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THRU: John R. Totter, Director, DBM

John R. Totter

TRIP TO THULE, GREENLAND, JANUARY 23 TO FEBRUARY 3, 1968, IN CONNECTION WITH B-52 CRASH, JANUARY 20, 1968

The request came Tuesday, January 23, at 10 a.m., from Mr. Winter, Deputy Director, Division of Military Application. He had spoken to Mr. Hollingsworth who, while agreeing that Wright Langham was the expert in Pu contamination problems wanted a man from his staff, preferably an M.D., to be at the site. A Danish scientific team proceeding at the same time from Copenhagen to Thule was thought to be medically oriented, but this turned out to be incorrect. Since Dr. Storer was already slated for Japan, I cancelled appointments, got my passport, some money and clothes, and reported to the Pentagon by 2 p.m. In Dr. Walske's office, Dr. Langham, who had come in from Oak Ridge, and I were briefed on the situation, as it was then known, and on the members of the Danish team.

After a short visit with General Scott who pointed out how very important it was for the crash to be taken care of properly, promptly and thoroughly, Colonel Moore and Colonel Shwiler furnished us with orders, took us to Andrews Air Force Base, got our cold weather equipment, and put us on an executive plane to McGuire Air Force Base. We were to have taken off next morning at 6 p.m. for Thule, but bad weather there caused the flight to be cancelled. A Colonel C. S. Dresser, was also waiting for this flight, and when we learned that he was the Commanding Officer of Thule Air Force Base returning from leave, we took advantage of the 24 hour delay to learn as much as possible about Thule. Thus, we were instructed about "Phases" the local name for wind storms off the ice cap. The characteristic of a Phase is that fine ice crystals are blown horizontally so as to fill the air and create the "white out" in which one promptly gets lost and freezes to death. Also, the velocity of the wind rapidly increases the "Chill Index" so that the normal -20° F to -40° F during the winter months has the cooling effect of something like -75° F or so. A man's bare hand will freeze solid under such circumstances within a minute. Annex I gives the safety procedures which are obeyed to the letter when the base intercoms and radio give warnings of Phases. A Phase can develop within fifteen minutes, but usually they are forecast about six hours in advance. Note is made of Phases because they condition all activities on the base. Throughout, the first consideration was

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that the base personnel not be put at risk. It is because of these sudden-death storms that the native Greenlanders (eskimos) build a small igloo whenever they make a rest stop; apparently they can read the weather signs as accurately as the meteorologists.

Thule is 76° 30' North and 68° 30' West, about 800 miles South of the North Pole, so that during January there is little or no light except for a light tinge of pink on the southern horizon that slowly fades into the sharp blackness of the nearly starless polar sky. As shown on the daylight-darkness chart (Figure I), the shift from total darkness to total daylight occurs rapidly. The early stages of the investigation and clean-up had to be made in near total darkness.

The fully-fueled B-52 was about 90 miles South of Thule at 28,000 feet when an electrical fire was discovered in the main compartment and its pilot radioed a "May Day." Within a few minutes, they were approaching the base at 9000 feet, and the men bailed out when over the Thule beacon. The rescue operation is described graphically in the "Thule Times" of January 26 (Annex II). Six of the seven made it despite parachuting from that height, clothed only in their regular lightweight flight gear; ground temperature at the time was -32° F.

For unknown reasons, the abandoned plane made a U-turn, losing 9000 feet altitude in roughly 18-20 miles and crashed onto the ice at North Star Bay about 7.5 miles slightly South of West of the base at about 5:30 p.m., January 21. A very sharp explosion accompanied the crash. This was followed by a large "column" of fire--actually a strip of fire but this could not be determined when viewed from the base. The plane had been under continuous radar surveillance and hence it was recorded that a fire "column" about 800 meters across shot up to about 800 meters. Figure II, a tracing from a geologic map, shows the general topology of the area and the location of the crash with respect to the base and depth of the bay. This part of the bay is the lower end of Wolstenholme fjord; the bottom has a long boat-shaped depression blocked by a sill between Cape Athol on the mainland and Wolstenholme Island. Thus, if anything went through the ice, which averaged 30 inches thick at the time, it should drop into the deepest part of the bay and stay in the hold of the "boat." The crash occurred about 45 minutes after a high tide at the neap phase (Figure III); the tides give rise to "leads" in the ice and to piled-up blocks and "slip-joints" at the shore line. (This figure not available at this time.)

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Subsequently, it was inferred that the plane must have reached near supersonic speeds, because pieces of its skin with sheared-off rivets and a bomb-bay door were found North of the crash point. The plane probably came in at about 15° to the surface with the left wing 60° low and impacted at greater than 500 knots per hour. The nose crashed back against the wing, loosed the four weapons and they exploded. The JP-4 fuel and heavy parts of the plane continued forward; one engine rotor was found 6 km down the ice. The Pu of the weapons was oxidized and aerosolized by the explosion; some impacted on interior surfaces of the plane as it blew apart; some was taken up in the fire column (v.i.); and some was spread forward on the ice along with the JP-4 and the residua of the plane.

The spread of fuel down the ice by momentum and its ignition created the "fire colume" (v.s.) which burned fiercely for 20 to 30 minutes with whitish flares suggesting the combustion of magnesium. The fire died out after about an hour and the residual fuel, carbon, bits and pieces of metal, and PuO₂-contaminated residua were refrozen into the surface ice which had melted during the fire. This was the composition of the "black streak" shown on the composite photo made from 3000 feet using chute flares on Thursday, January 25 (Figure IV). The streak subsequently was found to be about 2200 feet long and 350 to 400 feet wide.

No fission products were found on the ice or plane wreckage and hence the detonations were all "one-point."

* * *

To return to the time of the crash: The local rescue teams promptly went into operation with the help of the Greenlanders and their dog sleds. A Mr. Jens Ziglensen, the local factor for the Danish Trading Corporation, proved to be the key person in this and subsequent work on the ice as he alone spoke the Greenland language. He mobilized the Greenlanders and their dog sleds and after rescuing the fliers they were the first to inspect the crash site. They saw no life and nothing of any meaning to them so they returned to base without tramping around. Major General Richard Hunziker, Chief of the SAC "Broken Arrow" Response Group, arrived Monday, January 22, and got operations started but the Phase which prevented our taking off from McGuire on January 24 also stopped all operations on the ice. However, by the time we arrived Thursday, the dog teams had carried enough 4x8 sheets of plywood out to the streak area to construct a safe landing pad for the helicopters and to build an emergency shelter against sudden Phases.

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The first problem encountered by the "Broken Arrow" cadre was that their standard PAC-1S alpha-meters simply did not work at these temperatures. They supposedly met cold temperature specifications of -20° F, but at -40° F they failed on at least three counts. Hence, the contamination levels at the crash site and the streak were substantially unknown until Messrs. Tenney and Benedict of LRL, Livermore, arrived on Friday, January 26, ostensibly to test the field performance of the Fidler meters. Essentially, the Fidler was a lightly shielded NaI crystal with battery-powered electronics responding to the 17 kv X-rays of ^{239}Pu and/or the 60 kv X-rays of ^{241}Am . After relocating the batteries under their parkas, repairing some contacts and gradually cold-adapting the instruments, they calibrated them against known sources covered by average thicknesses of snow. The darkness and cold made civil engineering virtually impossible (Polaris is directly overhead), so the first isodose plot of the contaminated area was obtained by selecting an arbitrary starting point and then walking radially, recording the number of paces until the meter reading changed a given number of units. This resulted in the "semi-quantitative" chart shown in Figure V. This fully confirmed the decisions taken by General Hunziker on the basis of a very few PAC-1S readings, to red-flag the streak and a zone around it.

As it happened, the phase winds of January 24 spread the contamination transversely and each succeeding phase enlarged the contaminated area. As shown on Figure VI, however, a later reliable quantitative isodose plot, most of the activity was related to the streak.

A special team of weapons experts had priority in combing the area for pieces of weapons, using the dog sleds and helicopters.

The problems of existing, working, moving, and using instruments in the dark and cold during these first two weeks can hardly be overstated. It is to the credit of General Hunziker and Colonel Dresser that no one man was killed or lost, then or later.

* * *

Dr. Langham and I arrived shortly before the Danish team and were the first ranking Americans to talk with them. In fact, we received them and introduced them a bit later to General Hunziker. They were Professor Jørgen Koch, Consultant to Danish National Health Service, and Professor of Physics, Orsted Institute, University of Copenhagen; Professor Otto Mogens Kofoed-Hansen, Head, Physics Department, Danish Atomic Energy Commission, Risø; Mr. Per Grande, Head, Radiation

Laboratory, National Health Service of Denmark; Dr. Henri L. Gjørup, Head, Health Physics Department, Risø; and Mr. H. Lassen, Head of Division, Ministry for Greenland. Professor Kofoed-Hansen immediately began giving us a hard time about a Greenland hunter reputed to have approached the crash from the Narssarsuk area and finding nothing had gone back to his hunting. Why hadn't he been found? Weren't we going to decontaminate him? The others looked somewhat ill at ease, but nodded agreement. Just as we were about to see about arranging a search, General Hunziker walked in, welcomed them, told them that anything they wanted would be done, etc. This set very well and the mood changed. Shortly thereafter, we went to the briefing room for the first session with the newspaper men from both Europe and America. The European journalists had arrived on the same SAS plane with the four Danes. On the assumption that it was better for the AEC not to seem to be masterminding or to be responsible in this situation, I stayed out of the spotlight. I found Mr. Frank Tucker of the Danish Desk of our State Department and a Brigadier General in nondescript winter gear doing the same thing.

As it worked out, General Hunziker's frank situation report and Dr. Langham's description of the biohazards of Pu were quite sufficient. Only Professor Koch spoke for the Danes. He merely outlined their interest in determining the extent of the Pu contamination and of being assured that it would be safely taken care of, so that no harm could come to the Greenlanders. There were one or two sharp questions of a political nature, fielded neatly by Professor Koch and General Hunziker. The New York Times reporter, a rather impertinent, "mod" type of young man, insisted on calling the smoke column a mushroom. Professor Koch pointed out the difference and when the reporter said he preferred "mushroom cloud", Koch told him that it was reporters like him who didn't deserve to be called journalists, etc. The Times man merely smiled as though he had scored.

The weather turned bad Saturday, and soon the newsmen realized that they were accomplishing little by staying on in this uncomfortable climate. They had to remain because the Phase reached stage II and closed down everything for almost two days. They were happy to leave on the first outbound plane. On the whole they reported the situation fairly, but a few tried to make political hay out of it. Curiously, the Danish paper that had stirred up the most political furor over the accident editorialized next week on how many Soviet warships sailed through the Kattegat with nuclear weapons aboard and what would happen if one of them ran aground in the tricky waters of this narrow sea lane--or collided with another ship!

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That evening, Thursday, Dr. Langham and I were fully briefed on the situation as it was then understood, but the information was scanty and imprecise. In fact, the crash area was able to correlate the aerial photographs taken by magnesium photoflashes with the "dark streak" and the distribution of the debris. None of us, including the Danes, recognized that a hole had been blown in the ice at the north end of the streak although the question had been raised when parts of a weapon chute were found frozen into the ice of this area. I tramped back and forth over this area and saw only a jumble of ice blocks and pieces of metal, whereas Dr. Borge Fristrup, the Danish glaciologist, who arrived on February 1, immediately recognized that the ice at the north end of the streak was newly-frozen and that the blocks of ice had been upended and refrozen in abnormal positions. This was the clue that led to the suspicion that the concussion from the four weapons had blown a hole in the ice and thereupon close study of Figure IV and an aerial infrared photo of the crash spot revealed a circular pattern of fracture lines about 600 feet in diameter and a smaller circular area of ice that had been more severely disturbed.

It was obvious to all who examined the streak that this was the bits and pieces of residue of the plane, and the JP-4 fuel with carbon particles and PuO₂ refrozen into a "cruddy" kind of ice; the point of impact was marked by the "cracked ice." This black streak had been the base or surface for the "column of fire." A few heavy pieces of the plane, engine rotors, one landing gear, and wheels were found up to six kilometers south of the dark streak, indicating the momentum vector in the crash, and amply explaining how the JP-4 fuel could be splashed streakwise that far down the ice. Some of these large parts can be detected as black dots at the south end of the streak (Figure IV).

The skin, tanks and structural parts of the plane were literally blown to small bits; few pieces larger than 2 ft.² were to be seen and they had jagged irregular, torn edges. Later in February when there was daylight, squads of men moving shoulder to shoulder along surveyed sectors would pick up every possible piece of metal, plastic or other debris for storage on the base and eventual removal to the U. S. for burial. The pieces frozen into the ice of the black streak would be scraped up along with the carbon fuel and PuO₂ and stored pending burial in the U. S.

It was General Hunziker who hypothecated that the plane must have been close to supersonic speed in order to have flown the radar-defined course in the time available and therefore it might have begun to shed its skin. He made ranging trips north of the point of impact in a

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snow-cat and did find pieces of skin with clear evidence of sheared-off rivets.

The volume of black streak ice scraped up later came to 1.6×10^6 gallons which on melting gave about 3×10^5 gallons of a cruddy oil-water emulsion. The ice of the bay proved to contain a fair amount of entrapped organic detritus, mostly a cellulose nature, which also helped form this rather unstable emulsion.

* * *

The next morning, Friday, January 26, the pattern began to be established which we followed thereafter. General Hunziker ordered a large room set aside for use by the Danish scientists; this kept them out of the classified traffic pattern although they had full access to General Hunziker and his staff at all times. Also it was convenient for Dr. Langham and me to use this room and it worked out that we performed the scientific liaison between the Danes and General Hunziker as well as being their collaborators in the development of ideas, hypotheses and data. Officially we were Scientific Advisers to General Hunziker, but Dr. Langham doubled as Director of Health Physics activities whereas I worked with the Danes in analyzing the bio-ecological and medical hazards and planning what should be done about them.

Professor Kofoed-Hansen quickly established himself as the scientific spokesman for the Danes; it was obvious that he possessed unusual intellectual qualities and experience. His normal mode of operation, we soon learned, was to put together a tenable hypothesis and then say, "Prove to me that I'm wrong." This position of omniscience was peculiarly abrasive; one could not avoid wondering if there was an egocentric component in the science. I was able to be diplomatic about his modus operandi, but Dr. Langham and he disagreed repeatedly. Two examples are useful: 1) Rather out of the blue he announced on Saturday, January 27, that he proposed to inspect the weapon debris--this was after a dialogue between himself and Dr. Langham as to how much Pu each weapon contained and his having settled on $2 \text{ kg} \pm 20\%$. We suggested that this probably would not be possible whereupon he replied that after all this was Danish soil and he as an official representative of Denmark was empowered to inspect anything in Thule or shipped out of Thule; further, all such shipments would possibly have to go via Copenhagen. Dr. Langham and I communicated without words and left the room to see General Hunziker. Before we could find him, Dr. J. Koch, the formal leader of the Danish team, caught us in the staff room and said it was all a mistake. We let it go at that. In that connection, it must be made very clear that

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Professor Koch, Mr. Grande, and Mr. Gjørup are first-class professionals in their own fields and personally most delightful people.

2) On Friday morning Professor Kofoed-Hansen began examining the meteorology at the time of the fire and using the data supplied by our radar-meteorology people constructed the wind vectors and inversion chart shown on Figure VII. There can be no question that the Danes were sincerely concerned about the possibility of Pu getting into the food chains on which the Greenlanders depend. And so he was interested in the dispersion of PuO_2 by the fire. He first put an absolute exclusion of two miles radius around the streak for all Greenlanders except the working dog teams. Next he drew the diamond-shaped area based on Saunders Island and Thule as an exclusion area, but permitted the Greenlanders to travel along the dotted lines provided they did not stop.

The air was stable with an inversion at 1000 meters. Surface air flow was nominal, 5-7 miles per hour, to the west; at 500 meters it was to the southwest, and at 1000 meters movement was to the south. Thus the PuO_2 carried aloft in the fire column would be distributed chiefly toward the southwest (the Bering Strait ice). But if the heated air penetrated the inversion, then hundreds of square miles of mountainous land, ice cap, and ice in the Strait would be contaminated. He rejected our calculations of what the mean concentrations would be per square meter (we were taking the worst cases) saying that the potential hazard involving the Greenlanders, their food supply and way of life had to be proved or disproved. The other Danes agreed with him, although they also agreed with us that the concentrations would be acceptable by ICRP standards. They were aware of the hot-spot problem and when they brought this up, we had to agree that sampling of surface snow and eventually ice cores were in order.

Curiously, although the Danes were aware of the H component of the weapons and could estimate the number of curies involved, they never brought this up as a hazard. Possibly the great natural dilution capability of the environment made ^3H a moot hazard. Indeed, the Phase from the ESE that prevented our arrival on Wednesday, January 24, blew fine surface debris and contaminated snow northwesterly toward the shores of the islands and the open ice. A subsequent Phase on January 28 further expanded the perimeter of contamination in the bay. We, of course, were more concerned with the probable massive contamination in the black streak.

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The Danes set up a plan whereby Mr. Grande and Mr. Gjørup would collect snow samples along the ice and coast, south and southwest of the streak. We arranged for them to have the use of a helicopter and facilities for melting the snow and evaporating the water to do alpha counting using their own sophisticated equipment.* In a few days they confirmed that there were alpha counts in the snow, but very low. Their identification of the points where they had collected proved unreliable because of the darkness, so they collected a good many more samples which were reported later during their visit to the U. S. However, they found evidence of very low level Pu contamination distributed southward presumably by penetration of the inversion layer and by surface winds. In no case did the contamination per square meter of area approach biological significance. The total amount of Pu so distributed could not be estimated. This did not satisfy Professor Kofoed-Hansen; he was well aware that such levels of Pu were negligible and could never be a hazard, but he kept trying to tally up the total. Next he explored the possibility of PuO₂ having been blown into the water of the bay at the point of impact and this becoming a hazard. We quoted him the solubility of PuO₂ in sea water as being 2×10^{-4} and the $\sim 50 \text{ km}^3$ of water in North Star Bay being enough to dilute all the Pu of the weapons to well below ICRP continuously portable concentration, but he was still not amenable. We were careful never to bargain in any way. It was difficult not to argue with him, but he was clearly much better at dialectics than I. He had attended the 1964 Pugwash conference, but refused subsequent invitations and according to the others was politically uncommitted.

Professor Kofoed-Hansen next turned his attention to the hunting procedures, food habits and customs of the Greenlanders. But it was obvious that he was out of his element and Professor Koch took over. All of the early information was obtained from Mr. Ziglensen and from the Greenlanders with Ziglensen translating. Later, after February 1, this information was corroborated and amplified by the arrival of four additional Danish scientists; Dr. Frede Hermann, Hydrographer, Ministry of Fisheries; Mr. Borge Fristrup, Head of Department, Geographical Institutet; Dr. Christian Vibe, Assistant Professor, Zoological Museum, University of Copenhagen; and Dr. Paul Marinus Hansen, Head of the Greenland Fisheries Research Department. These men were all "old Greenland Hands" who were more explorer-naturalists than scientists like Koch and Kofoed-Hansen. It turned out that they were placed in secondary roles, but their information and knowledge of the area was essential for planning a monitoring/surveillance program.

* The Danes' field alpha monitoring equipment failed in the cold as badly as did our PAC-1S.

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Two technicians from Dr. Gjørup's laboratory at Risø also arrived with alpha spectrometry equipment which was set up in an empty barrack. This was to be used extensively during the next 6 to 8 months.

When we learned that the Danes intended to double their scientific personnel, there was at first a thought to match them man for man. General Hunziker, however, was aware that the Danes were primarily interested in ensuring the radiologic safety of the Greenlanders and the local environs and agreed to my suggestion to bring Dr. John Wolfe, Chief of the Environmental Sciences Branch of DBM, and an experienced Arctic ecologist, to Thule. He arrived shortly before the second contingent of Danes, one of whom, Fristrup, was a personal friend. This added greatly to the understanding being worked out as to what would be advisable for a sound surveillance-ecological program. The Danes were strong for surveillance, whereas Dr. Wolfe and I were more interested in the ecology of the area.

I felt strongly, and still do, that reactors are the ideal power sources for life and work in the Arctic, and Thule with its facilities is an ideal base from which to conduct studies of how reactors would influence the rather simple but extremely critical items making up the ecological web by which the Greenlanders live in the Arctic. Professor Koch considered my arguments for such a study, hopefully on a joint basis, and promised to give an answer "later." He answered when we met in Copenhagen in mid-February. In brief, the Danes did not wish to seem to be calling attention to Thule and the accident by setting up an ecological research program there--maybe later. Meanwhile, they would carry out studies of the Pu contamination of the environment.

* * *

The following is a composite-summary of information about the bio-ecology of the area gathered from interviews with Mr. Ziglensen; a group of Greenlanders with Ziglensen translating; Danish people working on the base, and lastly Drs. Hermann, Vibe and Marinus Hansen.

North Star Bay is a favorite hunting ground for the Greenlanders because the ice tends to be thin or to break into leads, so that the seals can surface and hence they remain in the area; the straits off shore are the last to freeze solid, due apparently to an eddy created by the current flowing northward along the western shore of Greenland, being turned westward by the shoulder of Greenland north of Thule and then meeting a strong southerly flow pouring out of the Kane Basin. Altogether the eddy creates a favorable environment for plankton, shellfish, and sea life in general, especially sea mammals.

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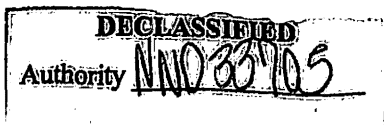
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There are about 80 to 100 people living in the immediate vicinity of the bay ("15 to 20 families") and possibly another 100 may come in, stay awhile and move on again. "Not more than 600 Greenlanders" were estimated for the entire population of this northwest corner of Greenland. The word "about" has to be used because the Greenlander normally is nomadic, thinking nothing of putting his family and things on his sledge and crossing the Bering Strait to Ellesmere Island, Canada, if the dogs are in good condition. He goes where he thinks the hunting is best; his social status rests solely on his ability as a seal catcher, "faenger." The Danes have been trying to settle them in villages by offering food, medical aid, housing, education, and trade goods, but with only modest success.

It was agreed, however, that the habits of the Greenlander are changing: They no longer eat blubber nor use it for lamps or heating; it is fed to the dogs and they use kerosene or a primus stove. Their rifles increase their food gathering effectiveness so they live largely on seal meat. On the other hand, they will trade walrus ivory for powdered milk which they have come to love. The Greenlander eats about 180 pounds of lean seal meat per year. During the summer he supplements his diet with mussels, birds' eggs, berries and an occasional fish. "We go fishing in summer only to escape the mosquitos" sums up their attitude toward fishing; actually the polar cod, the chief indigenous fish, is mostly gristle and bone. They catch large numbers of eider ducks, auks and related species and freeze them for use during the year by dropping them into pits in the permafrost. They will eat the occasional arctic fox, hare, "ice-bear," raven, or ptarmigan they may chance upon. And, if a whale is sighted in the Strait, everyone goes after it; if it is caught everyone within range of the bush telegraph shows up for a gluttonous fiesta lasting up to a month. The Greenlander is a compact, rugged, friendly, intelligent individualist who will pick up new ways of doing things if he is persuaded that they will help him survive in this most inhospitable climate. He seems to know that he can't depart too far from his locas in the ecological web without courting disaster.

The sledge dogs are a critical component in the Greenlander's culture. As long as they are in good condition and fertile he can go about his food gathering. They are nasty brutes that just don't quite dare attack their master, although stories were told of the dogs killing their master when he got sick and vomited, or cut himself, etc. They are trained from the beginning to respond to a whip or club, so that the driver commands instant obedience from them. The dogs decide among themselves who is leader and the order of precedence; the driver has to hitch each by its trace in that order, the leader having the longest trace and placed in the center. The dogs are routinely fed frozen walrus and offal; walrus meat and skin was said to be too tough for



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any other purpose. If a dog is injured or if the leader is deposed, it is shot, skinned and the carcass fed to the other dogs; the skin is made into linings for mukluks. The life span of the dogs is about five years.

The number of animals caught and used per year at North Star Bay as given by the Greenlanders is about:

1. Seals shot anywhere in the vicinity: 1000
2. Walrus killed in the shallows around the two islands (shown on Figure VII): 75
3. Arctic foxes shot on land: 200
4. Arctic hares shot on land: 20
5. "Ice-bear" shot on the edge of the ice: 3
6. White whale or narwhal: "Seldom"
7. Birds
 - a. Land: Ptarmigan: "as many as possible--can't say"
 - b. Migratory seabirds: Eider duck, little auk, guillemot and long-tailed duck. These nest extensively on the ledges of Saunders, Wolstenholme, Iganak, and Ederfugel Islands and Cape Athol, making this area a major rookery of the northland. The birds live on mollusks, crustaceans, small fish and planktonic material in the waters. The eggs are taken and the birds slaughtered from the time they arrive beginning in May. Numbers were not estimated. The Danes are trying to restrict egg gathering to a single first clutch as the birds will re-lay.
8. Fish: The polar cod is eaten mainly by the seals; other unnamed small fish are present, but fish are not eaten.
9. Mussels: The bottom is rich in various types. Where the shore is shallow the Greenlanders will wade out to gather the mussels for "snacks" in summer. The walrus' stomach contents, consisting exclusively of mussels (see Annex III) are eaten in their half-digested form as a special treat.
10. Plants
 - a. A small berry like a current grows on the north shore, but is sparse.
 - b. "Moss" (probably lichens) about an inch high grows sparsely in places where there is some soil. This may end up in the Greenlanders as they eat ("drink") the gut contents of birds, foxes and hares with gusto.
 - c. A low-growing plant having a profusely blooming red flower might reach man via birds, hares, and foxes.
 - d. Arctic willow is the nearest thing to a tree or bush, but very sparse. Only where the sun hits directly is the permafrost melted in summer and even then only to a depth of six inches. The ground is rocky glacial moraine, soil minimal.

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With only these very few sources of food, the potential routes of entry of the Pu into the Greenlander living around North Star Bay can be firmly identified. This minimal, tightly interwoven food net is discussed below.

The seals, the major food item, live on clams, shrimp, polar cod, and the general detritus of the bay (Annex III); these animals in turn feed on the zooplankton, phytoplankton, and micro-organisms. Three species of seals are caught in the area: a) the ring seal is a year-round resident and caught anywhere; it moves out to the ice flows in the Strait only if the ice becomes too thick for it to maintain a breathing hole. When one is killed in the bay, another moves into its territory, as the bay is a preferred feeding ground. b) The bearded seal lives year-round on the edges of ice flows in the Strait; its liver causes nausea and is not eaten. c) The harp seal migrates into the bay between June and September only and lives elsewhere during the rest of the year. Hence where seal meat is concerned, the worst case is the ring seal. The liver is eaten as a delicacy and nutritionally it is a main source of vitamins. The muscle provides protein and energy; while the concentration of Pu in muscle would be low compared to liver, the greater mass consumed might add to a significant total.

In the case of the seal only the PuO_2 put into the bay would create a risk. Taking the ICRP value of 3×10^{-4} Ci/cc of water as the 168 hour acceptable limit for human consumption, it can be shown that more than all the Pu in the weapons could be put into about one-third of one cubic kilometer of bay water, and the resulting solution would be acceptable for continuous consumption. The bay has about 50 km^3 of water and this is constantly changed by good currents (3 miles/hr.), tides and melting bergs and glaciers. Further, the solubility of Pu in sea water is about 2×10^{-4} and if the Pu were to be concentrated by plankton, it is discriminated against by the gut walls of both the seal and man each by a factor of possibly 10^{-3} . For these reasons there would seem to be no hazard to man, but the Danes and we agreed that the gut contents and livers of a number of seals caught during the summer should be analyzed for Pu. The seal would represent the chief "collection point" for passing Pu on to man, if the metal were present in a biologically assimilable form. Also these samples would average out the range of food sources and peregrinations of the seals.

The migratory sea birds are the second most important food item to the Greenlander. The birds live on small fish, shrimps and planktonic material obtained chiefly from the open waters of the Strait. When the bay ice breaks up about the first part of July, the birds begin to feed from the bay or wherever the marine life is most abundant. It seems highly unlikely that the eggs laid in late June would contain

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4. COORDINATE WITH:	
5. CLASSIFICATION CANCELED	
6. CLASSIFIED INFO BRACKETED	
7. OTHER (SPECIFY):	
NAME: D. Martiner	
DATE: 7-21-93	
SINGLE REVIEW AUTHORIZED BY: DOE M 474.1	
REVIEWER: (DC, DR, SC, etc.) 70	

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Pu but they will be examined, including the shells. The top fresh layer of droppings at the rookeries will be analyzed for Pu.

Mussels and shellfish from two sources will be collected for analysis. One will be the stomach contents of the walrus, which represents a large concentration of the foot part only of the mussel; the walrus discards all the rest. Therefore, mussels and other shellfish will be collected by dredging the shallows and also the deep part of the bay beneath the crash point. Not much is known about the metabolism of Pu in these animals other than particles of PuO_2 may be filtered out in the mantle and soluble Pu is incorporated into the mucopolysaccharides of the sheath of the syphon.

Because of the delight of the Greenlander in directly eating the liquid intestinal contents of birds and animals, the droppings and/or intestinal contents of each of the other animals listed above should be examined as an indicator of the PuO_2 present in this part of the food chain.

The growth characteristics of lichens are ideal for trapping dust and aerosols, and samples of these from potentially exposed locations will be analyzed.

In addition, samples of the sea water, bottom mud, plankton and detritus, dust, snow and ice cores will be taken as further information may indicate.

Finally, analogous control samples of the above are to be collected from (possible) Bylot Bay to the south and the Qanaq area to the north. Control data are required because of Pu fallout from atmospheric testing and because glacial deposits may contain abnormally high amounts of minerals of the uranium and thorium series. Good alpha-spectrometry is necessary to demonstrate that the alpha emitter in question is plutonium.

All the above were discussed freely and in detail with the Danes. I saw this as a unique opportunity to examine in quantitative fashion the ecological consequences of siting a reactor in the Arctic, especially as they are considering using a reactor to provide power for mining a huge mineral deposit further south along the west coast. But, as noted above, the Danes chose to conduct a minimal monitoring-surveillance program based on the data and reasoning as outlined. I am still not convinced that they appreciate the meaning and utility of quantitative ecological studies.

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The Danes indicated they would carry out the program themselves so that no one would raise accusations of bias, and they would fund it themselves. They also said they would monitor the shore to prevent the Greenlanders from picking up and hoarding bits of metal, etc. from the wreck which might be contaminated.

These ecological considerations dictated that the contaminated metal and black streak would have to be removed and buried, probably in the U. S. Despite the calculations, the Danes indicated they would advise their government that the contamination should be removed to the maximum feasible. This would have to be finished before June because the ice would begin to soften to the point where there would be ponds of water on the surface and the ice would be too weak to support vehicles. Also, the black streak would collect and retain heat to a greater degree than the clear ice and would drop through into the bay with whatever Pu might be entrapped. It was with this background that a team met with the Danes in Copenhagen two weeks later to formulate plans for removal and surveillance/monitoring.

Two dispatches from Thule transmitted to DOD and AEC concerning the ecological implications of the situation are presented as Annex IV and Annex V. They were transmitted under General Hunziker's imprimature.

* * *

The very high morale of the officers and men of the Air Force at Thule was very noticeable. Despite the isolation, lack of feminine companionship, and the cruel climate, the men had a can-do, proud attitude that made them into a smooth-working unit. It was very noticeable if only by contrast with the news about student riots, juvenile crime, etc.



H. D. Bruner, M.D.
Assistant Director for Medical
and Health Research
Division of Biology and Medicine

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BASE HOUSING OFFICE
THULE AIR BASE
GREENLAND

1 December 1967

PHASE CONDITIONS AND NOTIFICATION PROCEDURES FOR TDY-PERSONNEL.

FOREWORD

PURPOSE: To provide a readily available source of localized winter weather procedure information to all transient personnel assigned to the Thule Air Base.

Thule Air Base is located at approximately 76° 30' North, 68° 30' West, some 690 nautical miles north of the Arctic Circle and about 800 miles south of the North Pole. It is without doubt the Air Force's northernmost air base.

The winter weather can be very dangerous, especially the Arctic Winter Storm. The seriousness of Arctic Winter Storms cannot be over-emphasized. Protecting lives and property during these storms becomes a problem of major proportions and is the responsibility of all personnel assigned to this area.

In order for the Base Commander to implement pre-established procedures for the protection of life and property a method of classifying storm intensities has been established.

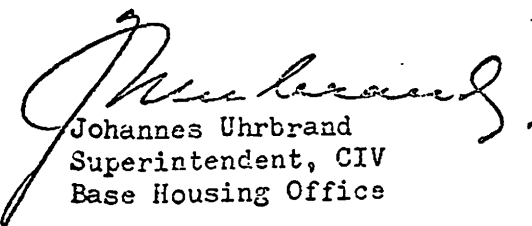
Storm intensities are divided into four Phase Condition Classifications: Phase Alert, Phase I, Phase II, and Phase III. The highest number representing the most serious threat to life and property.

A Phase will be declared to exist by the Base Commander and announced by the Base Command Post via the local Radio Station, TV - station, and PA - system.

Each Phase condition requires all personnel to react according to specific procedures outlined in TABR 355-1. This is a base regulation which is posted on all Bulletin Boards.

If you have questions, which are not answered here, we will be glad to supply the answers - just ask.

And if there is anything else we can do to make your visit more pleasant, please do not hesitate to call EXT. # 7276.


Johannes Uhrbrand
Superintendent, CIV
Base Housing Office

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1. A combination of Wind - speed and Visibility constitute a Phase Condition.
2. PHASE ALERT: A Phase Alert is the initial warning to implement plans for the protection of life and property.
3. PHASE I CONDITIONS: Wind: 20 - 30 Knots. Vis: Greater than 1/2 to 3/4 mile. Chill Index: V.
During Phase I all pedestrian traffic will be in accordance with the Buddy System.

a. Buddy System: Refers to the practice of two or more individuals or vehicles traveling together from one location to another.

4. PHASE II CONDITIONS: Wind: 31 - 50 Knots. Vis: Greater than 1/4 to 1/2 mile. Chill Index: V.
During Phase II, only personnel performing essential duties as determined by the Unit Commander or Chiefs of Staff sections, will continue to work. All other personnel will return immediately to their quarters and report their present to the CQ. Pedestrians will travel in accordance with the Buddy system. Pedestrian traffic will be permitted only for necessary travel between place of duty, quarters, or dining halls, and must be authorized in each instance by the duty supervisor or CQ.
Personnel remaining on duty will be responsible for notifying Base Housing Office EXT. # 7276 of their location.

a. During Phase II, dining halls will continue their normal operation; all other community facilities will be closed.

5. PHASE III CONDITIONS: Wind: 51 Knots or more. Vis: 1/4 mile or less. Chill Index: IV.
All personnel will be accounted for during Phase III. Persons remaining on duty or unable to return to their quarters will immediately notify Base Housing Office EXT. # 7276 of their location, NOT LATER THAN 15 MINUTES after the announcement of a Phase III Condition.

Remember: Failure to follow these procedures for Arctic Winter Storms can result in frostbite or even death from freezing.

The most important thing to remember:

1. Is to call EXT. # 7276 if you are unable to return to your quarters.
2. To contact your CQ if you are present in your quarters.

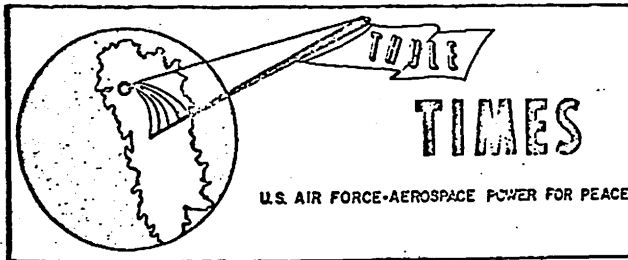
If the CQ should not be present please call EXT. # 7276.

If you don't, the Housing Superintendent or the Housing Clerk on duty will contact the Base Command Post, and ask for an emergency Ground Rescue Section to rescue you. Such an action will bring the rescue personnel in a needless danger, if you already are in a safe place.

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NN033705



Vol. XV, No. 4, Thule AB, Greenland, Jan. 26, 1968



Downed Airmen Rescued

After successfully parachuting from his stricken aircraft, SSgt. Charles E. Snapp (c.) is assisted by TSgt. Jack D. Waughtel (l.), Rescue Survival Technician; and Sgt. Robert T. Switala, Ground Rescue Volunteer. (USAF Photo by AIC Joseph F. Thomas)

Six Survivors of B-52 Crash Now Listed in "Good" Condition

According to AF medical authorities, all six survivors of the B-52 crash are now listed in "good"

condition. All six are in AF hospitals undergoing treatment for their injuries. Air Force sources said four of the men are in the Thule Base Hospital, suffering from bruises abrasions, and chills. The four are Major Alfred J. D-Amario 38, Bact, Maryland; Captain Richard E. Marx 29, Los Angeles, Cal; Captain John M. Haug, 36, Phoenix, Arizona and SSgt Calvin W. Snapp, 29, Morristown, Tennessee.

Captain Curtis R. Criss 43, North Wayne, Maine, is also at Thule Hospital suffering from a dislocated shoulder, frostbite in the fingers and several toes.

The sixth survivor, Major Frank F. Hopkins, 35, Dodge City, Kansas, is at Andrews AFB, Maryland, Base Hospital, suffering from a broken arm and minor frostbite.

PRIDE Certificates Awarded to MAC Men

Two airmen assigned to the 8th Weather Sq. have been awarded MAC's Bronze PRIDE Certificate for the period Sept. through Nov. 1967.

They are Sgt. Robert P. Messer and AIC William D. Richards, of Det. 48.

Both airmen were cited for a steady and significant reduction in error incidence in operations related to their weather observing work.

Sgt. Messer is single and hails from LaGrange Illinois, while bachelor AIC Richards is from Milford, Connecticut.

Strategic Air Command B-52 Crashes in North Star Bay

Crewmembers of the USAF Strategic Air Command B-52 which crashed Sunday near Thule Air Base, Greenland, are ready to fly again. From his bed in the Thule Dispensary, Capt John M Haug of Phoenix, Arizona, reaffirmed his faith in the giant bomber and called it a "very safe aircraft." He said, "I feel a lot safer in the B-52 than I do on the highways."

Electronics Warfare Officer, Captain Richard E Marx, of Los Angeles, Cal, was quick to reaffirm the comments of Capt Haug, and added, "As soon as the order was given to bail out, our survival training came into play. When we hit the ground, this training made the difference between life and death." He was referring to SAC's mandatory Crew Survival Training. Captain Marx's near brush with death had a special happy ending Tuesday when he received word that his wife had given birth to a baby girl. "Don't know what we'll call her," said the happy Capt, "I'll have to talk to my wife." (which he did, thanks to the global communications system of the Air Force.)

Gunner for the aircraft SSgt Calvin W. Snapp, of Morristown, Tenn, recalls "that beautiful beacon," he saw as he descended in his parachute. All crew members were able to eject within sight of Thule and this was a key factor in their survival. In the -32 degree temperature and total polar darkness of Thule, the air crew could have survived only a limited time.

Even as the aircraft wreckage was still burning, personnel at the Aerospace Defense Command Base were beginning a massive air and ground search involving dogsleds

aircraft, and tracked snow vehicles. Jens Zinglersen of the Royal Greenland Trade Department, has been credited with playing a major role in the rescue. Zinglersen organized dogsled teams to aid in the search for survivors; acted as interpreter between the U.S. Team and Greenland Eskimos; and was the first to arrive at the accident scene. In spite of the severe weather conditions, six of the seven crewmen were rescued.

(Continued on Page 4)

Air Base Group Men Lauded at CO Call

Public recognition was the order of the day during Commander's Call for the 4683ABG NCO's on Monday.

Air Force Commendation Medals were awarded to SSgt. Richard A. Hoyle and SSgt. Hunter, by Sq. Commander, Lt. Col. Paul F. Molloy.

SSgt. Jess C. Morales was the recipient of a Certificate of Merit, from the Systems Command for his outstanding performance of duty while assigned Det. 1, AF Satellite Control Facility, 6594th Support Group. His wife Anni, son Bernd and daughter Sharron, reside at 34 84 Mt. Prieta Drive, San Jose, Calif.

Sgt. Benjamin Del Castillo and Airman Jerry A. Frieson were given Certificates of Achievements for attaining 90% percentile scores on their respective SKT's. Spt. Del Castillo's wife Melinda and their two children, Anthony and Diana, live at 858 Mohawk Dr., Livermore, Calif.

SSgt Hoyle received his medal by distinguishing himself while functioning as an instructor and course

(Continued on Page 4)



All eyes - ce are on the ADC Press Service's calendar girl, Uschi (pronounced "oo-she") Keszler, who performs in the 1968 Shipstads and Johnson Ice Pollies. This 1965 German figure skating champion cuts a pretty figure no matter where she performs.

Late Evening Viewing From AFRTS

It's A Small World - To-night. The late Spencer Tracy stars in this romantic comedy about love down South.

Rogues of Sherwood Forest - Saturday. The son of Robin Hood springs into action! John Derek is the hero.

The Jackpot - Sunday. A funny Jimmy Stewart opus. He wins a radio-quiz jackpot and then the trouble starts.

Blondie Beware - Monday. Dagwood takes charge of a big account at the office and she's a blonde.

Michael Shayne, Private Detective - Tuesday. The hero is Lloyd Nolan who's got a murder on his hands. Lots of good, clean - you know what!

Member of the Wedding - Thursday. Julie Harris is a young girl filled with

the pains of growing up. Ethel Waters and Brandon DeWilde co-star.

Marco Polo - Feb. 2. An action-packed tale of the explorer who brought back gunpowder with all that silk and stuff. Rory Calhoun stars as Marco.

AFTV Highlights

"Eric Hoffer, Passionate State of Mind" SPECIAL. A study of the philosophy of a unique individual reported by Eric Sevareid. Seen Monday at 7 p.m.

"Dean Martin Show" on Monday at 9 p.m. Dino's pals are Petula Clark, Don Rickles and Roy Rogers and Dale Evans. Lots of song and fun.

"Bell Telephone Hour" on Tuesday at 7 p.m. The show is devoted to Romeo and his Juliet as we see it performed in different ways.

... B-52 Crashes in Bay

(Continued from Page 1)
ed within 20 hours of the crash.

Last man to be rescued after 20 hours in the snow was Capt. Curtis R. Criss, of North Wayne, Maine. Capt. Criss, the navigator, was found wrapped in his parachute at 1:30 p.m. Jan 22 (Monday). The body of the seventh crew member was also recovered.

The aircraft, assigned to the 380th Bomb Wing, Plattsburgh Air Force Base New York, crashed on the ice of North Star Bay, some seven miles southwest of the Thule runway. It was approaching for an emergency landing, after having declared an emergency, because of a fire in the navigator's compartment and intense smoke in the aircraft. An Air Force investigating team is currently at Thule. The cause of the accident has not been determined.

The pilot diverted from normal flight to Thule Air Base, the nearest airfield, due to an inflight emergency. At that time he was 90 miles south of

Thule Air Base, over Baffin Bay.

In addition to the 4683 Air Base Group, units participating in the search included: Det. 18, Eastern Aerospace Rescue and Recovery Center; Alaskan Air Command; 54th Aerospace Rescue and Recovery Sq., Pease AFB, N. H.; Cape Athol Coast Guard Station; Signal Research Unit #7, U.S. Army; HQ US AF, Det. 220; Philco, RCA; and Federal Electric Civilian Contractor personnel; Danish Construction Corporation employees; and Greenlanders of the Thule Area.



... CO Call

(Continued from Page 1)
writer for Course ABR 64730 (supply), at Amarillo AFB, Texas, during the period 15 November 1965 to 31 August 1967. His wife Nettie is waiting for him at 613 So. Retta, Ft. Worth, Texas.

SSgt Hunter achieved his recognition while assigned to the 750th Radar Sq. Boron Air Force Station, California, from 1 Oct. 1966 to 31 August 1967. His meritorious service as Personnel Technician included complete reorganization of the Personnel Section and elimination of deficient areas.

Lottie, his wife, and their three sons, Randy, Veto, and Terry reside at 31-D West Seymour Drive, Goldsboro, N. C.

DANISH MOVIE--This week's Danish Movie is entitled "Gøngehøvdingen." It is set in the 16th Century but will be shown at the Base Theater tomorrow at 8 a.m. and 11 p.m.

Luncheon Specials

Lunch is served from 11 a.m. until 2 p.m. in the NCO Open Mess.

Monday - Chicken Fried Steak and Meat Loaf

Tuesday - Spaghetti with Meat Balls and Pot Roast Beef Sandwiches

Wednesday - Vienna Meat Loaf and (Luksemad) with Egg

Thursday - Breaded Pork Chops and Chile Con Carne

Feb. 2 - Shrimp Basket Fried Fish Portion and Fried Chicken.

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Survey of the distribution of the most important food elements on Walrus, Bearded Seal, Ringed Seal, Narwhal and White Whale in the Thule district.

	<i>Cardium</i>		
	<i>Mya</i>		
	<i>Saxicava</i>		Walrus
	<i>Macoma</i>		
	<i>Astarte</i>		
	<i>Buccinum</i>		
	<i>Cucumaria</i>		
	<i>Psolus</i>		
	<i>Rossia</i>		
	<i>Lycodidae</i>		
	<i>Cottidae</i>		Bearded Seal
	<i>Amphipodae</i>		
Ringed Seal	<i>Decapodae</i>		
	<i>Gadus saida</i>		
White Whale	<i>Reinhardtius</i>		Narwhal
	<i>hippoglossoides</i>		

As it will appear from the above table the Walrus is the only one feeding on bivalves, which practically are its only food source. The Bearded Seal feeds on everything except just mussels, so that these two important animals do not compete. The Bearded Seal, on the other hand, is the only one eating the big *Buccinum* gastropods which represent part of its most important food items. The Ringed Seal will feed equally often on amphipods, shrimps and Polar Cod, according to its place of occurrence. The Narwhal feeds on shrimps, Polar Cod and Greenland Halibut, and the White Whale is satisfied with the two last mentioned species.

This table should of course only be regarded as a survey from which greater or smaller deviations can take place, according to season.

	Berries	
	<i>Vaccinium uliginosum</i>	
	<i>Empetrum nigrum</i>	
	Little Auk	↑
	Polar Cod	↑
		Zooplankton
		↑
	Bivalves	← Phytoplankton
	Crustaceans	
	<i>Cottus</i> sp.	
Arctic Fox		

Annex IV

MEMO OF PROGRESS OF DISCUSSIONS WITH DANES ON MONITORING-SURVEILLANCE OF NORTH STAR BAY

Prepared by H. D. Bruner at Thule, January 31, 1968

With the immediate aspects of the health hazard of the accident known and under control, two of the members of the Danish Scientific-Investigative Team (J. Koch, O. M. Kofoed-Hansen) have turned their attention to the long range health-ecological problems that they anticipate. They focus on the potential contamination of the natural food supply of about 200 Greenlanders resulting from the melting of the contaminated ice of North Star Bay and its introduction into the food chains. The Greenlander is a nomadic hunter (faenger) whose culture is based on hunting.

Calculations based on International Committee on Radiological Protection standards indicate that if more than all the weapon plutonium were to be distributed into a cubic kilometer of the bay water, that water would be fit for continuous consumption by a population. Although this calculation is accepted, the Danish Team would wish to have zero Pu contamination of the bay, and the team has been taking a fairly hard line toward this, such as scraping up the contaminated layers of ice and snow and doing something with it. They were fully aware of the Palomares clean-up operations.

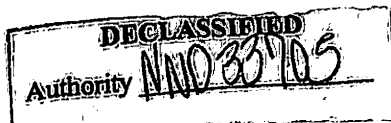
It is still to be determined whether small amounts of Pu were deposited on the snow on the headland to the south or on the islands to the west by the fire column and/or subsequent winds. But, because Pu may conceivably get into the several food chains, we have been looking into what can and should be done.

Arriving shortly are additional Danish Consultants: Dr. Vibe (Mammalogist), Dr. Martin-Hansen (Fish Specialist), Dr. Hermann (Oceanographer), Dr. Fristrup (Glaciologist). Presumably, they will be able to provide data on various aspects of the environment so that we can better estimate the possible alpha contamination of the population via the food sequence. Regardless of cleanup or anything else, they will probably insist on a food surveillance program involving analysis of Pu in bay water, in seals, in migratory birds (the island on the west of the bay is a major arctic rookery), in the walrus, in mussels and the polar cod, and in the occasionally caught whale, polar bear, ptarmigan, arctic fox and hare. The minimal requirements for such surveillance would be several clean dissection rooms and space for the sampling equipment, Pu extraction equipment, and the special detector systems for Pu

but all that can be accomplished easily. The collection and sampling must be carried out in a preplanned, controlled fashion if the data are to be trusted. The base can provide these facilities, but Danish people will probably want to carry out most of the program; we might wish to analyze aliquots. This might continue for three or four years depending on how often a trace of Pu is found in a sample.

Such surveillance programs generally end up raising many more questions than they are intended to answer. Therefore, it should be planned and organized as a first-class quantitative investigation into this relatively uncomplicated ecological web that concerns man depending chiefly on sea mammals. Such quantitative data do not seem to be available; they will be needed if reactors are sited in the arctic. By curious coincidence Denmark plans to build one somewhere in the southern third or half of the west coast of Greenland.

In summary, some agency of our government probably will have to take scientific and fiscal responsibility for a cooperative study with Denmark of the total ecology of this area into plutonium as a contaminant.



Annex V

MEMO REGARDING POSSIBLE SURVEILLANCE PROGRAM THAT MIGHT BE CARRIED OUT
BY THE DANISH GOVERNMENT TO ASSURE THE SAFETY OF THE THULE INHABITANTS

Prepared by H. D. Bruner at Thule, February 2, 1968

I. Premises:

- a. There are probably no more than 80-100 Greenlanders in the immediate vicinity of North Star Bay. There are probably less than 600 who might be involved if they were all to come visiting as they are in the habit of doing.
- b. The Greenlander is a hunter not a fisher. His status is determined by his ability as a hunter. He does not eat fish except under pressure.
- c. The Greenlander male weighs about 125 pounds and consumes an average of 80 kilos of lean seal meat per year (180 pounds). All the seal is used at Thule; man saves the pelt and gives the blubber, flippers and viscera except the liver to the dogs. About 1000 are killed per year here.
- d. The diet is supplemented when possible by the flesh and eggs of the eider duck, auk, guillemot, squaw duck and ptarmigan, in about that order. The number killed is not clear, but it is appreciable.
- e. The walrus is hunted here mainly for his ivory, although the flippers may be boiled and the stomach contents (chiefly the foot of pecten bi-valves) may be taken for a delicacy. Almost 75 are shot. The meat is given to the dogs.
- f. During summer mussels are dug at low tide. The amounts eaten are not clear but are not very much.
- g. Fox meat, polar bear meat and ravens may be eaten but they are going out of favor. They have to be boiled to hell and gone before they can be masticated. They are scavengers and range widely.
- h. The Arctic hare is eaten with pleasure but only 20 or so are killed per year. They eat the vegetation found on soil on the mountain sides and valleys.
- i. Only very rarely is a white whale or narwhal killed. It ranges widely up and down the coast of Greenland.



II. Probably Valid Assumptions:

- a. There are some 50 cubic kilometers of salt water in North Star Bay whereas one cubic kilometer of bay water would be more than sufficient to dilute the PuO_2 from all four weapons to below MPC for continuous oral consumption.
- b. The major contamination area of the bay lies above the mid point of a glacial trench 625 to 750 feet deep, becoming shallower at each end. The tide was one hour after high of the neap phase and the currents mild. Anything which penetrated probably is in the trench and will tend to stay there.
- c. The high storm winds on the surface of the bay and the adjacent mountains will blow contaminated snow onto areas not originally contaminated. On the bay the winds tend to blow it toward Baffin Strait and open water where the seal hunting area is. If the fire column dropped PuO_2 over onto the land, the PuO_2 ought to accumulate most in the niches where there may also be soil supporting sparse vegetation. The soil is underlain by permafrost and the surface water tends to run off before the surface soil loosens during summer.
- d. The Danish Government has a very paternalistic policy toward the Greenlanders and appears determined to look out for their interests as much or more than they would for themselves.
- e. Not having much experience in contamination control, the Danes will probably attempt many things in the way of protective surveillance, a good number of which will be waste motion.
- f. The Danes are knowledgeable and competent as to conventional laboratory radiation biology and health physics, but they are not strong in modern dynamic ecology.
- g. It is expected that we shall help them construct a sound surveillance program and, no doubt, help in other ways.
- h. The "scar area" with its black impregnation and the cracked circle will probably melt faster than the surrounding ice. This may be fast enough to melt out the area entirely and drop the remaining Pu and debris into the water of the bay.

There may be natural concentrations of uranium or thorium daughters in this area in excess of possible plutonium contamination. The closeness of Thule to the polar stratospheric-trophospheric exchange may also be a source of extraneous contamination. Evidence has already been obtained that snow on Thule Air Force Base has non-plutonium alpha contamination.

III. Recommendations:

a. Following cleanup of the pieces and bits of the plane now going on, there will be a period of two and a half to three months before the ice breaks up in which surveillance studies on the bio-environment can be carried out.

These probably will not provide much useful information, but the Danes correctly feel that they must protect the local population by surveillance of the food chains.

b. Extensive discussion of the food and hunting habits of the Greenlanders with the natives themselves and Danes familiar with the natives indicate that the following food chains could contribute the most significant data:

1. The detritus-plankton, to shrimps and fish, to the seal, to man:
The point of attack, so far as man is concerned, is to determine levels of Pu in the contents of the lower colon and feces. The liver, gall bladder and mesenteric lymph nodes would be checked if Pu appears in the gut contents in appreciable amounts. If the animal is collected so as to avoid all contamination of its pelt, the pelt may be checked by alpha survey meter.

If Pu does enter the body on a long-term basis, it will localize in bone. Skeletal muscle should have a concentration about two orders lower. In short, it is highly unlikely that the muscle of the seal could be a source of transfer of Pu to the Greenlander unless the physiology of the seal is completely different from other mammals.

If Pu is found in the gut, the liver should also be monitored before being eaten.

2. The plankton-algae-detritus, to duck, to man; or the duck egg to man:

The droppings of the ducks roosting and nesting on Saunders Island and at other rookeries can be monitored in situ by use of a standard alpha-probe counter. If alpha activity is detected in the fresh feces, last year's droppings should be checked as well as droppings in rookeries outside the North Star Bay area.

If the feces of the ducks are radioactive, then individual ducks and their eggs should be sampled. The gut, liver and flesh can be analyzed for Pu rather than the whole animal. If captured cleanly, the plumage should be monitored with an alpha detector.

Other migratory species, such as the little auk, can be similarly tested.

3. Mussels, to man:

The mussel, although consumed in limited amounts, is important because it is dug out and eaten directly by the Greenlander and because it has a mantle mechanism for filtering and retaining

particulates such as PuO_2 . These can be dug up from the flats at low tide and analyzed directly for Pu.

The results will give an estimate of the distribution of PuO_2 particulates in the area as well as the possible presence of PuO_2 in the food of the walrus which now is eaten only by the sledge dogs in this area.

4. No other food chains are of sufficient importance in the diet of the Greenlander to warrant the time and expense of study at present.

5. Sampling of animals should be recognized to be a random statistical procedure and the collection of animals and the interpretation of the data made on that basis.

c. Because there are no reliable data on the movements of water in North Star Bay, the area should be instrumented to obtain current and flow data in selected areas of the bay while the ice is still present to provide a platform. An instrument such as the Richardson Recording Current Meter should work in this environment.

IV. The ecological research program, set up to supplant this monitoring-surveillance program, will require data such as the above in order to know which groups of biota can be studied most profitably.

In any case, the surveillance program should have a well defined plan for termination as soon as possible.

FIGURE I

DAYLIGHT-DARKNESS CHART FOR THULE

DAYLIGHT - DARKNESS CHART

THULE AB. GREENLAND

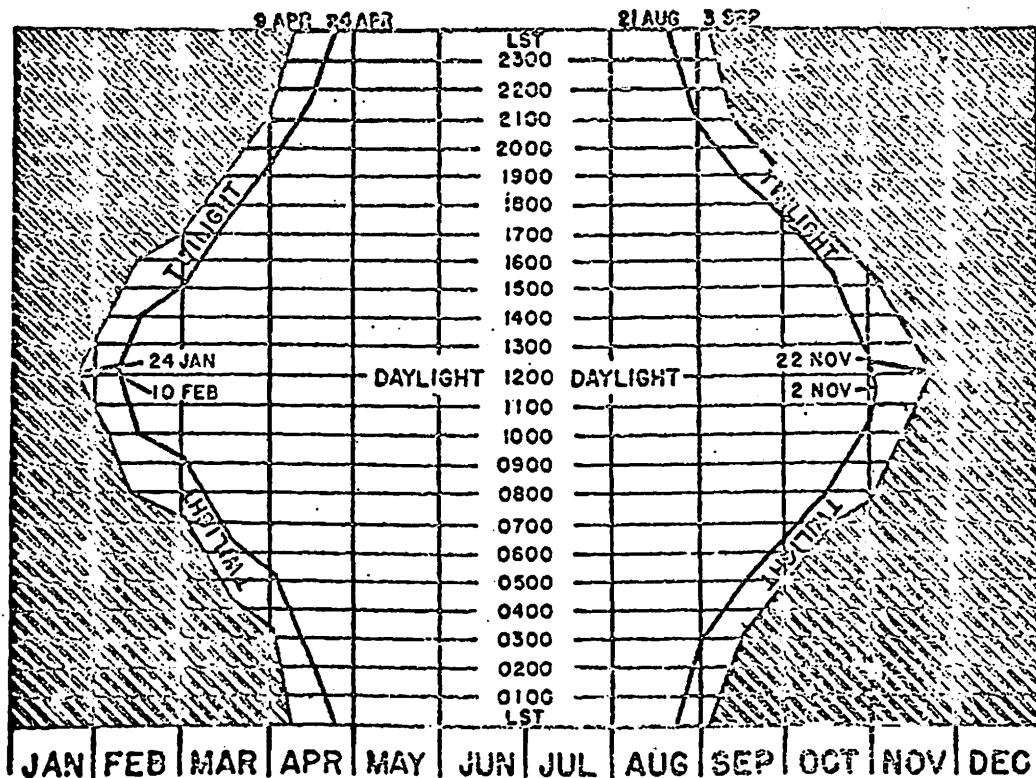
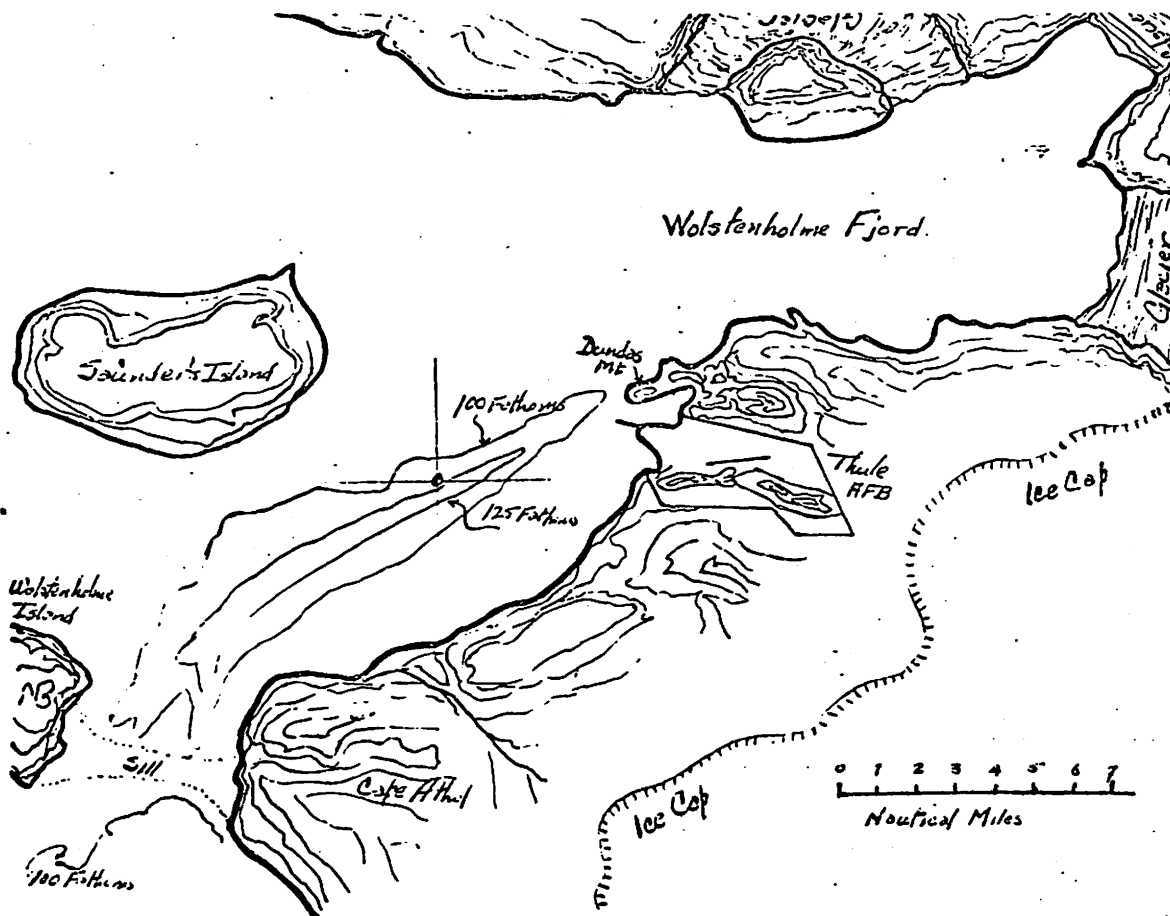


FIGURE II

SKETCH MAP OF THE POINT OF THE CRASH IN NORTH STAR BAY WITH
CONTOURS OF THE BOTTOM, AND LOCATION OF THE ICE CAP, AND GLACIERS



TIDE TABLES FOR NORTH STAR BAY

FIGURE III

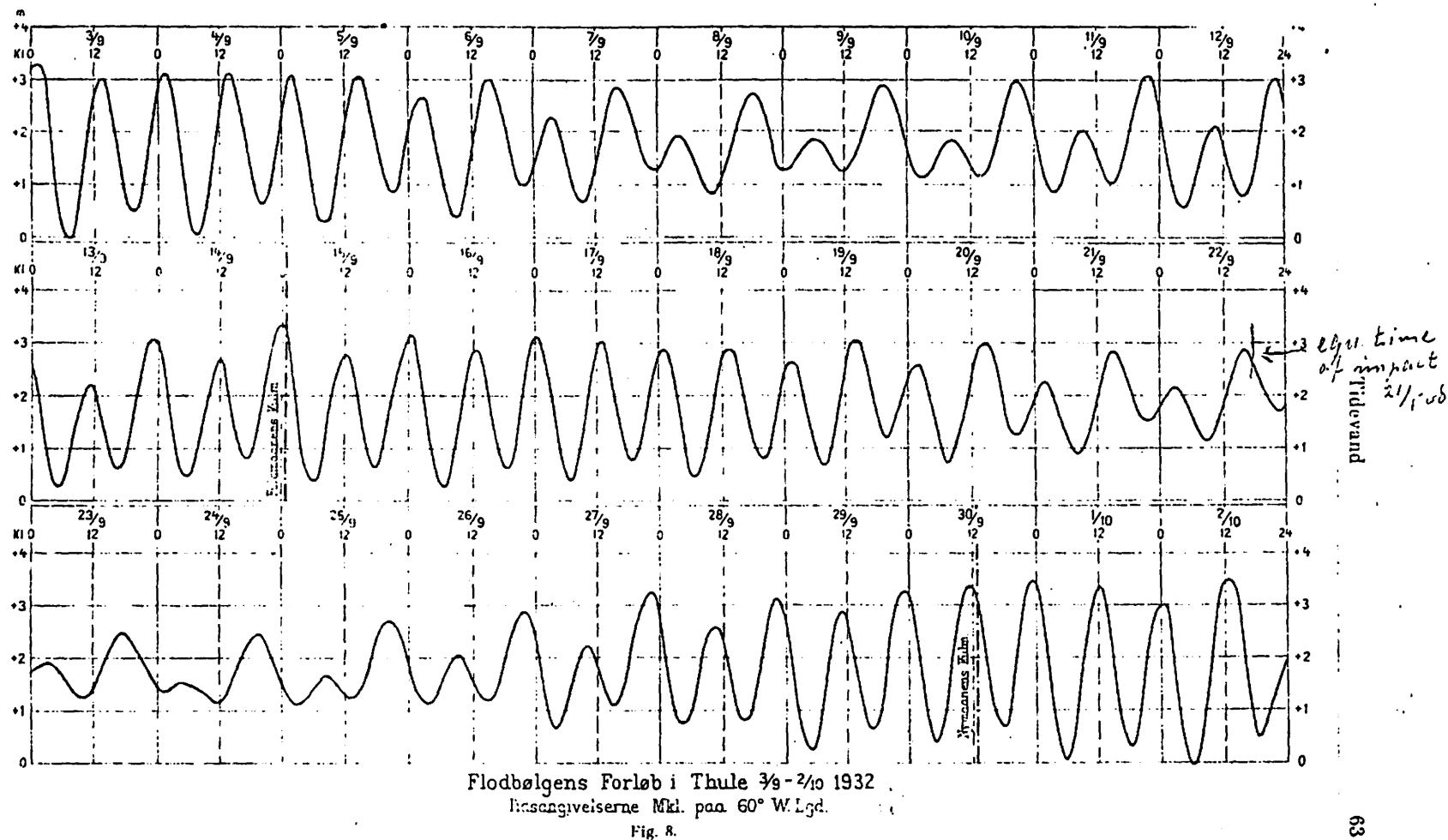


FIGURE IV

A COMPOSITE AERIAL PHOTO OF THE BLACK STREAK. THE FINGER-LIKE TIP POINTS A LITTLE WEST OF SOUTH. A RETICULAR AREA OF CRACKED ICE AT THE NORTHERN END RELATES TO THE EXPLOSION. TINY DOTS OF BLACK AWAY FROM THE STREAK ARE LARGER PIECES OF DEBRIS.

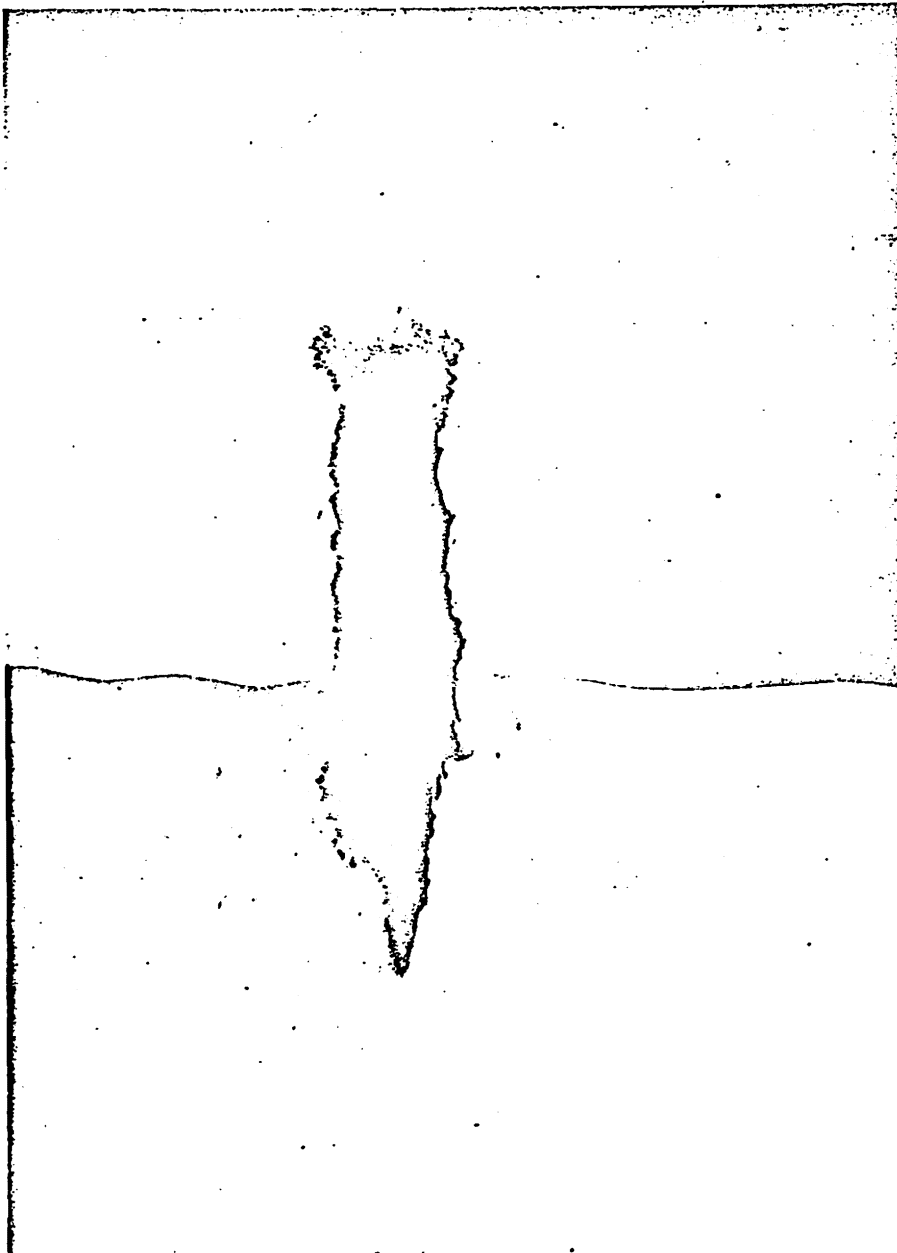
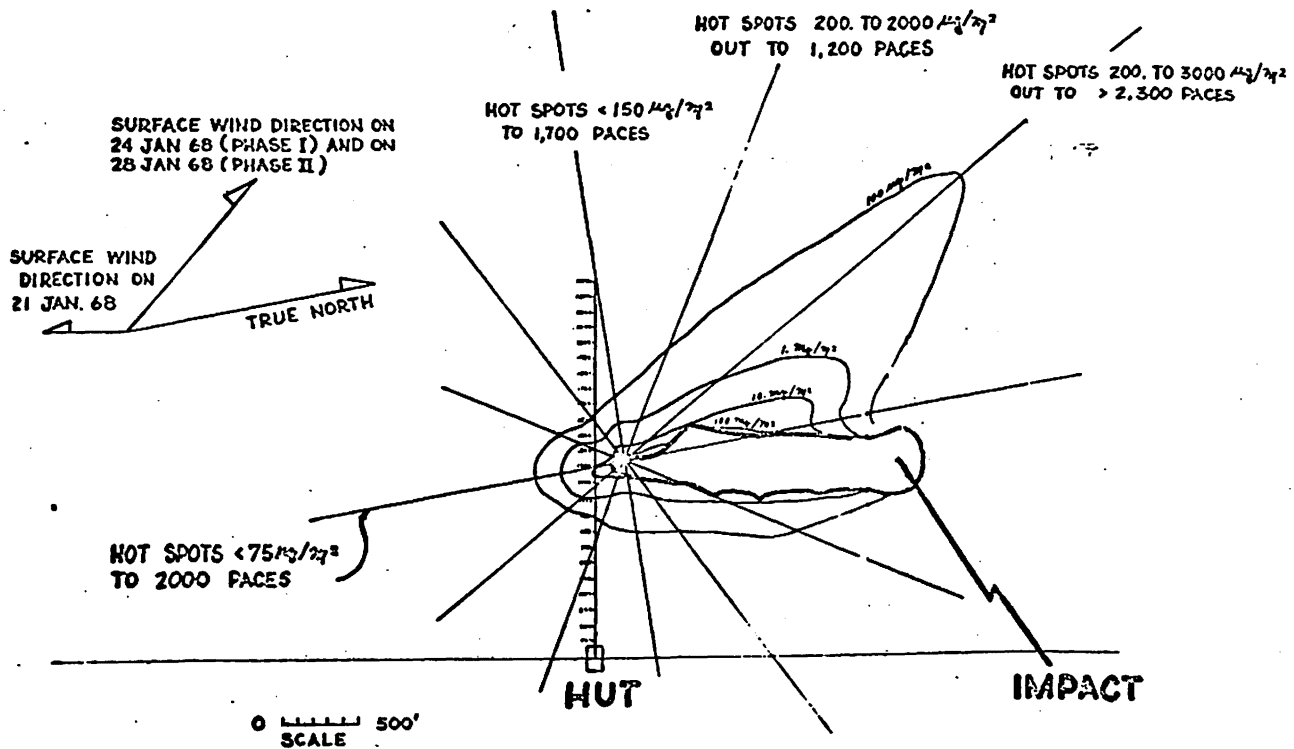


FIGURE V

THE FIRST ISODOSE CHART CONSTRUCTED BY COUNTING THE NUMBER OF PAGES
REQUIRED FOR REDUCTIONS OF ORDERS OF MAGNITUDE AWAY FROM THE ARBITRARY
STARTING POINT USING THE FIDLER INSTRUMENT



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