NVO-108

PROJECT CANNIKIN

D+30 DAY REPORT

PRELIMINARY OPERATIONAL AND TEST RESULTS SUMMARY

FEBRUARY 1972

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE
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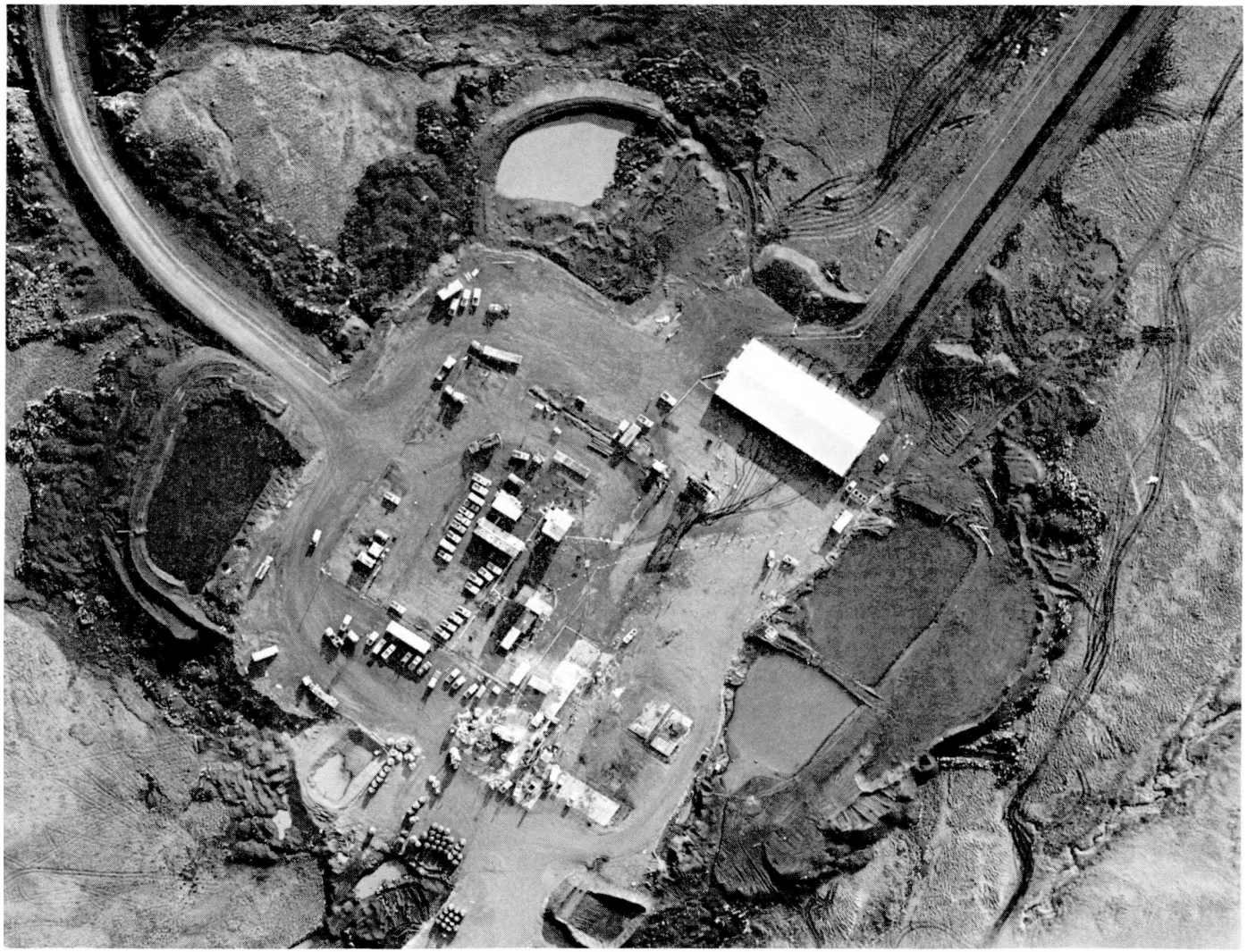
SUMMARY

CANNIKIN, a test of a nuclear device for the Spartan Antiballistic Missile, was conducted at Amchitka Island, Alaska, at 11:00 a.m., Bering Standard Time (BST), November 6, 1971. The device, designed and constructed by the Lawrence Livermore Laboratory (LLL), was emplaced 5,875 feet below the surface and was detonated from a control point on the Island some 23 miles distant. The seismic measurements indicate that the device performed as expected with a yield of less than five megatons.

Work has begun to obtain samples of the device debris. This entails drilling back into the shot region to obtain rock samples in which the device debris is incorporated. If the work proceeds on schedule, postshot drilling is expected to be completed by Spring 1972. The analyses of the material obtained are required to evaluate fully the performance of the Spartan warhead.

There has been no release of radioactive effluent as a result of CANNIKIN and no large earthquake was triggered from the detonation. Teleseismically, the shock had a body-wave magnitude of 6.8 and a surface-wave magnitude of 5.7. CANNIKIN did not produce a measurable tsunami. Bioenvironmental effects were noticeable, but were confined to the Island and the waters immediately around it. Except for slight but noticeable ground motion at Adak and Shemya, no effects have been reported from any off-Island location.



CANNIKIN SURFACE GROUND ZERO (SGZ) AREA AS IT LOOKED TWO DAYS BEFORE THE TEST -- STEMMING OF THE EMPLACEMENT HOLE HAS BEEN COMPLETED AND ALL OF THE TECHNICAL FACILITIES ARE BEING READIED FOR DETONATION

I INTRODUCTION

1.1 General

This report summarizes as of December 6, 1971, the CANNIKIN scientific results, the operational program, and the various effects on the Amchitka Island environment.

Final interpretation of the information presented herein will be reserved until such time that all of the analyses have been completed. As the individual final effects reports on CANNIKIN are published, they will immediately be made available to the public.

1.2 Chronology

In the early summer of 1966, it became apparent that the Nevada Test Site would not be adequate for the test of the Spartan Warhead. Later that fall, detailed geologic site explorations were undertaken at Amchitka Island , Alaska (Figure 1-1), including exploratory hole drilling which was commenced in January, 1967.

Verification of the suitability of Amchitka was obtained through the MILROW test on October 2, 1969. MILROW was a calibration test of about one megaton in yield, fired at a depth of 4,000 feet, and was designed to provide base-line information from which the effects of a larger detonation could be predicted in such fields as oceanography (tsunami studies) biology and ecology, geophysics and geology, hydrology and seismology.

MILROW verified the advance evaluations and predictions. These predictions were used to ensure that the proposed higher-yield experiment (CANNIKIN) could be conducted safely and that the experiment was adequately designed from a safety point of view.

Drilling of the CANNIKIN emplacement hole was begun in August, 1967, and was concluded in March, 1969 (Figure 1-2). Hole casing was all in place by July, 1969, when operations were suspended pending MILROW execution.

The mining of a 52-foot diameter underground test chamber for CANNIKIN was started in September, 1970, and was completed in July, 1971. Device insertion was initiated on September 8, 1971, and downhole device emplacement commenced on October 13, 1971. Upon receipt of the requisite authority to conduct the test, stemming of the emplacement hole was initiated on October 27, 1971. Preparations then proceeded without interruption to the established first readiness time of 11:00 a.m., Bering Standard Time, November 6, 1971, when the CANNIKIN detonation occurred.

Postshot drilling commenced on November 27, 1971.

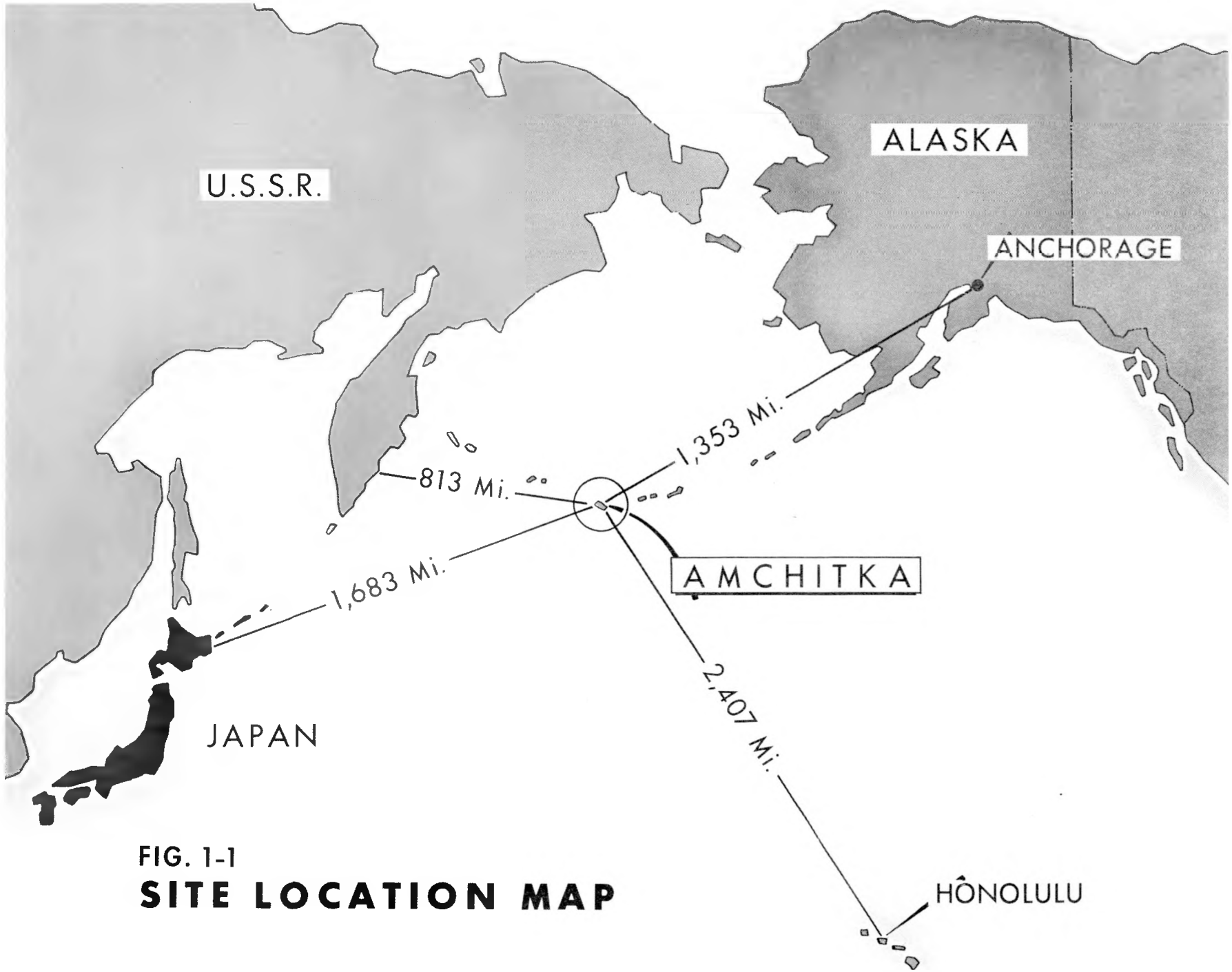


FIG. 1-1
SITE LOCATION MAP

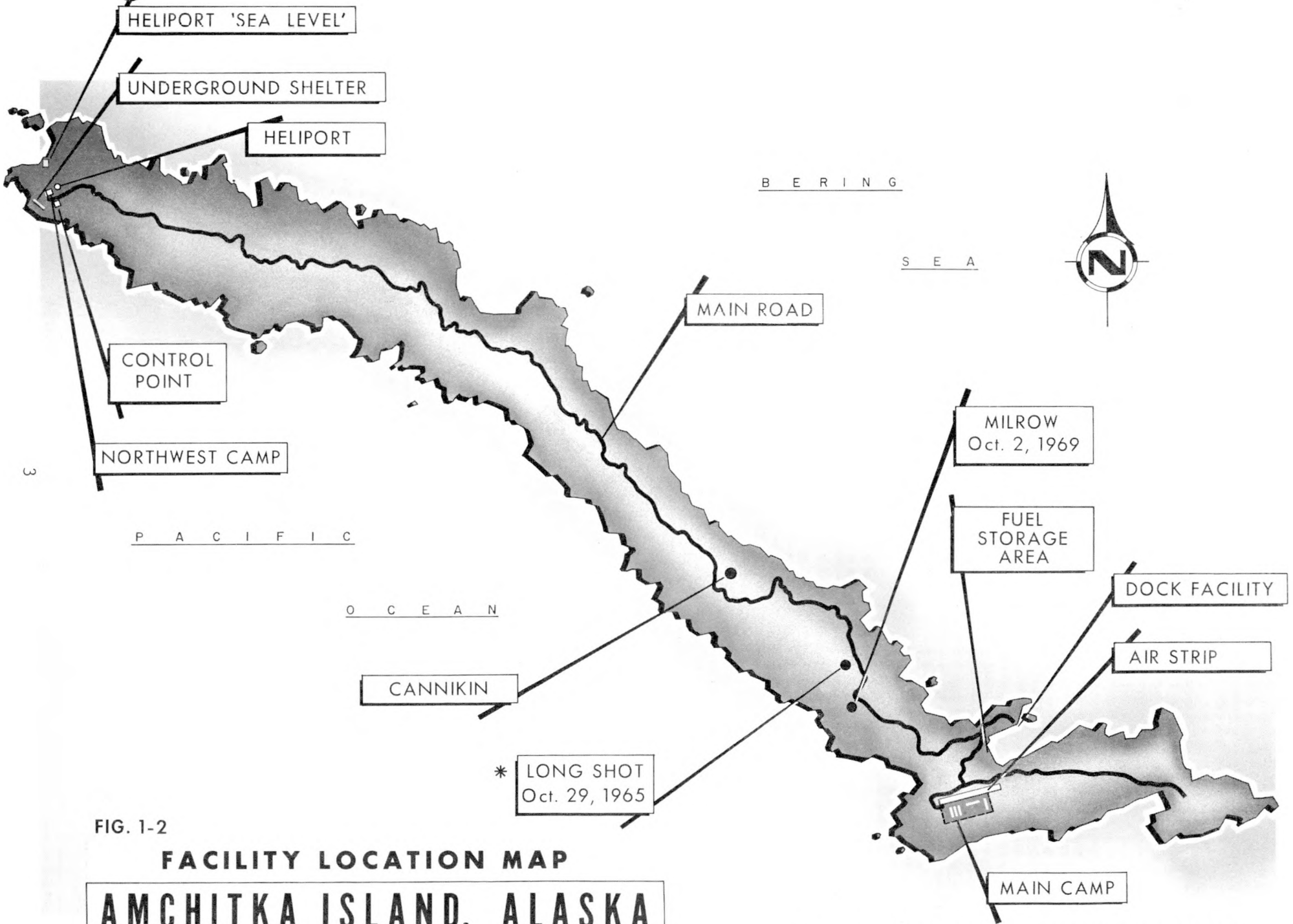


FIG. 1-2

FACILITY LOCATION MAP

AMCHITKA ISLAND, ALASKA

* DOD UNDERGROUND DETECTION EXPERIMENT

II AUTHORIZATION

2.1 Objectives

CANNIKIN was a proof test of the warhead for the Spartan missile of the Safeguard Ballistic Missile Defense Program. Congress had voted funds for the protection of Minuteman missile sites and for that protection to become reality, a proven warhead for the Spartan missile was required. Several nuclear experiments had been conducted in the program to develop the warhead. CANNIKIN was the experiment which was to show that the final design operated as expected and that the design could be certified for stockpile.

The CANNIKIN device was the most intricate design ever undertaken in the weapons program and incorporated features that were different from any other nuclear weapon produced. The Spartan system is designed for long-range intercept outside the atmosphere with X-rays as the kill mechanism. The principal reasons for the full-yield test were:

(1) To minimize the possibility of stockpiling a defective design;
(2) To measure the yield of the device; and
(3) To measure the X-ray flux and spectrum.

The final results of the CANNIKIN test, if as predicted, will permit the AEC to certify the Spartan warhead for introduction into the stockpile within the appropriate deployment schedule.

2.2 Presidential Approval

The President, on October 27, 1971, approved the detonation of the CANNIKIN device.

2.3 Court Decisions

2.3.1 Committee for Nuclear Responsibility, Inc., et al. v. Glenn T. Seaborg, et al., USDC, District of Columbia, (Civil 1346-71)

The suit, commenced July 8, 1971, sought an injunction against the CANNIKIN detonation. The litigation was procedurally complicated and involved many appeals. The Government filed its Motion to Dismiss, or alternatively, for Summary Judgment on August 18, 1971, and, on August 27, 1971, the District Court granted the Government's Motion for Summary Judgment.

On October 5, 1971, the U.S. Court of Appeals, District of Columbia, reversed and remanded the case. The District Court thereafter denied several separate requests for injunctive relief. These denials were sustained by the Court of Appeals

(on separate occasion) and finally sustained by the Supreme Court which on November 6, denied the request for injunction. (No attempt is made herein to detail the many legal claims, demands and appeals.)

2.3.2 The Aleut League v. Atomic Energy Commission, et al., USDC, Alaska, Civil A-127-71

This suit commenced September 2, 1971, seeking injunction against CANNIKIN detonation. Plaintiffs' Motion for Preliminary Injunction filed on September 14, 1971; the Government's Motion for Summary Judgment or alternatively to dismiss was filed on September 21, and hearings were held in Anchorage on both Motions on September 27 and 28, 1971. On October 8, the Court denied Plaintiffs' Motion and reserved judgment on the Government's Motion with a full hearing on the merits scheduled for October 13. On October 12, both parties stipulated the September 27-28 hearings would be considered the full hearing. Briefs were thereafter filed by both parties. By decision dated November 2, 1971, the Court reviewed, in detail, the facts relative to the case, and dismissed the petition. There was no appeal from this decision.

III SCIENTIFIC ACCOUNT

3.1 General

The LLL technical program on CANNIKIN consisted of the following six separately identified experiments (Figure 3-1):

(1) Prompt Diagnostics
(2) Hydrodynamic Yield
(3) Radiochemical Yield
(4) Ground Motion
(5) Cavity Growth
(6) Stemming Motion

The status of each of the above experiments is described below.

3.2 Prompt Diagnostics

The Reaction History portion of the prompt diagnostics experiment confirms the predicted device performance. With all detectors in operative condition at shot time and 100 percent return from the recording systems (oscilloscopes), it is anticipated that additional information will be obtained when the analysis is completed.

The X-ray portion of the prompt diagnostics experiment produced excellent signals. All paired channels were in agreement with each other. Of the 157 recording systems (oscilloscopes) used to record the X-ray diagnostics, minor difficulties occurred on six; however, these six will yield useful data. There were no background noise problems on any of the channels.

3.3 Hydrodynamic Yield

Seven transducers located in three different instrument holes measured the velocity of the shock wave from the detonation. Good data were recorded on all of the transducers and digitizing the magnetic tape records has been completed. These data, when related to previously measured velocities as a function of energy, will be used in the final yield determination.

3.4 Radiochemical Yield

Postshot drilling operations started on November 27, 1971. Samples of the device debris are expected to be recovered by March 1, 1972.

Radiochemical analyses of these samples will be carried out at the Lawrence Livermore Laboratory.

3.5 Close-in Ground Motion

Early analyses of the data from the Sandia close-in ground motion experiment indicated that information was derived from all the

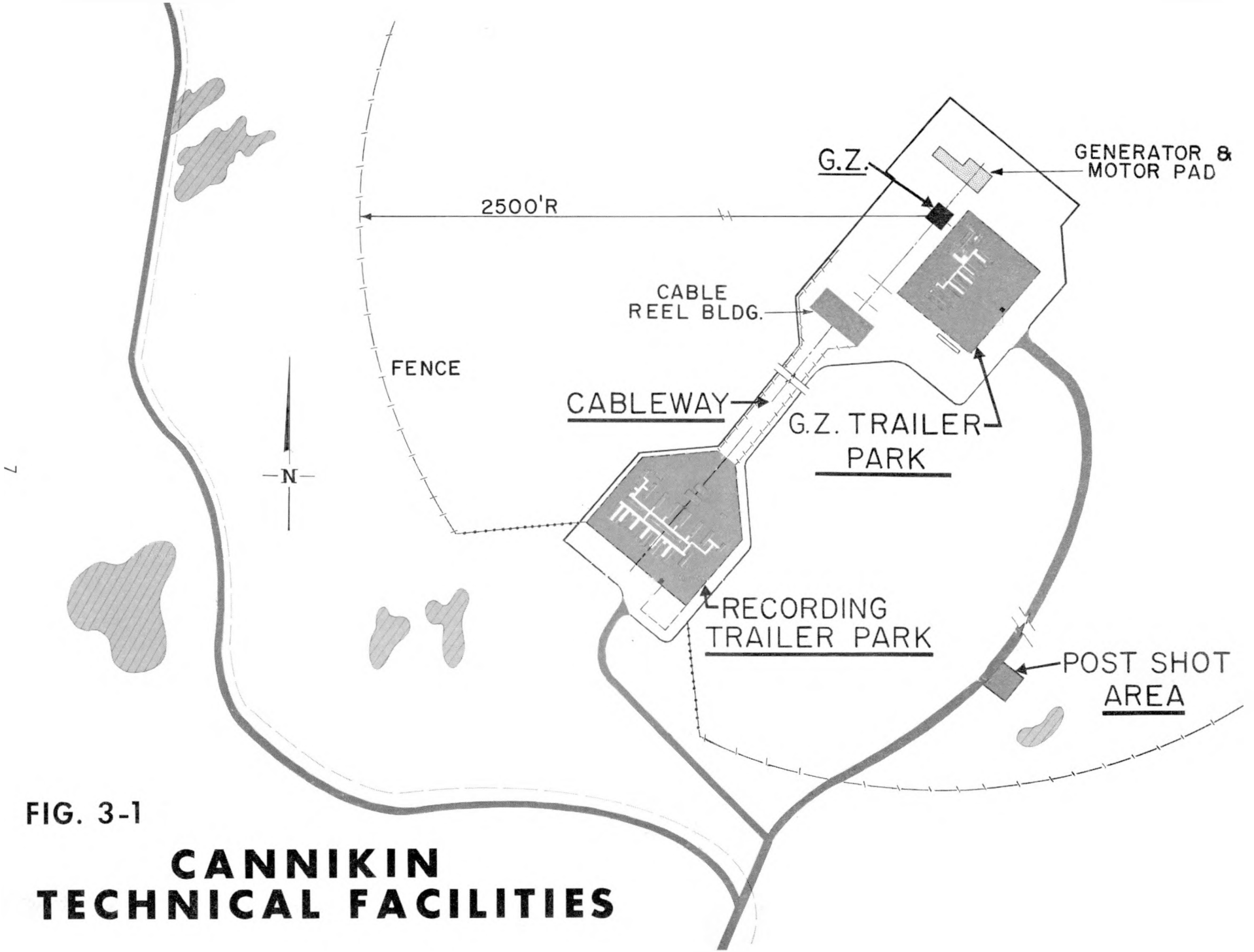


FIG. 3-1

CANNIKIN TECHNICAL FACILITIES

installed gauges. However, data collection stopped when a power transfer circuit malfunctioned at the recording trailer about 1.8 seconds after detonation; consequently, ground motions after that time were not recorded and some desired data were lost.

Most of the peak values observed are either within or slightly above the values predicted on the basis of the MILROW data. Vertical array data implied a separation or spallation of the rock layers below a depth of 200 feet.

Surface motion records indicated spallation beneath all stations out to 18,000 feet from surface zero. Loss of instrument power before arrival of the motion at station S-35, over 34,700 feet from surface ground zero, prevented recording of data from that station.

(See Section 6.2.2 for additional information regarding the distant ground motion measurements.)

3.6 Cavity Growth

Three transducers functioned properly and gave the locations for the large fractures created by the outgoing shock wave. The rate of advance of the air shock down the dewatering drift was also measured by one of these transducers. Analysis of these data will wait until after the hydrodynamic yield analysis has been completed.

3.7 Stemming Motion

Data recorded on magnetic tape is awaiting analysis.

IV OPERATIONS

4.1 General

An operational control program was carried out preparatory to the detonation of the CANNIKIN device to assure the safety of all persons on or in close proximity to the Island.

4.1.1 On-Island Area Control

An Island personnel phase-down plan was undertaken on D-1 and D-day which reduced the on-Island population to 242 persons. A systematic personnel muster system combined with effective aerial and surface sweeps assured the AEC Test Manager that all on-Island personnel were accounted for and located at the Northwest Camp (some 23 miles from surface ground zero) well in advance of the established detonation time.

4.1.2 Air and Sea Control and Surveillance

A military support task group (JTG 8.3) was established to assist the AEC in assuring that the waters surrounding and the air space above Amchitka Island were adequately monitored to verify that no unauthorized persons were within the established Warning Area during shot time.

Additional support by this group included the capability to respond to emergencies, perform aerial and sea monitoring and sampling and documentary photography. Units assigned included:

Aircraft

2 EC-121 Air Controllers
2 WC-130 Tracker/Samplers
3 P-3 Surveillance
1 NC-135 Photo
1 P-3 Patrol Aircraft (Standby - Pool Tracker/Adak)
1 WC-135 (Standby - Long-range Tracker/Anchorage)

Ships

1 Coast Guard Cutter (Sweep & Surveillance)
2 Destroyers (Sweep & Surveillance)

In addition to those units assigned to JTG 8.3, and in response to Alaskan concerns, the Navy positioned two ships (destroyer and escort) in the Aleutian area as a means for Island evacuation in the event it was necessary.

Environmental Protection Agency (EPA) personnel with radiation detection equipment were assigned to the U.S. Coast Guard Cutter, the two U.S. Naval Destroyers and the two U.S. Air Force sampling aircraft.

A Canadian government C-54 scientific aircraft which was to join the air array was unable to participate and had to return to Cold Bay, Alaska, due to icing and engine trouble.

In the process of routine surveillance, one contact was identified within the 50-mile Warning Area--a small American fishing vessel located in a bay on the Eastern side of Semisopochnoi Island. The captain of this vessel was advised by the assigned Coast Guard Cutter on November 4, 1971, that he was safe at this location, but if he got underway, he should head north and east to clear the Warning Area. The vessel was advised again on November 6, 1971, prior to shot time. The vessel held this position and no known problems arose as a result of the detonation.

4.1.3 Scientific Support Vessels

Two special ships were chartered by the AEC, the Motor Vessel "Pacific Apollo" to provide logistic support to the marine elements of the effects study program and the fishing ship "Commander" to conduct exploratory fishing in the Amchitka waters before and after the CANNIKIN detonation.

4.2 Detonation

A number of readiness briefings were conducted during the week prior to D-day to assure that all elements were on schedule and to review the developing weather conditions. On November 5, all systems were brought to a state of readiness in spite of heavy winds of gale force. Weather predictions for the following day looked favorable; therefore, a shot time of 1100 hours was established for November 6, 1971.

A final readiness review was made on D-day at 0400 hours and updated hourly thereafter commencing at H minus 3 hours. The weather at shot time was as follows:

> A deep, low pressure area centered near the Pribilof Islands and a high pressure area centered near 44 N 160 E produced northwesterly winds and mostly clear skies in the Amchitka vicinity. Surface and low level winds aloft were from 300 degrees at 30-40 knots. Air temperature was in the high thirties and low forties.
>
> Initial trajectories predicted for any accidental release of radioactive material were toward the east-southeast and were expected to curve southward after 24 hours, then to curve toward the west after 36 hours. (Such trajectories in the event of an accidental release meant that no radioactive material would be carried over any inhabited areas for several days. In this length of time, the decay and dispersion of the material would have reduced any exposures to individuals to very low levels.)

All personnel evacuation aircraft were cleared off the Island by 0600 hours. No delays occurred during the countdown and the test was conducted as scheduled.

4.3 Postshot Reentry & Early Time Surveys

Initial reentry survey to assess damage to roads and facilities in and around ground zero was authorized by the AEC Test Manager within one hour after the detonation of the CANNIKIN device. An airborne survey revealed that relatively light damage was evident at the recording trailer park and that ground parties with some assistance from road maintenance crews could proceed with data recovery operations. Ground parties were dispatched to accomplish these tasks within two hours after shot time.

Damage surveys of the Main Camp and the associated airfield and control tower located at the southern end of the Island were initiated about two and one-half hours after shot time. Only minor damage was noted and reactivation of these facilities was undertaken shortly thereafter. (The Adak evacuees returned to Amchitka by about 1600 hours.)

Early time environmental effects aerial surveys and observations were also initiated within two and one-half hours following shot time. Follow-on ground parties commenced their surveys at about 1500 hours with the first Bering Sea beach survey being made at about 1640 hours. All surveys were effectively terminated at sunset or shortly thereafter.

4.4 Property Damage Complaints and Claims

Property damage from ground motion arising from the CANNIKIN detonation was not anticipated beyond the Island of Amchitka itself. Seismic recording stations installed throughout Alaska and particularly on a number of remote islands in the vicinity of Amchitka indicated that ground motion of perceptible levels did not extend beyond approximately 230 miles.

One complaint of damage for residential cracked plaster was received from Santa Rosa, California--more than 2,400 miles distant from the point of detonation. Seismic data recorded by the Earth Sciences Laboratories of the National Oceanic and Atmospheric Administration indicated that ground motion in the Santa Rosa area was lower by a magnitude of 1,000 than the accepted threshold level of damage. The damage from this complaint was considered to be coincidental to the CANNIKIN detonation and to have resulted from local causes. The complainant was so advised.

V RADIOLOGICAL SAFETY

5.1 On-Island Radiological Safety

At detonation time a total of twenty certified radiological safety monitors were located as follows: fourteen at the Control Point, one on the "Pacific Apollo," one on the "Commander," two on Adak Island, and two in Anchorage. Background environmental samples of air, water, soil and vegetation were collected preshot. Similar samples were collected postshot. All on-Island personnel were issued film badges for personnel dosimetry. A total of 112 stations of various types of environmental monitoring units were positioned around the Island. These units included Remote Area Monitoring System units, air sampling units and thermoluminescent dosimeters.

No radiation levels attributable to CANNIKIN above predetonation background were detected on any of the environmental sensing equipment at the CANNIKIN site, the MILROW site, the LONGSHOT site, Northwest Camp or anywhere on Amchitka Island.

Radiological monitoring personnel have relocated their monitoring equipment in support of the postshot drilling operations which are now underway.

5.2 Off-Island Radiological Safety

Certified radiation monitors employed by the Environmental Protection Agency, Western Environmental Research Laboratory of Las Vegas, Nevada, were located at population centers in the Aleutian Chain and Western Alaska commencing approximately one week prior to D-day.

As shown in Figure 5-1, these locations included: Adak, Akhiok, Akutan, Atka, Attu, Belkofski, Chignik, Chignik Lagoon, Chignik Lake, Cold Bay, False Pass, Ivanof Bay, King Cove, Nikolski, Nelson Lagoon, Old Harbor, Pauloff Harbor, Perryville, Sand Point, Shemya, Squaw Harbor, St. George, St. Paul, and Unalaska.

A communications conference call was established among EPA personnel at the above locations prior to the test to transmit local weather, sea conditions and readiness status. This network was maintained throughout the immediate postshot period in order that timely notification could be given in the event of any hazardous condition (including unusually severe storm activity).

Monitors were also located on participating military vessels and airplanes including the U.S. Coast Guard Cutter "Confidence," the USN Destroyer "Lloyd Thomas," and the USN Destroyer "Cochrane," and the two sampling aircraft. Background environmental samples of air, soil, vegetation, water, snow, milk and foodstuffs, as available, were collected prior to detonation throughout the Aleutian Chain and

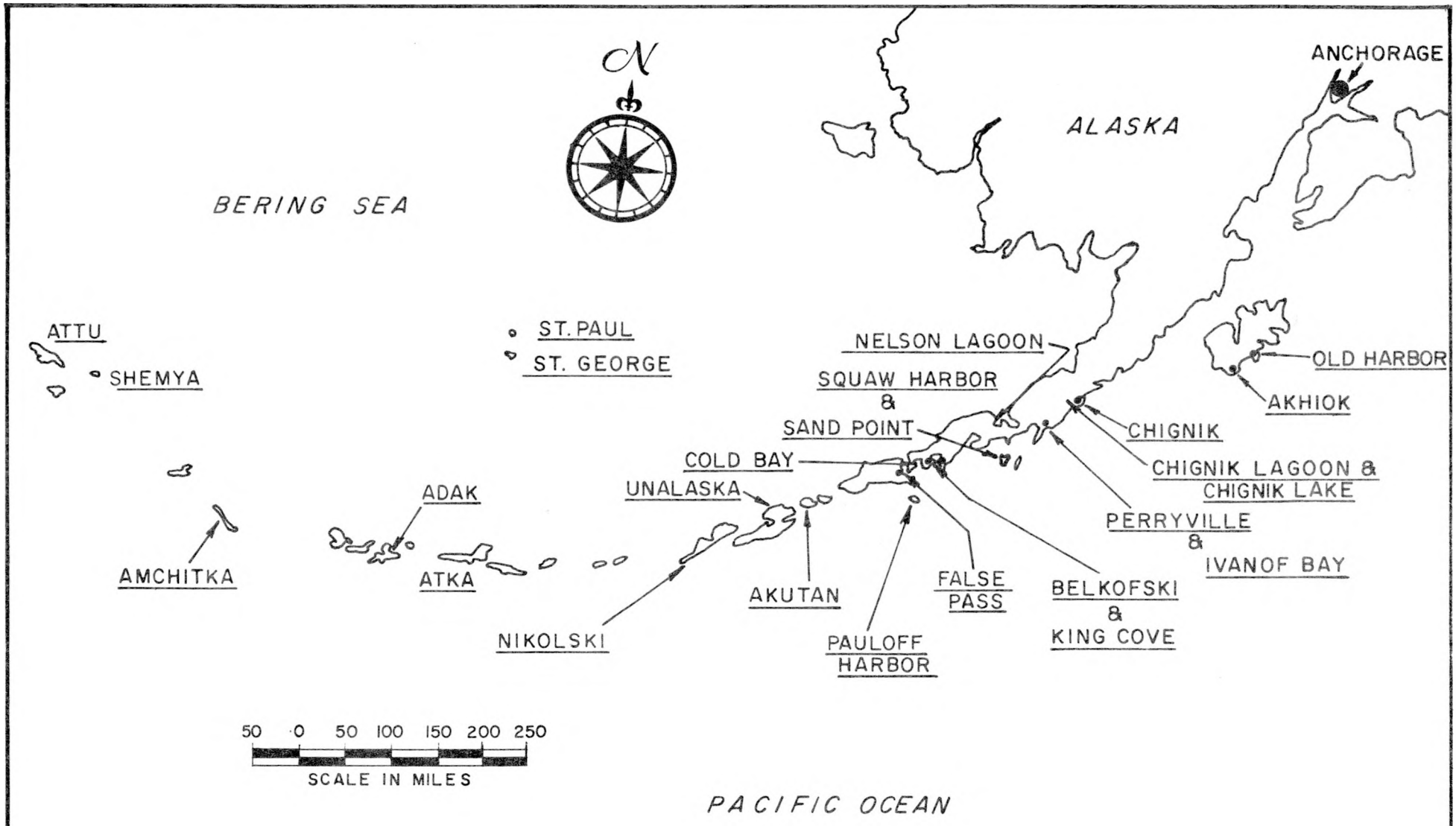


FIG. 5-1 LOCATION OF EPA/WERL RADIATION MONITORS ON EVENT DAY.

on the Alaskan mainland. Postdetonation samples are presently being collected for comparative purposes.

Fifteen air sampling stations were operated both pre- and postshot by Alaskan residents at the locations shown in Figure 5-2.

Thermoluminescent dosimeter (TLD) stations were also established preshot at all the air sampling stations. Five of the stations manned by residents were also equipped with gamma exposure rate recorders. The thirty-five EPA certified radiation monitors on locations throughout the Alaskan Chain were equipped with exposure rate and personnel dosimetry equipment.

Measurements and analysis of preliminary data to date have indicated no radiation levels above normal background in any of the off-site areas. Analyses of the environmental samples are underway, but will not be completed for some time.

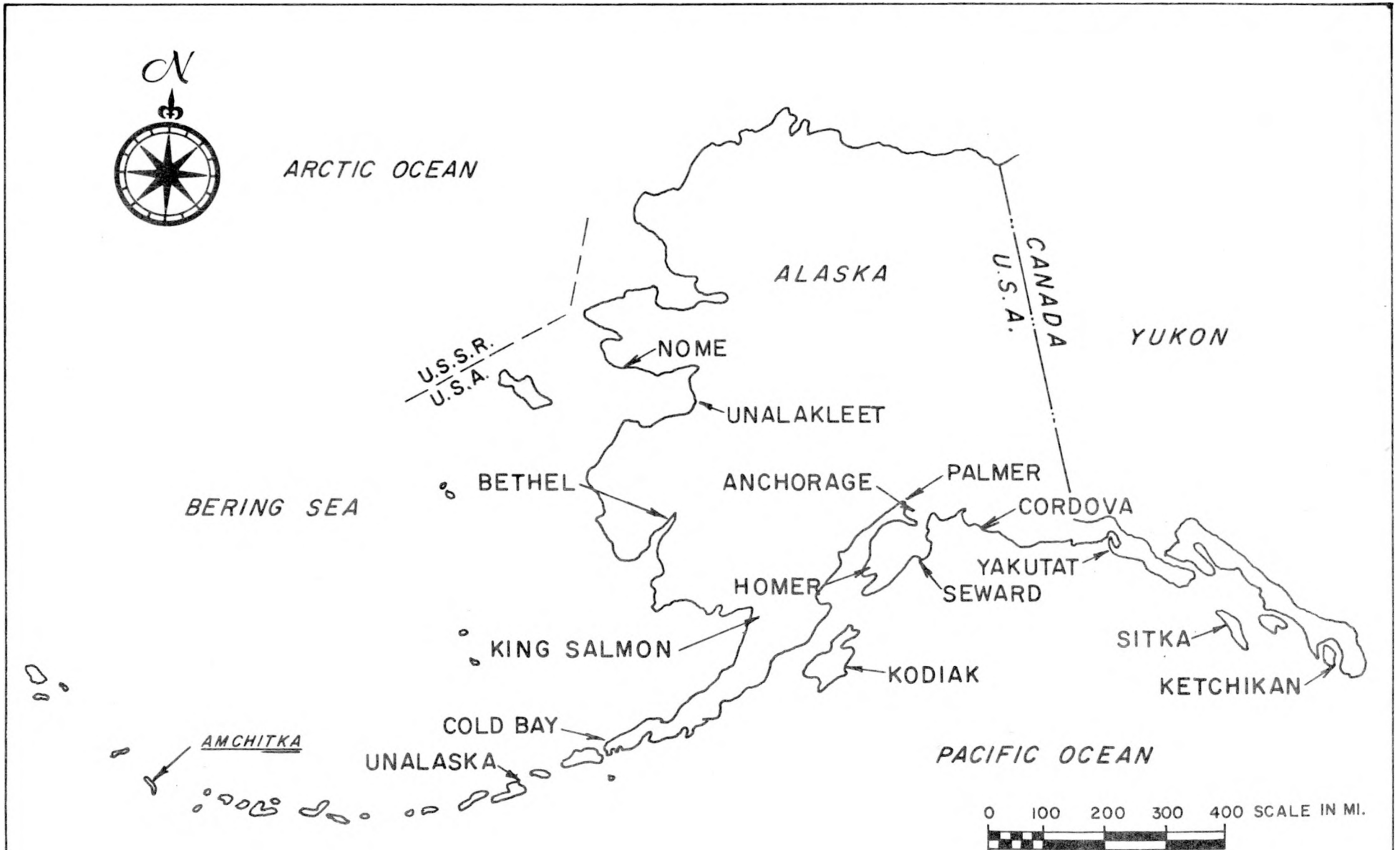


FIG. 5-2 EPA/WERL AIR SAMPLING STATIONS OPERATED BY ALASKAN RESIDENTS.

6.1 General

The information reported herein is preliminary and should not be considered final: the geophysical data will be presented at the annual Geological Society of America/Seismological Society of America meeting at Honolulu, Hawaii, in late March 1972, and the biological results will be published in technical reports and journals on a timely basis.

An extensive program to monitor and evaluate the long-term effects of CANNIKIN on the environment is now in progress. Biological and environmental sampling are planned for a few years and the hydrological and geophysical studies will be continued for at least a year.

6.2 Geophysical Effects

6.2.1 Seismology

CANNIKIN was detonated at 11:00 a.m. (Bering Standard Time) on November 6, 1971. Based upon the measurements of 43 receiving stations in the Worldwide Standard Seismometer Network, the NOAA/Earth Science Laboratory (NOAA/ESL) now reports that the shock wave from the detonation had an equivalent body-wave magnitude (m_b) of 6.8 and an equivalent surface wave magnitude (M_S) of 5.7.

A continuously recording network of high-gain seismometers on Amchitka, Rat, Semisopochnoi, and Amatignak Islands (Figure 6-1) has recorded in excess of 1,000 aftershocks since CANNIKIN. A large percentage of these aftershocks are attributable to rock falls within the explosion cavity and the readjustment of the rocks surrounding the cavity. All aftershocks have been small (m_b less than 4.0), shallow focus (less than four miles deep) and confined to within about 10 miles of SGZ (surface ground zero).

Most of the aftershock activity ceased 38 hours after CANNIKIN at 12:54 a.m. (BST) on November 8, with the collapse of the explosion cavity. NOAA/ESL-Palmer, Alaska, reported the event as an earthquake with a body-wave magnitude of about 4.9. A few aftershocks have been recorded since collapse and appear to be along a preexisting fault plane located about six miles southeast of SGZ.

At this time, it appears that CANNIKIN did not interact with the natural large-scale tectonic processes of the region.

6.2.2 Ground Motion

Special seismometers were deployed on Amchitka, Rat, Semisopochnoi, Amatignak, Shemya, and Adak Islands to obtain measurements of the ground motion produced by the explosion.

Distances from the detonation site to the recording stations ranged from 6 1/2 to 230 miles. Preliminary data analysis indicates the peak vector components of the ground motion (acceleration, velocity and displacement) agreed very well with preshot predictions which had been based upon MILROW and Nevada Test Site experience. Some data analysis remains to be done, but in general, it appears that as expected, the motion from CANNIKIN was slightly larger than that observed from MILROW.

6.2.3 Strain Measurements

A network of 26 linear strainmeters and 8 tiltmeters (Figure 6-1) at 9 locations in the Aleutian Islands, at a distance of 6 to 700 miles from surface ground zero, were operating at detonation time. Permanent strain steps were observed at all strainmeter stations. The strainmeters located on Amchitka registered the largest step which was as high as 30 parts in 100,000 at the stations located about 6 miles from SGZ. The amplitudes of the strain steps observed at Rat Island and all of the more distant stations were less than the amplitude of normal earth tidal strains. Historically, with other high-yield underground detonations at Amchitka and the Nevada Test Site, a quasi-static or decaying strain step had been observed, suggesting the ground was elastically deformed but returned or nearly returned to a preshot condition within a few hours. This kind of strain was not observed at CANNIKIN. This fact, coupled with the asymmetry of the measured close-in strain field suggests that complex fault movements occurred locally. Extensive analysis and interpretation remain to be completed.

Four magnetometers (Figure 6-1) had been emplaced on Amchitka to monitor any changes of the earth's magnetic field as a result of CANNIKIN. Owing to the severe storm on the day before, only three instruments operated through CANNIKIN. Changes in the magnetic field strength within a mile or two of SGZ have been interpreted as stress-release within the shot contained block and a stress pattern consistent with a dislocation or movement along a nearby fault.

6.2.4 Water Waves

A variety of instruments were emplaced in the oceans surrounding Amchitka for the purpose of documenting the water-wave effects from CANNIKIN (Figure 6-2).

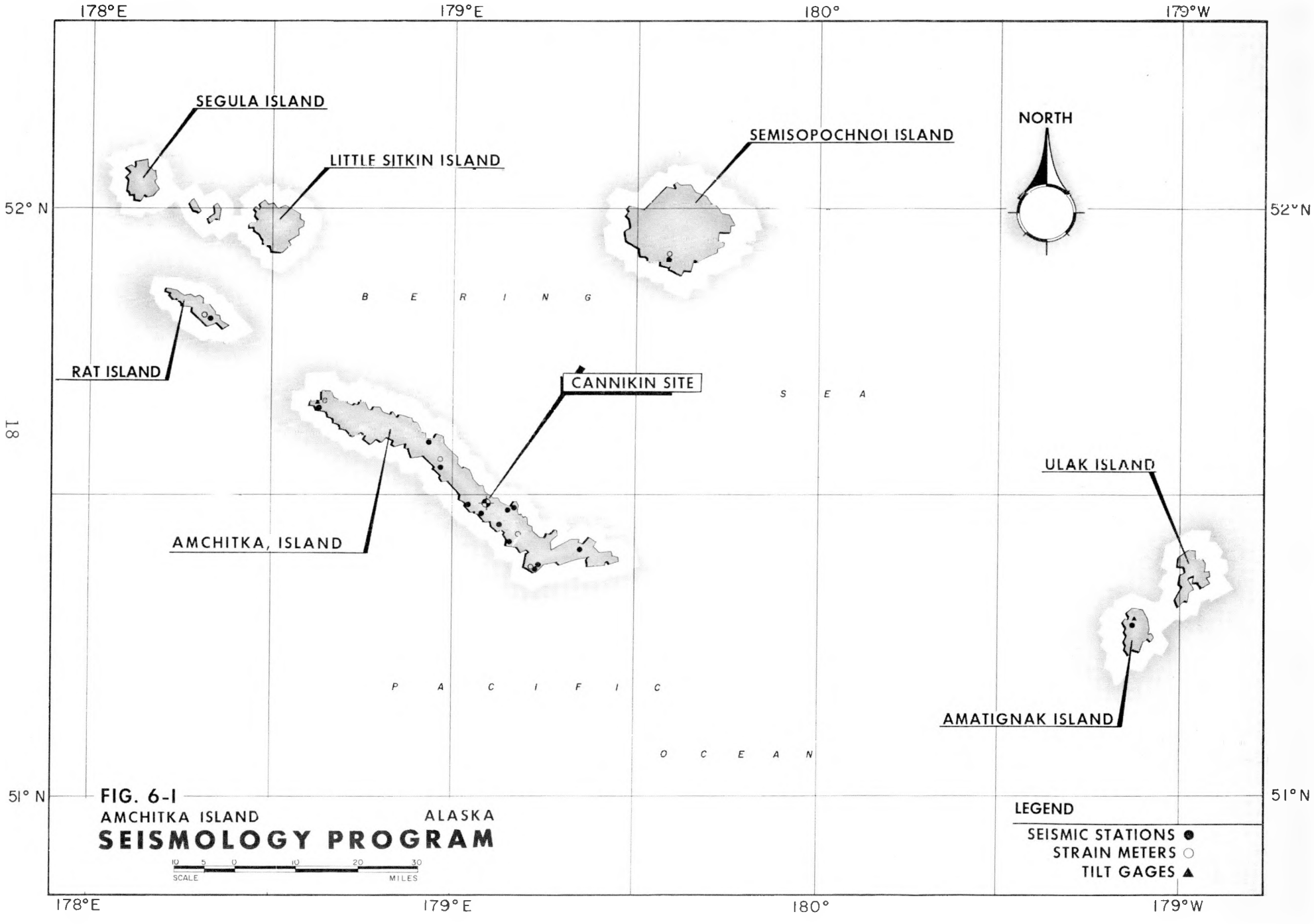


FIG. 6-1

AMCHITKA ISLAND ALASKA

SEISMOLOGY PROGRAM

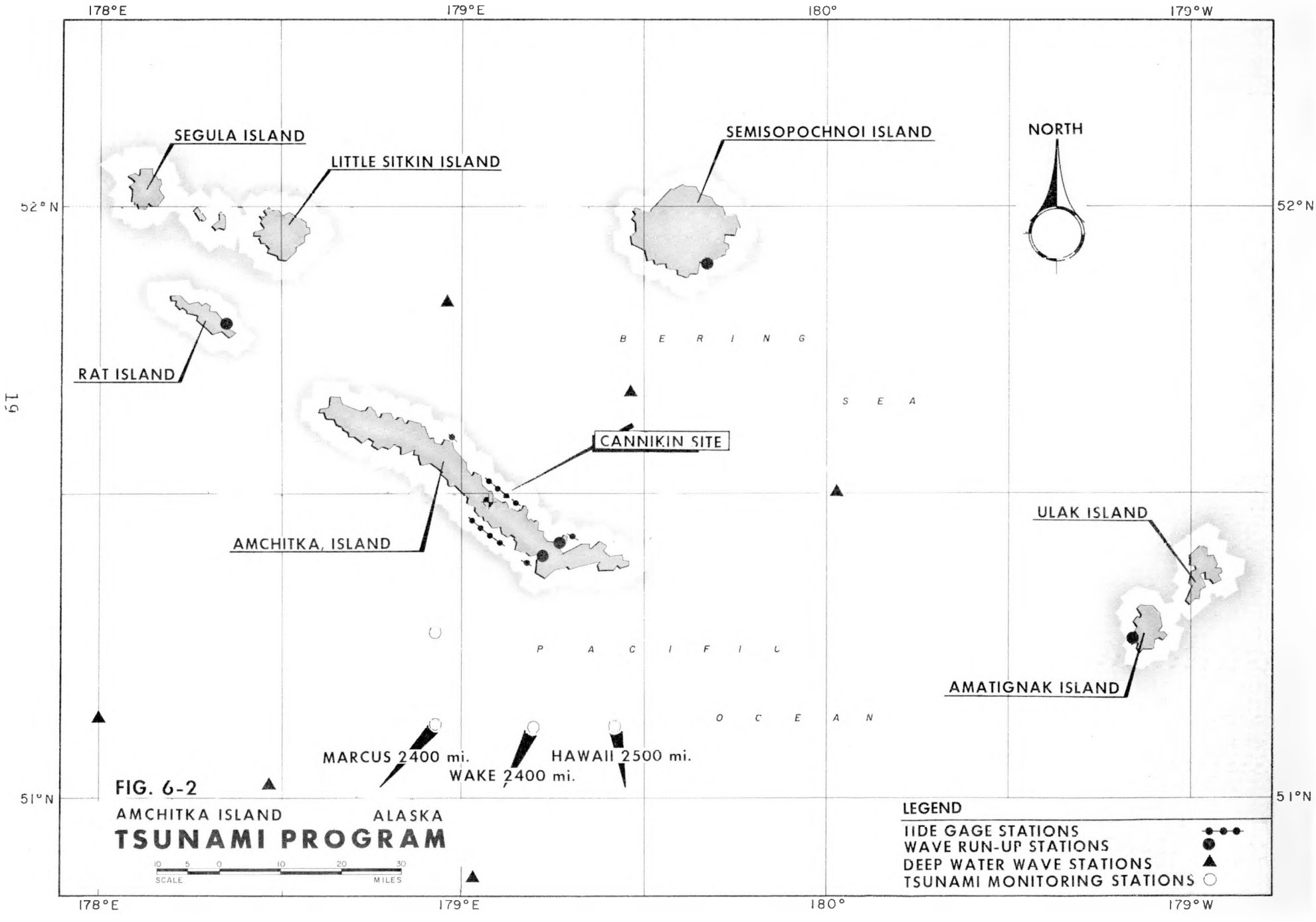


FIG. 6-2

AMCHITKA ISLAND ALASKA

TSUNAMI PROGRAM

Ten tide gauges were deployed along the Bering and Pacific Coasts in 50 to 80 feet of water near the CANNIKIN site. Data from these instruments are currently being analyzed but a preliminary review indicates that the Bering Sea floor at a distance of about 1 1/2 miles northeast of SGZ was permanently uplifted about 1.8 feet. At 5 miles north of SGZ displacement was not detected. Instruments located about 3 miles southwest of SGZ show uplifts of the Pacific floor of 2 to 3 inches.

Six free-fall tide gauges were deployed at distances ranging from 17 to 46 miles on both sides of Amchitka in waters ranging in depth of from 4,000 to 13,000 feet. Only 4 of the instruments were recovered and none of these had recorded any tsunami-like waves, implying that any wave that might have been generated as a result of the sea floor uplift was of the same order or smaller than natural long-period background waves.

Shallow-water gauges located in four bays on Amchitka detected induced seiching which persisted for several hours. The seiche period varied from 10 to 20 minutes, depending upon the bay configuration and depth, and the maximum wave amplitudes were about three to four inches. Similar instruments at Rat, Semisopochnoi, and Amatignak Islands did not record any readily detectable anomalous wave action.

6.3 Surface and Hydrologic Effects

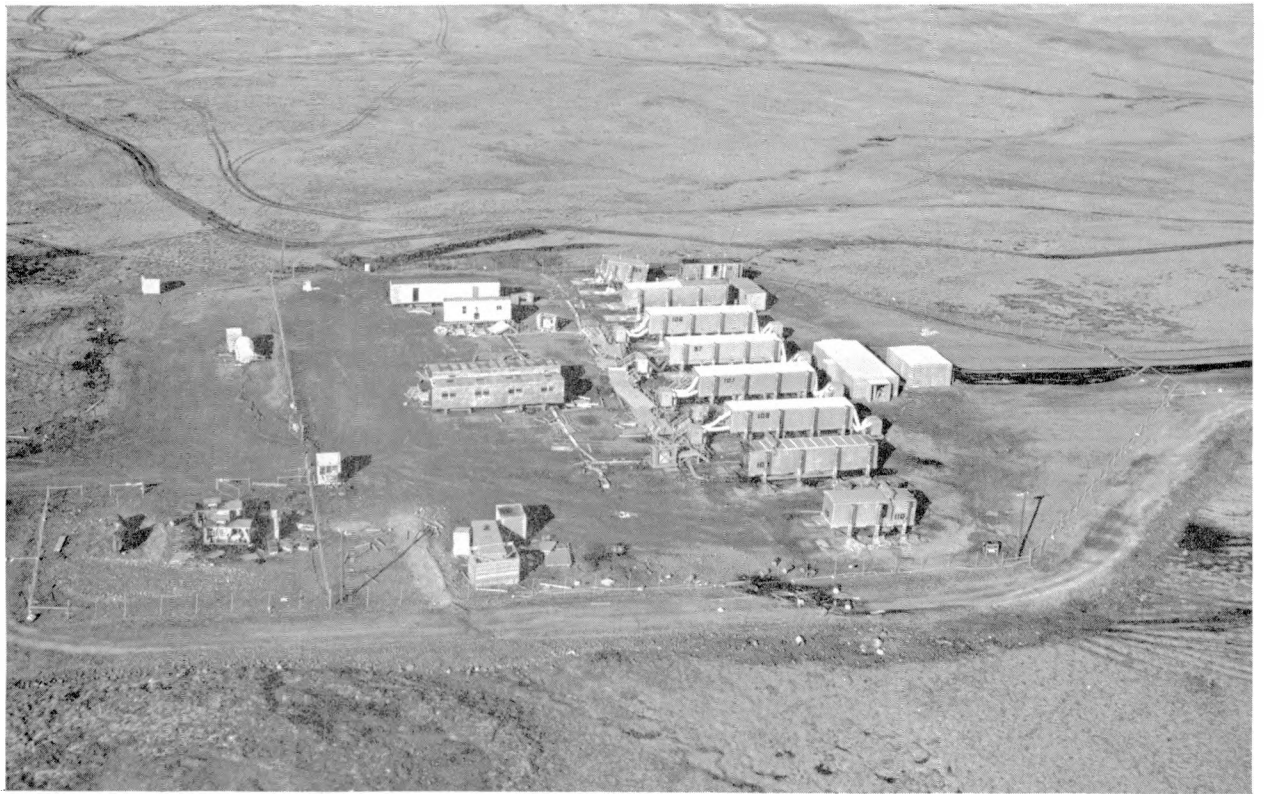
Visible surface effects of CANNIKIN were carefully documented. The tundra surface in the SGZ area was considerably cracked and disturbed. CANNIKIN produced a collapse depression about a mile and one-half across which is roughly triangular in plan and is asymmetrical with respect to SGZ. The sink appears to have formed along a system of preexisting faults or joints. The deepest point of the sink, a small area 1,600 feet easterly of SGZ, is 55 feet lower than its preshot elevation: SGZ itself subsided only about 16 feet. The tundra surface at a distance of two miles northwest of SGZ appears to have undergone a permanent subsidence of about 0.1 foot. A similar displacement was observed 1 1/2 miles to the southeast. The sink has started to fill with surface water to form a shallow lake.

Vertical displacement has been observed on two faults located 2,800 feet north and 2,500 feet south of SGZ respectively. The northerly fault displays an offset along 1,500 feet of its length while the southerly fault shows movement for about 4,700 feet of its length. Maximum vertical displacement on each fault is about 2 feet. No faults at distances greater than one mile from SGZ are visibly offset. A detailed ground survey is being completed.

Four lakes, located 3,000 to 4,000 feet east of SGZ, have drained through cracks in the lake bottoms and one lake, 4,300 feet southwest

FIG. 6-3 (Above) D+1 DAY VIEW OF THE SGZ AREA, LOOKING TO THE NORTHWEST

FIG. 6-4 (Below) ALSO LOOKING NORTHWESTERLY, THE RECORDING TRAILER PARK SHOWS LITTLE EVIDENCE OF THE EFFECTS OF THE DETONATION



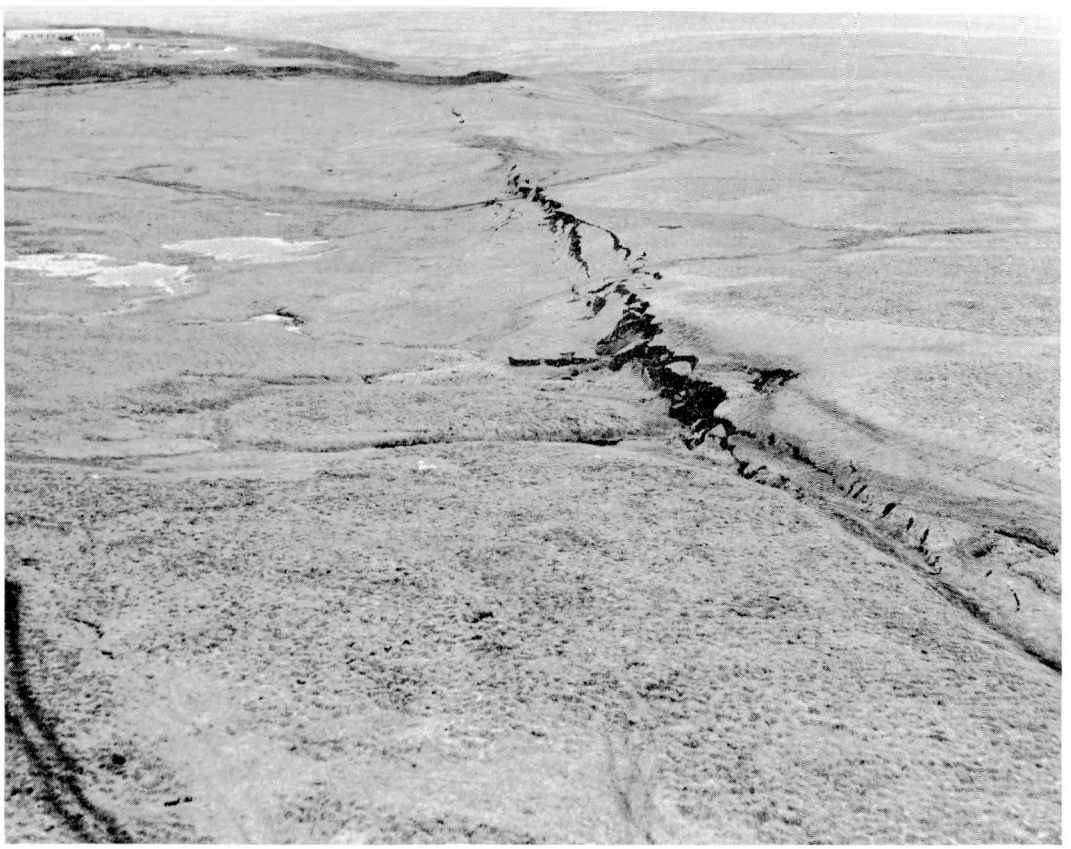


FIG. 6-5 VERTICAL DISPLACEMENT ON PREEXISTING FAULT NEAR SURFACE GROUND ZERO (LOOKING SOUTHEAST)

of SGZ, has been partially drained. Other lakes between two and six miles from SGZ were tilted slightly and have lost some water, indicating minor ground displacement at these distances.

Cliff spall along the Bering Coast was greater than anticipated but was largely confined between the faults mentioned above. Preliminary ground surveys indicate this section of the coast may have been permanently uplifted about four feet. Scuba divers report some undersea rock spall (or rock falls) along a submerged cliff in the same vicinity. No significant spall has been reported on the Pacific Coast although relatively small amounts of rock and turf were dislodged at scattered locations.

A small creek, which had drained the CANNIKIN site at a rate of 1,420 gpm (gallons per minute) preshot, has been reduced to a rate of 60 gpm. Nearly two million gallons of water per day which formerly flowed to the Bering Sea are either forming small lakes in the sink, going into shallow ground storage, or flowing into the collapsed chimney. Five other streams on Amchitka were instrumented for CANNIKIN and all showed a temporary increase in the rate of flow due to the explosion.

Five bore holes were instrumented to measure the aquifer response. All received positive pressure pulses from both the force of the explosion and the cavity collapse. The pressure responses have been decaying slowly since collapse.

Fifty-five water samples were collected from the CANNIKIN, MILROW and LONGSHOT sites after the detonation of CANNIKIN. Preliminary analyses of several of the samples indicate that radioactivity is not above normal background.

The dike of a pond holding drilling mud, about 4.7 miles northwest of surface ground zero, developed cracks from CANNIKIN ground motion, and an estimated 5,000 cubic yards of drilling mud escaped before the cracks were sealed. Most of the mud flowed into a small creek that empties into the Pacific Ocean, with the inflow being at a point about one and a half miles from the ocean. On the basis of other experience, it must be assumed that organisms in the affected portion of the creek were destroyed, but that the creek will experience at least some degree of ecological recovery within a few years.

6.4 Biological Effects

Since CANNIKIN, numerous surveys have been made, and are continuing, in an attempt to observe and record any effects on biota of the Island and its surrounding marine environment. Based upon the effects observed at this time, there will be no permanent harm to the Island's population of any mammals, birds, fish, invertebrates, or plant life.

As of November 28, 1971, a total of 19 dead sea otters had been recovered. (One of these was taken in a bottom trawl at a depth of

FIG. 6-6 ROCK FALLS ALONG THE BERING SEA COAST AFTER DETONATION

180 feet in the Bering Sea, about one and a half miles off shore. It was found 15 days after the detonation and was badly decomposed.) Two additional injured otters were observed in the sea but were not recovered. Also, two abandoned otter pups were seen but not recovered. It is assumed that all of these died, making a total of 23, of which 16 were on the Pacific side and seven on the Bering side. It is unlikely that more explosion-injured sea otters will be found. Of the 19 recovered sea otters, 12 underwent autopsies. Findings indicated that seven were killed by pressure effects in water, two died from rockfalls, and three were fatally injured by vertical acceleration (upthrust of the ground). It should be assumed that these 23 casualties represent only a portion of the otters killed by the detonation. Adverse wind conditions and other factors made 100% recovery of dead or fatally injured animals impossible.

Preliminary visual censuses have indicated a considerably reduced number of sea otters in the Bering Sea off the CANNIKIN site. However, the postshot counts made to date are not adequate to support any final judgments as to the precise degree of population reduction. Weather and sea conditions at this time of the year make reliable population estimates impossible. Weather and sea conditions for otter censusing at Amchitka are generally most favorable during mid-September through mid-October, and annual counts have been made during this period since 1968 by the U.S. Fish & Wildlife Service. Further judgment as to the effect of CANNIKIN on the Island otter population must wait until the 1972 counts, made during the same period, and under comparable conditions, are available.

Four dead seals were found on the beach, and all were autopsied. All apparently died from pressure effects. A survey of Seal Beach, which is about 2.5 miles from CANNIKIN SGZ on the Pacific side of the Island, showed a normal number of seals (about 75) on the beach several days after the detonation.

Concerning marine fish, nearly 300 dead rock greenlings and several specimens of other species were found on the Bering Sea beach adjacent to CANNIKIN SGZ. Several cod and one rockfish were found during Pacific Ocean beach surveys. One dead rockfish was recovered in a bottom trawl at a depth of 120 feet on the Bering Sea side off CANNIKIN SGZ. Immediately postshot, the catch per unit effort (i.e., catch per hour) in the Bering Sea waters up to 300 feet deep off CANNIKIN SGZ was lower in bottom trawl sampling as compared to pre-shot catches in the same areas. At two weeks postshot the number of fish increased in bottom trawl catches from the Bering Sea, which suggests that fish populations in the area were recovering by immigration from surrounding areas. No reduction was noted in the Pacific Ocean trawl catches during this period.

Based upon the beach distributions of dead fishes and the lower catch per unit effort in postshot bottom trawls in shallow Bering Sea waters, it is believed that only some small precentage of the total number of

fish killed was actually collected. Severe weather during and after event time made searches for dead fish on surface waters very difficult. Also, heavy seas and prevailing winds may have carried some dead fish offshore, making it impossible to find and recover them.

Intertidal benthic invertebrates and algae are dying along a short section of uplifted beach adjacent to CANNIKIN SGZ on the Bering Sea coast. Also rock and turf falls have smothered some bottom organisms in this region. Long-term studies of the floral and faunal changes are in progress. Observations (necessarily limited because of unfavorable weather and tide conditions) on the Pacific Coast indicate smaller effects in the intertidal benches than those observed on the Bering Sea side.

A scuba survey of ocean-bottom transects near CANNIKIN SGZ on both the Pacific and Bering sides of the Island showed no significant difference in numbers of sea urchins postshot, as compared to those counted preshot. (This survey was done because urchins are a part of the diet of sea otters.)

Autopsies of 16 dead birds found on the Island (15 on the beach) indicated that all but one died of the effects of the explosion, seven from pressure effects and eight from vertical acceleration. The other bird apparently died of natural causes. No eagles or peregrine falcons were among the dead birds.

Three bald eagle nesting sites along the Bering Coast and two on the Pacific Coast were lost in cliff falls (out of about 100). In addition, another eagle nesting site on each coast appears unstable and subject to weather damage. Eagles often change nesting sites, and it is not believed that the losses will affect the population. No peregrine falcon nesting sites used in 1971 were lost, but one used in 1969 and another, used in 1970, were destroyed.

Large numbers of freshwater fish in lakes near CANNIKIN SGZ were killed from detonation-related causes. Current estimates are that approximately 10,000 three-spined sticklebacks and some 700 Dolly Varden char were killed from all causes. The stickleback is a small (2 to 3 inches in length) freshwater fish which is one of the common food items of the Dolly Varden, a game fish. Some fish were stranded on shore when water was thrown from the lakes by ground shock; others were stranded on the exposed bottoms of lakes that drained after the detonation. Still others found dead in the lake waters were presumably killed by shock effects. The kills are not expected to result in long term damage to these fish populations.

VII ENGINEERING & LOGISTICS

7.1 General

The engineering and logistics activities during the 30-day post CANNIKIN period were primarily concerned with the identification and repair of damaged structures, roads, and other facilities; initiation of the postshot drilling effort; and providing support to the effects evaluation personnel.

Following postshot drilling, the site will be placed in caretaker status. Current AEC planning visualizes that commencing in FY-1973, remobilization for Island clean-up and restoration will be effected.

7.2 Damage to Structures, Road and Base Camp Facilities

A preliminary damage survey of support facilities on the Island except for surface ground zero was conducted on D-day and D+1 day. Measures had been taken before CANNIKIN to protect those facilities most susceptible to damage from ground motion. As expected, only minor damage occurred.

Cracking and sluffing of shoulders occurred on Infantry Road, between mile nine and mile thirteen. Repairs have been completed. The access road to the recording trailer park was repaired to allow the remaining trailers to be removed from the site. The access road to the postshot pad was repaired so that construction of postshot facilities could be accomplished. Boulders were removed along the lower dock road.

Berms at the drilling mud pits, located 4.7 miles northwest from SGZ, had severe cracking and sluffing which resulted in the loss of mud. An 8-inch mud circulating line was broken. Repairs have been completed.

Two minor leaks occurred in the Base Camp piping systems. The water supply to the main camp had been disturbed and produced silty water several days; however, the system has been repaired and checked and now is in satisfactory condition.

The airfield and navigational facilities were restored to operation and were given final FAA approval at 10:00 a.m. on D+1 day.

7.3 Island Population

The total Island population on Amchitka was reduced from 455 persons on D-1 day to a level of 283 on December 1, 1971, and will continue to decline as postshot activities are concluded.

The makeup of the December 1 population mix was as follows:

Construction	0
Maintenance & Operations	95
Camp Operations	32
Postshot Drilling Associated Personnel	86
Misc. Technical Staff	70
Total	283

7.4 Postshot Drilling Status

Postshot drilling commenced on November 27, 1971, and as of December 6 the 36-inch diameter conductor pipe had been cemented to a depth of 20 feet, and the 20-inch casing had been run and cemented to a depth of 267 feet.

As previously noted, postshot drilling is expected to be completed by about March 1, 1972.

7.5 Phase-Down Activities

The Northwest Camp was closed on November 19, 1971.

In the Main Camp, barracks are being closed and winterized as the population drops. Excess vehicles are also being winterized and placed in storage along with other surplus equipment.

The charter air flights from Anchorage to Amchitka were reduced from twice weekly to once a week in late November and early December, and since mid-December have been on an every-other-week basis.

Other major activities have included the loading of the diagnostic trailers and certain other heavy equipment and materiel on a barge for return to the Nevada Test Site.