND-WATER	STARTED: 8/14/78 — DATE HOLE COMPLETED: 8/14/78
EL. TOP OF HOLE: 909.5	LOGGED BY: B. NIEWICZ	APPROVED BY:	Approved by: HUSKY OIL N P R Ops. Inc. Date

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0–1				Pt		BROWN FIBROUS SILTY ORGANICS
1–3.5	76.2 173.9	☒ ☒		OL 14.6% OLI		DARK BROWN ORGANIC SILT
3.5–7.5	41.7	☒		SM, Vx		GRAY SILTY SAND WITH SOME COBBLES

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA
SHALLOW EXPLORATION LOG

PROJECT	LISBURNE
SHEET OF	1 1
LOCATION (Coordinates or Station)	N. OTUK CREEK E. BORROW SITE
DRILLING AGENCY	☐ OTHER ☐
HOLE NO.	FIELD 7-79-8-138 PERMANENT Same
NAME OF DRILLER	
WEATHER	CLOUDY
TYPE OF HOLE	TEST PIT ☒ AUGER HOLE ☐ CHURN DRILL ☐
DEPTH TO	
DEPTH DRILLED INTO	
TOTAL DEPTH OF HOLE	4.2'
SIZE AND TYPE OF BIT	
DATUM FOR ELEVATION SHOWN	☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT	PICK, SHOVEL AND BAR
TYPE OF SAMPLES	GRAB
TOTAL NO. OF SAMPLES	1
DEPTH TO GROUND-WATER	3.2'
STARTED	8/27/78
DATE HOLE COMPLETED	8/27/78
EL. TOP OF HOLE	
LOGGED BY:	M. BURST
APPROVED BY:	
Approved by: HUSKY OIL N P R Ops. Inc. Date	

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0				Pt		BROWN FIBROUS ORGANICS
1				GW		WELL GRADED SANDY GRAVEL WITH SOME COBBLES AND SILT
2	12.0	☒		(FIELD MOISTURE)		
3	▽ (groundwater 3.2')					
4						

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA

SHALLOW EXPLORATION LOG

PROJECT	LISBURNE
SHEET	1 OF 1
LOCATION (Coordinates or Station)	N. OTUK CREEK E. BORROW SITE
DRILLING AGENCY	☐ OTHER ☐
HOLE NO.	FIELD 7-79-8-135 PERMANENT SAME
NAME OF DRILLER	
WEATHER	CLOUDY
TYPE OF HOLE	TEST PIT ☒ AUGER HOLE ☐ CHURN DRILL ☐
DEPTH TO	
DEPTH DRILLED INTO	
TOTAL DEPTH OF HOLE	4.8'
SIZE AND TYPE OF BIT	
DATUM FOR ELEVATION SHOWN	☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT	PICK SHOVEL AND BAR
TYPE OF SAMPLES	GRAB
TOTAL NO. OF SAMPLES	1
DEPTH TO GROUND-WATER	3.8
STARTED	8/27/78
DATE HOLE COMPLETED	8/27/78
EL. TOP OF HOLE	1704.4
LOGGED BY:	M. BURST
APPROVED BY:	
Approved by: HUSKY OIL N P R Ops. Inc. Date	

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0						
0–2				GW	12"	GRAY WELL GRADED SANDY GRAVEL WITH SOME COBBLES, BOULDERS AND TRACE SILT.
2.5–3	8.0	☒		(FIELD MOISTURE)		
4.8						
5						

3A.

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA
SHALLOW EXPLORATION LOG

PROJECT	LISBURNE
SHEET / OF	1 / 3
LOCATION (Coordinates or Station)	N. RIG AREA OF E DRILLING PAD
DRILLING AGENCY	☐ OTHER EX SSCo
HOLE NO.	FIELD 7-79-00-151 PERMANENT SAME
NAME OF DRILLER	M. KNIGHT
WEATHER	O'CAST OCC SNOW 13-20°F
TYPE OF HOLE	AIR ROTARY — TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐
DEPTH TO	
DEPTH DRILLED INTO	
TOTAL DEPTH OF HOLE	32'
SIZE AND TYPE OF BIT	4 1/2" ROCK BIT
DATUM FOR ELEVATION SHOWN	☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT	MAYHEW 200
TYPE OF SAMPLES	GRAB
TOTAL NO. OF SAMPLES	2
DEPTH TO GROUND-WATER	
STARTED	10/2/78
DATE HOLE COMPLETED	10/2/78
EL. TOP OF HOLE	
LOGGED BY:	G. LANG
APPROVED BY:	
Approved by: HUSKY OIL N P R Ops. Inc. Date	

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0				Pt		DARK BROWN FIBROUS ORGANICS
1				OL		DARK BROWN ORGANIC SILT
2				OL, Vs		BROWN ORGANIC SILT
3						
4						
5						
6						
7						
8	147			(FIELD MOISTURE)		
9						
10						
11						
12				ICE		CLEAR TO CLOUDY ICE
13						

35.

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA
SHALLOW EXPLORATION LOG

PROJECT	LISBURNE
SHEET 2 OF 3	
LOCATION (Coordinates or Station)	N. RIG AREA OF DRILLING PAD
DRILLING AGENCY	☒ OTHER EXSSCO
HOLE NO. FIELD	7-79-0045
PERMANENT	SAME
NAME OF DRILLER	M. KNIGHT
WEATHER	O CAST OCC SNOW 13-20°F
TYPE OF HOLE	AIR ROTARY; TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐
DEPTH TO	
DEPTH DRILLED INTO	
TOTAL DEPTH OF HOLE	32'
SIZE AND TYPE OF BIT	4½" ROCK BIT
DATUM FOR ELEVATION SHOWN	☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT	MAYHEW 200
TYPE OF SAMPLES	GRAB
TOTAL NO. OF SAMPLES	2
DEPTH TO GROUND-WATER	
STARTED	10/2/78
DATE HOLE COMPLETED	10/2/78
EL. TOP OF HOLE	
LOGGED BY:	G. LANG
APPROVED BY:	
Approved by: HUSKY OIL N P R Ops. Inc. Date	

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
13–23				ICE		CLEAR TO CLOUDY ICE
23–25				OL, Vx		BROWN ORGANIC SILT
25–				SH		BROWN GRAY SILTY SHALE BEDROCK

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA
SHALLOW EXPLORATION LOG

PROJECT: Lisburne	SHEET 3 OF 3
LOCATION (Coordinates or Station): N. Rig Area of E. Drilling Pad	
DRILLING AGENCY ☐ ☒ OTHER: Ex SSCo	
HOLE NO. FIELD: 7-79-00-151 PERMANENT: Same	NAME OF DRILLER: M Knight
WEATHER: O'cast Occ. Snow 13-20°F	
TYPE OF HOLE: Air Rotary — TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐	DEPTH TO: — DEPTH DRILLED INTO: — TOTAL DEPTH OF HOLE: 32'
SIZE AND TYPE OF BIT: 4 1/2" Rock Bit	DATUM FOR ELEVATION SHOWN: ☐ TBM. ☐ MSL.
TYPE OF EQUIPMENT: Mayhew 200	
TYPE OF SAMPLES: Grab	TOTAL NO. OF SAMPLES: 2
DEPTH TO GROUND-WATER:	STARTED: 10/2/78 DATE HOLE COMPLETED: 10/2/78
EL. TOP OF HOLE:	LOGGED BY: G. Lang
APPROVED BY:	Approved by: HUSKY OIL N P R Ops. Inc. Date

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
26				Sh		Brown Gray Silty Shale Bedrock.
27						
28						
29						
30	16.0			(Field moisture)		
31						
32						

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA

SHALLOW EXPLORATION LOG

PROJECT: LISBURNE — SHEET 1 OF 2

LOCATION (Coordinates or Station): N. DRILL PAD E.

DRILLING AGENCY ☐ ☒ OTHER Ex SSCo

HOLE NO.: FIELD 7-79-00-156 PERMANENT SAME

NAME OF DRILLER: M. KNIGHT

WEATHER: OVERCAST 13°-20° F

TYPE OF HOLE: AIR ROTARY — TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐

DEPTH TO:

DEPTH DRILLED INTO:

TOTAL DEPTH OF HOLE: 17'

SIZE AND TYPE OF BIT: 4 1/2" ROCK BIT

DATUM FOR ELEVATION SHOWN: ☐ TBM. ☐ MSL.

TYPE OF EQUIPMENT: MAYHEW 200

TYPE OF SAMPLES: GRAB

TOTAL NO. OF SAMPLES: 1

DEPTH TO GROUND-WATER:

STARTED: 10/2/78

DATE HOLE COMPLETED: 10/2/78

EL. TOP OF HOLE: 1839.0

LOGGED BY: G. LANG

APPROVED BY:

Approved by: HUSKY OIL N P R Ops. Inc. Date

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
0–0.5				Pt		DARK BROWN FIBROUS ORGANICS
0.5–2				OL		DARK BROWN ORGANIC SILT
2–5				ICE		CLEAR ICE
5–10	276	☒ (6–8)		OL, Vs		BROWN ORGANIC SILT
10–12				ICE		CLEAR ICE
12–				OL, Vs		BROWN ORGANIC SILT

HUSKY OIL

N P R Operations, Inc.
ANCHORAGE, ALASKA

SHALLOW EXPLORATION LOG

PROJECT: LISBURNE			SHEET 2 OF 2
LOCATION (Coordinates or Station): N. DRILL PAD E.			
DRILLING AGENCY: ☒ OTHER EXSSCO			
HOLE NO. FIELD 7-79-00-156 PERMANENT SAME	NAME OF DRILLER: M. KNIGHT		WEATHER: OVERCAST 13-20°F
TYPE OF HOLE: AIR ROTARY. TEST PIT ☐ AUGER HOLE ☐ CHURN DRILL ☐	DEPTH TO	DEPTH DRILLED INTO	TOTAL DEPTH OF HOLE: 17'
SIZE AND TYPE OF BIT: 4½" ROCK BIT	DATUM FOR ELEVATION SHOWN: ☐ TBM. ☐ MSL.		TYPE OF EQUIPMENT: MAYHEW 200
TYPE OF SAMPLES: GRAB	TOTAL NO. OF SAMPLES: 1	DEPTH TO GROUND-WATER	STARTED: 10/2/78 DATE HOLE COMPLETED: 10/2/78
EL. TOP OF HOLE: 1839'	LOGGED BY: G. LANG	APPROVED BY:	Approved by: HUSKY OIL N P R Ops. Inc. Date

DEPTH FEET	% WATER CONTENT	SAMPLE NO.	SOIL LEGEND	CLASSIFICATION	MAX SIZE PARTICLE	FORMATION DESCRIPTION & REMARKS
13						
14				OL, Vs		BROWN ORGANIC SILT
15						
16						
17						

LAKE BETTY EQUIPMENT

April 1978 to January 1979

Quantity	Description
1	D-7 Dozer with Winch
2	966 Loaders
2	Delta All Terrain Vehicles (15 ton)
2	Arctic Water Vans
1	12G Grader
2	Nodwell Service Vehicles
2	End Dumps
1	JD 450 Dozer
2	Tucker All Terrain Personnel Carriers
7	Fuel Tanks, 81,000 gallons total capacity
1	Generator Car on Skis
1	Office Car on Skis
1	Kitchen Car on Skis
1	Diner Car on Skis
1	Wash Car on Skis
6	6-person Sleeper Cars on Skis

LISBURNE EQUIPMENT LIST

Peak of Construction

Quantity	Description
4	D-8 Dozers with Rippers
2	D-7 Dozers with Winch
1	988 Loader
4	966 Loaders
2	12G Graders
1	Delta All Terrain Vehicle (30 ton)
4	Delta All Terrain Vehicles (15 ton)
12	End Dump (16 cubic yard)
3	Arctic Water Vans
1	Watson 2000 Earth Auger
1	Crushing Plant with 54" Cone Crusher
1	20 ton Crane
4	Nodwell Service Vehicles
7	Pickups
7	Light Towers
2	Heavy Hauling Sleds
6	Tucker All Terrain Personnel Carriers
5	Compactors
1	JD 450 Dozer
2	Herc Lowbed Trailers
6	Fuel Tanks totaling 120,000 gallons
3	Generator Cars
1	Kitchen Car
2	Diner Cars
3	Wash Cars
2	Office Cars
31	6-person Sleeper Cars
1	Incinerator

APPENDIX III
ABBREVIATED DAILY REPORTS FROM BETTY LAKE/LISBURNE CONSTRUCTION

12/21/78
Betty Lake: Two Beavers (BLM & Const.) arrived with three mechanics and laborers. Will start generator and water van and stay night. Will put in Otter strip as soon as possible. Communications are poor without Knifeblade repeater. Picked shortest day of the year.

12/22/78
Betty Lake: Four people remained overnight. Camp opening up. Ice thickness measurements due today.

12/23/78
Betty Lake: Otter strip in, ready for Otter. Lighting going in. Poor visibility yesterday. 40" at near end of lake - much better than expected.

12/27/78 -34 at Betty Lake (BTL)
Betty Lake: Otter positioned at Lonely coming with lights today. Otter should base down here tonight. Clearing snow for Herc strip.

12/28/78
Blowing snow; 30-35 knot winds. Zero to 1-mile visibility. Betty Lake: Otter strip lights in. Clearing Herc strip.

12/29/78 +31/BTL
Betty Lake: 50% of Herc strip cleared.

1/2/79
Warm and flyable/Betty Lake: Strip cleared. Putting in Herc lighting. 30" ice in center of lake - need cold weather. Staking trail to Lisburne. Close water source lakes frozen.

1/3/79 Warm, clear, 7 mile visibility
Betty Lake: Snow removal and setting up location. Checking more water sources at Lisburne site today.

1/4/79 +31/BTL
Betty Lake: No contact this morning.

1/5/79 +25/BTL
Betty Lake: Lisburne water source visited by Construction Foreman (3' ice/42" water, 30" water).

1/8/79 -5/BTL
Betty Lake: Waiting freeze down of ice, may need Otter fuel haul.

1/9/79
Betty Lake: Waiting Herc strip freeze down.

1/10/79 -10/BTL
Betty Lake: Otter fuel lift starting pumping operation.

1/11/79 -17/BTL
Betty Lake: Pumps coming in from Prudhoe Bay.

1/12/79 +20/BTL
Betty Lake: Pumps arrived today. Ottering fuel - 4,200 gal. yesterday.

1/15/79 +14/BTL
Betty Lake: Stationing survey party at Lisburne. Warm temperatures hampering flooding efforts; average thickness - 39 inches.

1/16/79 +10/BTL
Betty Lake: Pumping water to help build ice on lake. Need cold weather.

1/17/79 +20/BTL
Betty Lake: Pumping water, freezing slowly in warm temperatures. Will check Smith Mountain Lake for 5,000' frozen to bottom.

1/18/79 +15/BTL
Betty Lake: Watering Herc strip. Checked Smith Mountain Lake - 41" ice with water.

1/19/79 +10/BTL
Lisburne/Betty Lake: Watering ice strip, staking Herc strip at Lisburne.

1/22/79 Blow yesterday; poor weather today, +2/BTL
Betty Lake: 42" average thickness after some cold weather this weekend. Continuing watering. Surveyors at Lisburne.

1/23/79 +19/BTL
Betty Lake: Pumping operating going; waiting on ice.

1/24/79 +19/BTL
Betty Lake: Pumping on Herc strip, 42" average.

1/25/79 -2/BTL
Betty Lake: Pumping and hauling water to thicken lake ice.

1/26/79 -30/BTL
Betty Lake: Estimate 6-7 days to complete airstrip. Average ice depth 43.5".

1/29/79 -29/BTL
Betty Lake: Put in runway lights on Wednesday; 45" average thickness; 42" minimum.

1/30/79 -37/BTL
Betty Lake: Herc lights going in tomorrow. Strip check possible by Friday.

1/31/79 -38/BTL
Betty Lake: Putting in runway lights.

2/1/79 -50/BTL
Betty Lake: Runway lights in today. Airstrip average 48 1/2"; low of 45".

2/2/79 -55/BTL
Betty Lake: Pump and 2 Delta's working in spite of cold. Runway lights in. Ready for strip check today as soon as weather permits.

2/5/79 -42/BTL
Betty Lake: Strip open; Herc's coming in. Working on weather shack and generator.

2/6/79 -42/BTL
Betty Lake: Lighting in; herking in by day; should pick up as South Meade to East Simpson rig move completes.

2/7/79 +8/BTL - wind gusting
Betty Lake: Herc's coming in; wind beginning to gust. Assembling mobilized equipment; preparing for overland move to Lisburne.

2/8/79
Betty Lake: First 10 loads into Betty Lake - minus one load on skis. The earth satellite station will be moved north on Monday, February 12. There are a total of 33 people at Betty Lake.

2/9/79
Betty Lake: Thirteen Herc loads in last 24 hours. Putting Herc refueling system in.

2/12/79 -9/BTL
Betty Lake: Ice fog closed airport 1400 to 2100 hours. Eight loads in yesterday; readying for overland move; 50 loads moved so far.

2/13/79 -30/BTL
Betty Lake: RCA dish received at 11:00 p.m. Projecting Thursday move of Cat Train to Lisburne.

2/14/79 -32/BTL
Betty Lake: RCA dish moving to Lisburne. One Herc moving equipment; assembling equipment.

2/15/79 +2/BTL
Betty Lake: Weather down, 1/2 mile visibility in blowing snow. Five Herc loads last 24 hours. RCA dish approaching Lisburne; weather hampering operation.

2/16/79
Betty Lake: Advance crew will arrive site today. Big move to Lisburne scheduled for Monday.

2/20/79 -11/BTL
Betty Lake: Began overland move to Lisburne. Small camp at Lisburne being utilized for survey and RCA dish installation.

2/21/79 +12/BTL
Lisburne: Cat Train will arrive from Betty Lake today. Surveyors laying out location.

2/22/79
Lisburne: Cat Train arrived and began ripping in borrow pit. Camp set up. Shutting down fueling operation at Betty Lake. Hauling miscellaneous equipment over trail. Awaiting completion of telephone installation.

2/23/79
Lisburne: Phone is working. Will work night shift tonight. Initial ripping is going well. Improving winter trail to water source.

2/26/79
Lisburne: Otter strip open; 300 loads of gravel; ripping borrow site; trail from camp to Otter strip; no communications from Betty Lake to Lisburne (phone). Surveyors working in reserve pit area. 94 people in camp. 26,000 gal. diesel; 3,500 gal. Mogas.

2/27/79
Lisburne: Mobilization road to airstrip and apron area hauled out today. Proceeding with haul to runway today. Otter strip in.

2/28/79 -14/BTL
Lisburne: Apron subgrade - 80% of gravel hauled. Hauling to airstrip. Will build Otter strip section first. Improving trail to potable water source.

3/1/79 -23/BTL
Lisburne: Hauling gravel to runway; 403 truck loads hauled yesterday; 1,994 loads hauled to date; about 1/2 day's worth of material stockpiled. Cats continuing to rip.

3/2/79 -27/BTL
Lisburne: Temporary gravel Otter strip may be activated this weekend. 392 truck loads to Herc strip. Ripping in borrow pit.

3/5/79 -46/BTL
Lisburne: Job shut down today due to cold; equipment breaking down; hauled gravel over weekend; gravel Otter strip nearly operational.

3/6/79 -29/BTL
Lisburne: 40,000 yards hauled to date. Compaction gear having problems in cold weather. Small fire in service unit on Nodwell. Will install Otter lights tomorrow. Medivac last night - heart attack victim - in serious condition at Providence Hospital this morning.

3/7/79 -21/BTL
Lisburne: Otter strip should open late today. Gravel cover to Station 44. Hauling water to Herc strip.

A62

3/8/79 -31/BTL, calm
Lisburne: Hauled 379 loads to airstrip yesterday.

3/9/79 -30/BTL
Lisburne: Gravel - 6 trucks, 196 loads; east side runway at 44+00; west side runway at 57+00; Otter strip lights in; NDB ground checked; survey crew working on pad and Herc strip.

3/12/79 -38/BTL
Lisburne: Completed gravel haul for mobilization strip. Try for strip check on Friday. Hauling gravel for pad road. Surveyors laying out dikes. Out of 4 compactors, only grid roller working. Generator and 8-man survival down. 3,500 gal. Mogas - tank leaks. Drilling crew for blasting due in today. Betty Lake has 25,000 gal. diesel; 6,000 gal. Mogas.

3/13/79 -43/BTL
Lisburne: Finished gravel haul to mobilization strip; icing. Runway light crew in today. Access road 900' from drill pad. Continuing ripping in Borrow Site #8.

3/14/79 -34/BTL; -32 at Lisburne (LISB)
Lisburne: Working on airstrip overruns, installing lights. Strip check may be made on Friday morning. Pad road subbase - 100%; Drill pad, 1,928 cubic yards - 80,000 cubic yards left in Borrow Pit #8. Mechanical problem with test shot equipment. 40 pallets HI-35 1-1/2" delivered from Betty Lake. Surveyors on pad area. Need well coordinates. Betty Lake has 22,000 gal. diesel; 5,600 gal. Mogas.

3/15/79 -34/BTL
Lisburne: 4,216 c.y. gravel hauled to date on pad dikes; 6,084 c.y. to date on road to pad. Starting on dike insulation today. Runway lights complete tonight. Strip check tomorrow.

3/16/79 -38/BTL; -30/LISB
Lisburne: Roads - 22%; Airstrip 26%. Strip check today. Runway lights in. Communications to hook up weather shack. Drilled 126 holes for blasting test. Hauled 5,800 c.y. to pad for reserve pit dikes. 130 people on site.

3/19/79 -30 and clear in most areas
Lisburne: 24 Herc and Electra loads yesterday. 441 loads gravel to pad. Hauling out of test shot area in reserve pit.

3/20/79 -39/LISB
Lisburne: 17,864 yards of gravel hauled to pad to date. Also hauling from reserve pit into pad. Unloading aircraft continues, over 60 heavy loads in since Saturday morning.

3/21/79 -39/LISB, clear, wind forecast to pick up
Lisburne: Airlift continuing. 256 loads gravel to pad. 259 loads reserve pit material also hauled. Excavating flare pit.

3/22/79 -15/LISB, calm
Lisburne: 299 loads gravel to pad; 370 loads reserve pit to pad, averaging 75% usage on trucks; 3 D-8's ripping borrow pit; 1 D-8 ripping in reserve pit; opening Borrow Pit section #7. Powder for shooting reserve pit arrived last night.

3/23/79 +23/LISB, 17 knot winds
Lisburne: Airlift continuing 29 loads yesterday. 446 loads gravel to pad; 202 loads from reserve pit, blast last night very successful.

3/26/79 +26/LISB, warm and windy
Lisburne: Warm temperatures. Continue to shoot reserve pit. 375 loads of gravel to pad yesterday - 36,000 to date. 207 loads from reserve pit yesterday - 8,000 to date. Laying insulation on pad areas. Crusher in operation, meeting specifications. 160 heavy airlift loads to date.

3/27/79
Lisburne: Beacon out. Weather down. 4,871 cubic yards borrow to pad. 1,401 loads reserve pit to pad. 11,000 cubic feet insulation drill pad 68,000 to date. Hauling from Borrow Pit #7. Crusher operation underway. Drilled weather shack piles and pad pile holes.

3/28/79
Lisburne: Blasting for reserve pit. Borrow for drill pad - 41,900 cubic yards; reserve pit to spoil - 7,677 cubic yards; reserve pit to pad -10,674 cubic yards. Setting insulation pallets along runway. Developing Borrow Pit #7. Drilling for piles on bridge 3 holes to date.

3/29/79 +2/LISB
Lisburne: Heavy airlift continues. 361 loads borrow pit to pad - 44,000 cubic yards to date. 11,600 cubic yards reserve pit to pad to date. Shot more of reserve pit. Crusher running; material within specifications. Ripping Borrow Pit #7.

3/30/79 +10/LISB
Lisburne: Airlift continues. 665 loads from reserve pit to pad; 92 loads from reserve pit to borrow pit. Pad work progressing well. 144 people on site. 187,000 gal. diesel fuel on site. Preparing to close airstrip today.

4/2/79 -18/LISB
Lisburne: Heavy airlift over. Herc strip shut down. Otter strip operational. Roads - 35%; Airstrip - 38%; Drill Pad - 58%. Hauled 3,000 yards to airstrip; crushed 1,500 cubic yards; hauled reserve pit material to pad. Starting piling at pad.

4/3/79 -14/LISB
Lisburne: 64% crushed; going well. Laying insulation and base course on airstrip. 61% of reserve pit excavated. 75% of gravel hauled to pad. 27 holes in on piling. RCA dish and weather shack being relocated onto piling.

4/4/79 +9/LISB, light snow, calm
Lisburne: 72% crushed out; 17,000 cubic yards hauled on airstrip base course to date; 76% borrow placed on pad; 57% on reserve pit; 17% drilled on piling.

4/5/79 +23/LISB
Lisburne: Hauling borrow to airstrip and pad; slurrying bridge piling; RCA dish moved. Borrow Pit #7 producing very good material. 31% on gravel airstrip subbase. 22% on drilling piling for rig.

4/6/79 +5 LISB, clear and calm
Lisburne: Bridge piling 90% installed; beginning to set some rig piling. Placed airstrip insulation and hauled gravel to strip. Hauled to pad.

4/9/79 -34/LISB
Lisburne: Placing insulation and gravel on runway. Crushing nearing completion. Camp pad nearing insulation subgrade line. 53% on airstrip insulation; 53% on airstrip base course, 84% on crushed gravel, 79% on borrow to pad haul; 69% on reserve pit to pad; 45% on drilling piling.

4/10/79 27/LISB
Lisburne: Piling 51% drilled, rock at 60 ft., slurry 39%. 55% on airstrip insulation; 57% on airstrip base course; 85% on crushed gravel; 80% on borrow to pad haul; 73% on reserve pit to pad.

4/11/79
Lisburne: Blasting in reserve pit - should finish Friday. Crushing should finish tonight. Working on Herc strip and taxiway - complete Sunday. Laying insulation on drill pad one drill on piling. Drill pad excavation - 84%; Borrow Pit - 82%; Piling - 6 drilled, 123 to date - 54%; Piling set and slurried - 27 - 112 to date - 48%.

4/12/79
Lisburne: Working Aliquot #4, laying out #6, finish drilling reserve pit today, drilling for rig piling, installing caps on bridge piling, crushing completed. All 12 trucks hauling on airstrip. Airstrip insulation and membrane - 32,490 today; 586,390 to date - 64%. Airstrip top course -3,555 today; 46,430 to date - 67%. Airstrip crushed 2,300 today; 24,000 to date; 100%. Airstrip surface material - 540 today; 2,943 to date -9%. Drill pad reserve pit excavation 2,500 today; 68,500 to date - 88%. Drill pad borrow 27 to date - 9%. Piling drilled - 15 today, 138 to date - 60%. 48 piling set and slurried for bridge; 17 capped to date.

4/16/79 -27/LISB
Lisburne: Betty Lake completely shut down. Start to place crushed course on runway. Expect to shoot conductor hole tonight. Placing insulation in apron area. 90% of the base course on airstrip. Reserve pit nearing completion. Beginning to insulate camp pad area, continuing to drill piling.

4/17/79 -18/LISB
Lisburne: Insulating drill pad. Shot conductor hole last night, drilling and shooting finished, hauling to road and pad. Working on reserve pit slopes and gabions. 94% on airstrip insulation. 93% on base course. 37% on crushed course. Working on bridge.

4/18/79 +7/LISB
Lisburne: 99% on reserve pit, sloping and shaping remain; 100% on airstrip insulation; 97% on airstrip base course; 50% on airstrip crushed course; 87% on piling drilling; 76% on piling slurry; insulating camp level and erecting bridge.

4/19/79
Lisburne: 38% on road bridge to airstrip; 100% on base course; 82% on borrow to pad; 29% on drill pad insulation; 89% drilled on piling; 77% slurried; 50% on bridge. Dressing borrow sites.

4/20/79 +21/LISB
Lisburne: Drilling pilot hole for conductor, strip check tomorrow morning. Laying insulation and gravel on pad. Started rehab on borrow pits.

4/23/79 +22/LISB
Lisburne: Airstrip completed. Thaw prevented opening strip. Refrozen today. Hauling from Borrow Pit #7. Moved mechanics shop area up on apron. Winds prevented insulation placement yesterday. 91% complete on piling. Conductor hole shot again, 70.3' down with 26" pilot hole. Hard drilling. Bottom 38' in rock. 60% complete on bridge.

4/24/79 +31/LISB, gusty
Lisburne: High winds yesterday. Strip checked by Electra operator. Heavy turbulence for aircraft last night. Fuel skid being hooked up. Water haul road softening up. Hauled 3,000 cubic yards on road from bridge to apron 48% on roads. Bridge decking begins today. 87 ft. of 26 inch pilot hole down on conductor pipe excavation.

4/25/79
Lisburne: Electra buried nose wheel in runway. Hercs still operating in. No insulation placed due to high winds. Drilling conductor; will shoot again. 80% on bridge. Hauling material for reserve pit slopes. High winds hampered operations.

4/26/79 +20/LISB, winds down, clear
Lisburne: Received fuel last night. Also received Hercs. Hauling to road - apron to bridge. Hauled 2,300 cubic yards to pad - 81%. Hauled reserve pit material to borrow. Pad insulation at 50%. Drilled piling -92% complete. Conductor 52" to 51', 26' to 89', shot holes to 95'. Job at 83.2%, bridge nearly 100%.

4/27/79 +30/LISB
Lisburne: Having trouble with winds and insulation laydown. Hauling on road - bridge to apron. Hauling borrow to reserve pit slopes. Sprung conductor hole last night. Having trouble keeping hole straight at 86' depth. Dressing borrow sites. Camp full. Ramp full of airplanes.

4/30/79 +26/LISB
Lisburne: Roads 83.9%; 94% complete on borrow to pad; 84% complete on insulation and membrane on pad; 92.1% complete on pad. Conductor hole drilling complete. 63% on piling. Overall job - 89.6% complete. Maintaining airstrip.

5/1/79
Lisburne: Hauling borrow to drill pad. Reserve pit material to borrow. Placing insulation and membrane - 85%. Cellar box in. Lisburne Otter stuck at Lonely due to weather.

5/2/79
Lisburne: Need another self-propelled roller badly; placing pipe in conductor hole; hauling reserve pit to borrow; borrow to pad. Compacting airstrip.

5/3/79
Lisburne: Lots of airlift, rig, and water in yesterday. High was +51 yesterday. Working in piling area. Hauling borrow to pad and reserve pit to borrow. Starting wind-down of job. Roads - 85%. Airstrip - 97%; compacting; Reserve Pit - 95%; Borrow to Pad - 94%; Drill Pad - 95%; Piling - 85%. Starting insulation of conductor pipe.

5/4/79 +22/LISB, 1 mile - 200', ground fog. Light snow last night; wind at 2 mph
Lisburne: Airstrip - 100%; Drill Pad - 96%; Piling - 98%; Conductor Pipe - 30%; Bridge - 100%. Road to pad needs 10K cubic yards. Road to airstrip 100%. Crew reduction delayed due to weather. BLM man on site - will start Monday. Seismic employee burned - medivaced to Fairbanks by site Otter with medic. Removing soft spots in runway and apron -good for Herc but not for Electra. Gravel hauled to reserve pit blanket -70% complete. Reserve pit excavation complete today. Insulation on drill pad complete today. Otuk River flowing full width - approximately one foot deep.

5/7/79 +20/LISB
Lisburne: Manpower reducing as work winds up. Hauling borrow to drill pad and reserve pit. Compacting airstrip. Setting conductor.

5/8/79 +18/LISB
Lisburne: Working over soft spots on runway. Hauling to road 73%. Hauling to pad 99%. Reserve pit complete. Drill pad 99.5%. Piling - working on caps - 78% capped. Conductor pipe 100%

5/9/79 +21/LISB, fog and snow
Lisburne: Working on runway; hauling material to road and pad; drill pad - 99.5%; piling complete; finishing bridge deck. Road will be complete Saturday.

5/10/79 +15/LISB, fog and low overcast
Lisburne: Working on runway; strip in excellent shape due to cold weather. Bridge complete. Hauling on road to pad.

5/11/79 +14/LISB
Lisburne: Road will finish tomorrow; Herc strip in excellent shape. Hauled out drill pad; finish dressing pad.

5/12/79 +17/LISB
Lisburne: Dressing borrow pits and maintaining airstrip. Hauling construction equipment to Lonely.

5/15/79 +32/LISB
Lisburne: Maintaining airstrip; shipping equipment out. Providing subsistence support to drilling for rig move.

5/16/79 +26/LISB
Lisburne: Maintaining road and runway. Backhauling excess material and equipment.

5/17/79 +24/LISB with fog
Lisburne: Finish dressing borrow pits; maintaining airstrip; cleaning up.

5/18/79
Lisburne: Socked in solid. Cleaning up. Dressing borrow sites completed.

5/21/79 +29/LISB, runway fogged in
Lisburne: Maintaining airstrip and road. Shipping out equipment to Umiat.

5/22/79
Lisburne: Fogged in. Maintaining runway. Providing crane to drilling for rig up.

5/23/79
Lisburne: Fogged in. Maintaining airstrip and road. No Hercs yesterday.

5/24/79
Lisburne: Runway closed for maintenance until 10:00 a.m.

5/25/79 +47/LISB
Lisburne: Maintaining runway. Working on runway lighting.

5/29/79 2" snow at Lisburne, fogged in
Lisburne: One Herc in last 24 hours; runway still maintenance problem. Getting loads ready for backhaul to Lonely.

5/30/79 +23/LISB, fogged in
Lisburne: Maintaining airstrip. Equipment ready for backhaul.

6/1/79
Lisburne: Hauling out construction equipment to Lonely; maintaining strip.

6/2/79
Lisburne: Maintaining airstrip. Airstrip operation suspended today due to soft spots. Extremely moist material on top of insulation.

6/5/79
Lisburne: Construction equipment backhaul all out. Working on soft spots.

E2.

6/6/79 +49/LISB
Lisburne: Herc strip open. Soft spots being patched. Heavier compactor needed.

6/7/79
Lisburne: Working on runway; trying to get it to tighten up.

6/8/79 +65/LISB
Lisburne: Maintaining runway. Herc operator closed runway at 3:00 a.m. due to soft spot. Should reopen this morning.

6/11/79
Lisburne: One soft spot left in center of strip airstrip in good shape. Insulation cleanup is out approximately six miles from the pad. BLM man on site yesterday.

6/12/79
Lisburne: High winds grounded insulation pickup.

6/13/79 +28, 3" of snow and still snowing
Lisburne: Insulation camouflaged no cleanup. Working on runway. Test coupon of insulation under runway recovered - no damage from RAYGO 600 Compactor.

6/14/79
Lisburne: Continue apron repair and work on airstrip. Electra operator O.K'd strip yesterday (strip better than Lonely). Drilling holes for CRREL test section.

6/15/79 +47/LISB
Lisburne: Runway in excellent condition. Apron being worked on. GSI completed drilling thermocouple holes for CRREL test section. Single engine Otter in to move fuel for USGS.

6/18/79 +46/LISB
Lisburne: Received one load mud, 6 loads pipe. Worked on apron and runway. Insulation cleanup approximately 8 miles out. Need slope protection on reserve pit dike.

6/19/79 +42/LISB, 1/2" rain
Lisburne: Heavy rain softened strip; requesting reduced usage next 24 hours.

6/20/79 Rain at Lisburne 1/4" last 24 hours.
Lisburne: Very wet; holding airstrip, but request priority Herc traffic only. Otuk Creek flowing strongly.

6/21/79
Lisburne: More rain. Trimming site force. Maintaining airstrip and cleanup. CRREL installing additional thermocouples.

6/22/79 +42/LISB, rain and fog
Lisburne: Maintaining airstrip. Still raining 1/4" last 24 hours.

6/25/79
Lisburne: More rain - 0.4" period ending at 4:00 p.m. yesterday; 0.42" since then. Working on runway with compactor. No Herc traffic yesterday due to weather. Strip open to Herc traffic.

6/26/79 +29/LISB, snow
Lisburne: Maintaining airstrip more precipitation. Airstrip holding o.k.

6/27/79 Light snow at Lisburne
Lisburne: Runway wet; maintaining o.k.

6/28/79 Lisburne down
Lisburne: Marginal weather. No heavy aircraft, so reworking airstrip. One or two soft spots need to be worked out.

6/29/79
Lisburne: Electra strip check o.k. Massaging remaining soft spots. Working on apron.