National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

AUG 31 1998

Reply to Attn of: SD

TO: Federal, State, Local Agencies, and Other Interested Parties

FROM: SD/Senior Program Executive, Mission and Payload Development Division

SUBJECT: Mars Surveyor 1998 Environmental Assessment and Finding of No Significant Impact

The Mars Surveyor 1998 Environmental Assessment (EA) and the Finding of No Significant Impact (FONSI) (NASA Notice 98-114) are enclosed and are being distributed to Federal, State, local agencies, and concerned citizens and organizations that have expressed an interest, as well as selected repositories.

Should you have any comments regarding this EA or FONSI, they must be submitted in writing and received no later than October 5, 1998, and directed to the undersigned at:

Code SD
NASA Headquarters
Washington, DC 20546-0001

NASA will take no action prior to October 6, 1998.

William L. Piotrowski

William L. Piotrowski

Enclosures

Significant issues which have been identified to be addressed in the EIS include but are not limited to impacts to water and air quality, surface and ground water resources, land use, prime and unique farmlands, public health, cultural and biological resources, threatened and endangered species, recreation, and environmental justice.

Accordingly, specific purposes were developed to focus water supply scenarios and to establish criteria to be used by decision-makers in judging the alternatives during the NEPA process. Project alternatives considered for the environmental impact studies should protect and maintain sustainability of the Mesilla aquifer, and extend the longevity of the Hueco aquifer by limiting ground water depletions and by implementing aquifer storage.

Project alternatives should provide year-round drinking water supply from the Rio Grande Project of sufficient quantity and quality to meet anticipated municipal needs. Alternatives considered in the NEPA process should meet year 2030 M&I needs of Hatch, Las Cruces, northern and southern Doña Ana County, Anthony/Canutillo area, northwest and northeast El Paso, and areas served by the Canal and expanded Jonathan Rogers Water Treatment Plants. They should also attempt to provide raw drinking water supply with total dissolved solids (TDS) less than 1,000 parts per million (ppm) and sulfates less than 300 ppm since water with higher quantities cannot be conventionally treated. Additionally, project alternatives should also protect and enhance riverine ecosystems, specifically aquatic and riparian habitats; and should facilitate the efficient conveyance of agricultural water and water conservation.

Coordination with the United States Fish and Wildlife Service will ensure compliance with the Fish and Wildlife Coordination Act and section 7 of the Endangered Species Act of 1973, as amended. Cultural resources reconnaissance for the project area will be coordinated with both the New Mexico State Historic Preservation Officer and the Texas State Historic Preservation Officer. Other federal and state agencies, as required, will also be consulted to ensure compliance with federal and state laws and regulations.

3. Scoping Process

The USIBWC and EPWU/PSB will conduct scoping meetings and workshops to obtain information on which to base alternatives to be analyzed in the NEPA process. The USIBWC is the federal lead agency in the NEPA process and development of the EIS. The United States Bureau of Reclamation and United States Fish and Wildlife Service have indicated that they will participate as cooperating agencies pursuant to 40 CFR 1501.6, to the extent possible. Other federal and state agencies may also become cooperators as they are identified during the scoping process.

Three public scoping meetings and workshops for the proposed project will be conducted from 4:00 to 7:00 p.m. MDT on Wednesday, September 16, 1998 at the Gadsden Middle School Cafeteria, 1325 West Washington, Anthony, New Mexico; on Wednesday, September 23, 1998 at the Farm and Ranch Heritage Museum, 4100 Dripping Springs Road, Las Cruces, New Mexico; and on Thursday, September 24, 1998 at Jefferson High School Cafeteria, 4700 Alameda, El Paso, Texas. Comments are encouraged to be sent to the address given in this notice and will be accepted for 60-days following the date of this notice.

The environmental review of this project will be conducted in accordance with the requirements of NEPA, CEQ Regulations (40 CFR Parts 1500–1508), other appropriate federal regulations, and the USIBWC procedures for compliance with those regulations. Copies of the EIS will be transmitted to federal and state agencies and other interested parties for comments and will be filed with the Environmental Protection Agency in accordance with 40 CFR Parts 1500–1508 and USIBWC procedures.

The USIBWC anticipates the Draft EIS will be made available to the public by March, 2000.

Dated: August 20, 1998.

William A. Wilcox, Jr.,

Legal Advisor.

[FR Doc. 98–23804 Filed 9–1–98; 8:45 am]

BILLING CODE 4710–03–P

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

[Notice (98–114)]

National Environmental Policy Act; Mars Surveyor 1998 Missions

AGENCY: National Aeronautics and Space Administration (NASA).

ACTION: Finding of no significant impact (FONSI).

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321, *et seq.*), the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500–1508), and NASA policy and procedures (14 CFR Part 1216 Subpart 1216.3), NASA has made a FONSI with respect to the proposed Mars Surveyor 1998 missions, which would involve two flights to Mars. The baseline plan calls for each of the two spacecraft to be launched aboard a separate Delta II 7425 from Cape Canaveral Air Station (CCAS), Florida, between December 1998 and January 1999.

DATES: Comments on the FONSI must be provided in writing to NASA on or before October 5, 1998.

ADDRESSES: Comments in response to this FONSI should be addressed to Dr. William L. Piotrowski, NASA Headquarters, Code SD, 300 E Street SW, Washington, DC 20546. The Environmental Assessment (EA) prepared for the Mars Surveyor 1998 missions which supports this FONSI may be reviewed at the following locations:

(a) NASA Headquarters, Library, room 1J20, 300 E Street, SW, Washington, DC 20546 (202–358–0167).

(b) NASA, Spaceport USA, Room 2001, John F. Kennedy Space Center, Florida 32899. Please call Lisa Fowler beforehand at 407–867–2497 so that arrangements can be made.

(c) Jet Propulsion Laboratory, Visitors Lobby, Building 249, 4800 Oak Grove Drive, Pasadena, CA 91109 (818–354–5179).

The EA may also be examined at the following NASA locations by contacting the pertinent Freedom of Information Act Office:

(d) NASA, Ames Research Center, Moffett Field, CA 94035 (650–604–4191).

(e) NASA, Dryden Flight Research Center, Edwards, CA 93523 (805–258–2663).

(f) NASA, Goddard Space Flight Center, Greenbelt, MD 20771 (301–286–0730).

(g) NASA, Johnson Space Center, Houston, TX 77058 (281–483–8612).

(h) NASA, Langley Research Center, Hampton, VA 23665 (757–864–2497).

(i) NASA, Lewis Research Center, 21000 Brookpark Road, Cleveland, OH 44135 (216–433–2755).

(j) NASA, Marshall Space Flight Center, Huntsville, AL 35812 (256–544–5549).

(k) NASA, Stennis Space Center, MS 39529 (228–688–2164).

A limited number of copies of the EA are available, on a first request basis, by contacting Dr. William L. Piotrowski, at the address or telephone number indicated herein.

FOR FURTHER INFORMATION CONTACT: Dr. William L. Piotrowski, 202–358–0316.

SUPPLEMENTARY INFORMATION: NASA has reviewed the EA prepared for the Mars Surveyor 1998 missions and has determined that it represents an accurate and adequate analysis of the scope and level of associated environmental impacts. The EA is hereby incorporated by reference in this FONSI.

NASA is proposing to launch the Mars Surveyor 1998 missions, which would deliver a lander and an orbiter spacecraft to Mars. Current plans call for using two Delta II 7425 launch vehicles with a Star 48 upper stage to launch the two spacecraft onto Mars transfer trajectories in December 1998 and January 1999 respectively. The proposed mission design calls for the orbiter spacecraft to be placed into orbit at Mars in September 1999, and the lander spacecraft to be placed on Mars' surface in December 1999. During its mission, the orbiter would map the surface and atmosphere of Mars and serve as a communications relay for the lander mission. The lander would photograph and sample the surface of Mars near the south pole. Neither spacecraft nor the lander would carry radioactive material.

The primary scientific objectives of these missions are to search for evidence of past or present life, understand the climate and volatile history of Mars, and assess the nature and inventory of resources on Mars. These objectives are linked by the influence of water. The missions would map past and present potential water sources and the exchange between subsurface, surface and atmospheric media. While environmental impacts would be avoided by cancellation of the proposed mission, the loss of the scientific knowledge and database from carrying out the missions could be significant.

Of the reasonable launch vehicle alternatives, the Delta II 7425/Star 48 most closely matches the Mars Surveyor 1998 mission requirements, while minimizing adverse environmental impacts within the cost constraints of these missions.

Expected impacts to the human environment associated with the missions arise entirely from the normal launch of the Delta II 7425. Air emissions from the exhaust produced by the solid propellant graphite epoxy motors and liquid first stage primarily include carbon monoxide, hydrochloric acid, aluminum oxide in soluble and insoluble forms, carbon dioxide, and deluge water mixed with propellant by-products. Air impacts would be short-term and not substantial. Short-term water quality and noise impacts, as well as short-term effects on wetlands, plants, and animals, would occur in the vicinity of the launch complex. These short-term impacts are of a nature to be self-correcting, and none of these effects would be substantial. There would be no impact on threatened or endangered species or critical habitat, cultural resources, or floodplains. Accident scenarios have also been addressed and indicate no potential for substantial impacts to the human environment.

The launch vehicles' second stage would be ignited at an altitude of 118 kilometers (74 miles), which is in the ionosphere. Although the second stage would achieve orbit, its orbital decay time would fall below the limit NASA has set for orbital debris consideration. After burning its propellant to depletion, the second stage would remain in low Earth orbit (LEO) until its orbit eventually decays. The second stage is designed to burn up as it reenters Earth's atmosphere. The Mars Surveyor 1998 Project has followed the NASA guidelines regarding orbital debris and minimizing the risk for uncontrolled reentry into the Earth's atmosphere. No other impacts of environmental concern have been identified.

The level and scope of environmental impacts associated with the launch of the Delta II 7425 vehicle are well within the envelope of impacts that have been addressed in previous FONSI's concerning other launch vehicles and spacecraft. No significant new circumstances or information relevant to environmental concerns associated with the launch vehicle has been identified which would affect the earlier findings.

On the basis of the Mars Surveyor 1998 EA, NASA has determined that the environmental impacts associated with the mission would not individually or cumulatively have a significant impact on the quality of the human environment. NASA will take no final action prior to the expiration of the 30-day comment period.

Wesley T. Huntress, Jr.,

Associate Administrator for Space Science.

[FR Doc. 98–23824 Filed 9–2–98; 8:45 am]

BILLING CODE 7510–01–U

NATIONAL ARCHIVES AND RECORDS ADMINISTRATION

Records Schedules; Availability and Request for Comments

AGENCY: National Archives and Records Administration, Office of Records Services—Washington, DC.

ACTION: Notice of availability of proposed records schedules; request for comments.

SUMMARY: The National Archives and Records Administration (NARA) publishes notice at least once monthly of certain Federal agency requests for records disposition authority (records schedules). Once approved by NARA, records schedules provide mandatory instructions on what happens to records when no longer needed for current Government business. They authorize the preservation of records of continuing value in the National Archives of the United States and the destruction, after a specified period, of records lacking administrative, legal, research, or other value. Notice is published for records schedules in which agencies propose to destroy records not previously authorized for disposal or reduce the retention period of records already authorized for disposal. NARA invites public comments on such records schedules, as required by 44 U.S.C. 3303a(a).

DATES: Requests for copies must be received in writing on or before October 19, 1998. Once the appraisal of the records is completed, NARA will send a copy of the schedule. NARA staff usually prepare appraisal memorandums that contain additional information concerning the records covered by a proposed schedule. These, too, may be requested and will be provided once the appraisal is completed. Requesters will be given 30 days to submit comments.

ADDRESSES: To request a copy of any records schedule identified in this notice, write to the Life Cycle Management Division (NWML), National Archives and Records Administration (NARA), 8601 Adelphi Road, College Park, MD 20740–6001. Requests also may be transmitted by FAX to 301–713–6852 or by e-mail to records.mgt@arch2. nara.gov.

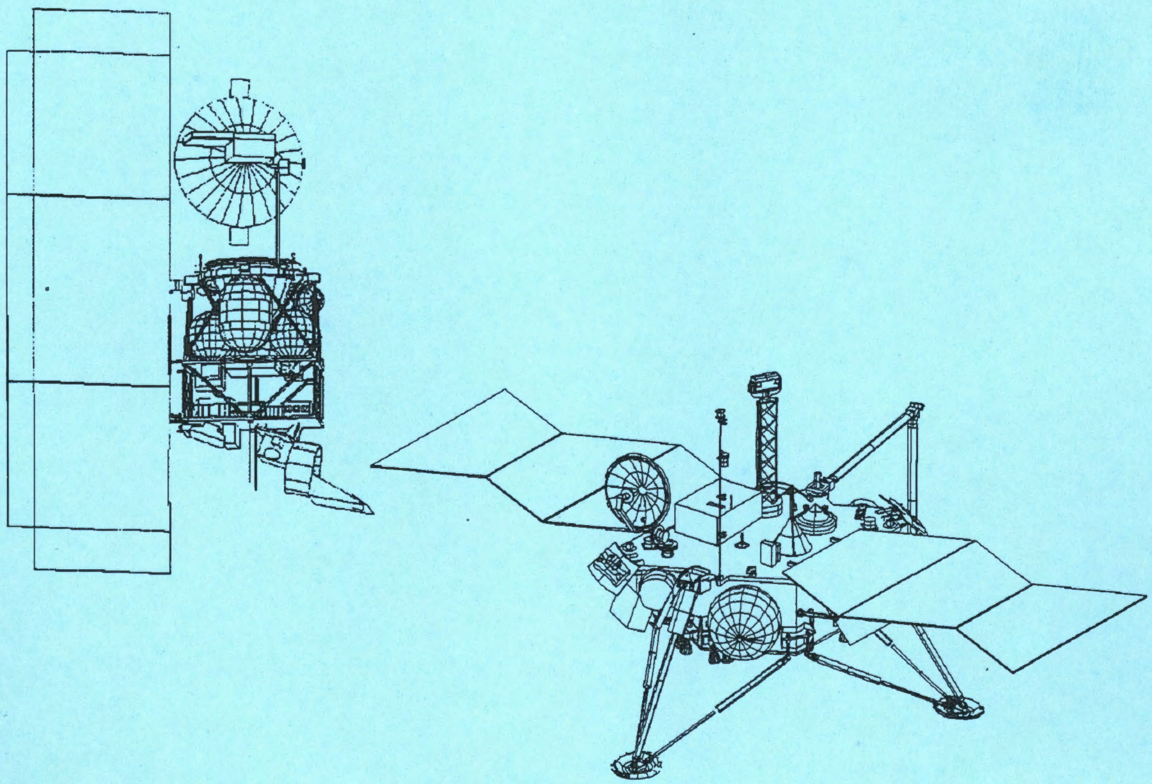
Requesters must cite the control number, which appears in parentheses after the name of the agency which submitted the schedule, and must provide a mailing address. Those who desire appraisal reports should so indicate in their request.

FOR FURTHER INFORMATION CONTACT: Michael L. Miller, Director, Modern Records Programs (NWM), National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740–6001. Telephone: (301)713–7110. E-mail: records.mgt@arch2.nara.gov.

SUPPLEMENTARY INFORMATION: Each year Federal agencies create billions of records on paper, film, magnetic tape,

National Aeronautics and
Space Administration

Mars Surveyor 1998 Environmental Assessment



July 1998

National Aeronautics and Space Administration
Office of Space Science
Mission and Payload Development Division
Washington, DC 20546-0001

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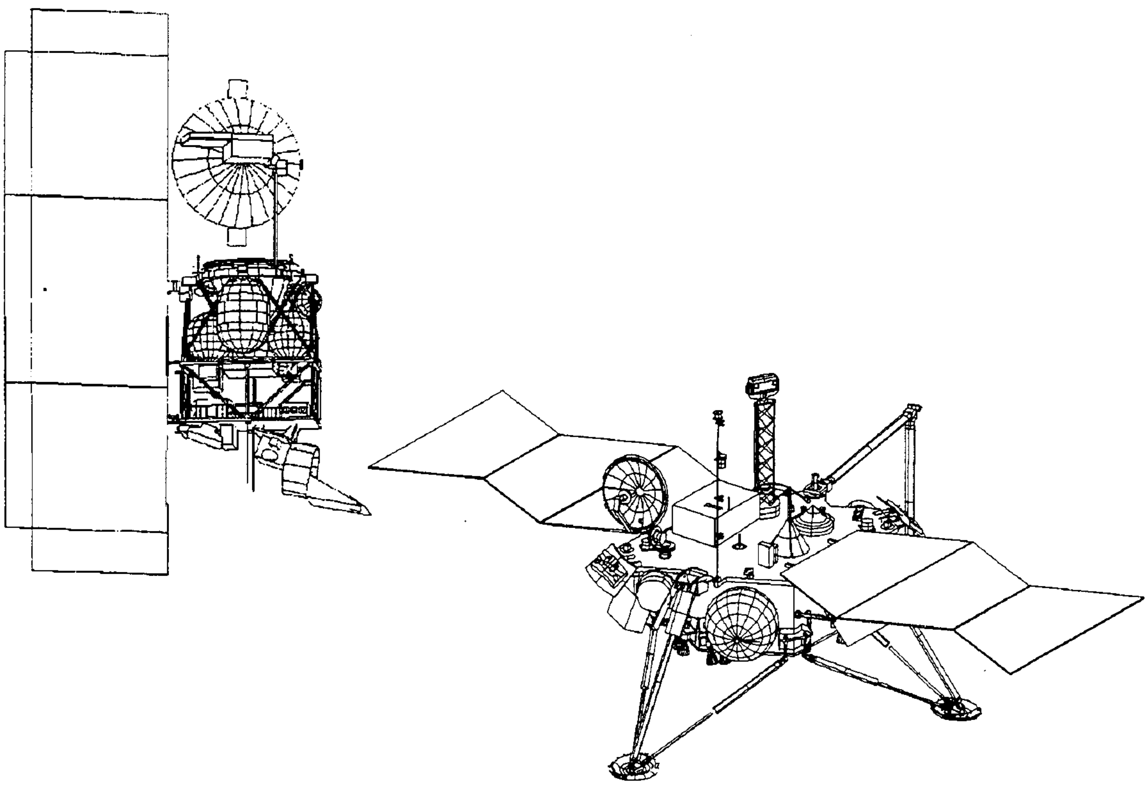
Mars Surveyor 1998
Environmental Assessment



July 1998

National Aeronautics and Space Administration
Office of Space Science
Mission and Payload Development Division
Washington, DC 20546-0001

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ACRONYMS AND ABBREVIATIONS

45SW	45th Space Wing
ACGIH	American Conference of Government Industrial Hygienists
AF	Air Force
AFB	Air Force Base
AFLC	Air Force Logistics Command
AGL	Above Ground Level
AIHA	American Industrial Hygiene Association
Al_2O_3	Aluminum Oxide
AQCR	Air Quality Control Region
BEMC	Brevard County Emergency Management Center
BLM	Bureau of Land Management
C	Celsius temperature scale, carbon
C_3	Injection Energy
CA	California
CAA	Clean Air Act
CCAS	Cape Canaveral Air Station
CCD	Charge Coupled Device
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_2O	glucose
CH_3OH	methanol
CHON	carbon, hydrogen, oxygen and nitrogen
Cl	chlorine
cm	centimeter(s) = 0.01 m = 0.3937 inch
CN	cyanide
CO	carbon monoxide
CO_2	carbon dioxide
CONUS	Continental U.S.
COSPAR	Committee on Space Research, International Council of Scientific Unions
CWA	Clean Water Act
dBA	decibels, A-weighted
DMCO	Delta Mission Check-Out
DOD	Department of Defense
DOI	Department of the Interior
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Office
DSM	Deep Space Maneuver
DSN	Deep Space Network, Defense Switch Network
EA	environmental assessment
EB	Electronics Box

EDL	Entry, Descent, and Landing
EEGL	Emergency Exposure Guidance Level
EO	Executive Order
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
ER	Eastern Range, Emergency Response
ERPG	Emergency Response Planning Guideline
ESE	East-South-East
F	Fahrenheit temperature scale
FCREPA	Florida Commission on Rare and Endangered Plants and Animals
FDA	Florida Department of Agriculture
FDEP	Florida Department of Environmental Protection, Federal Directoriate of Environmental Programs
FDH	formaldehyde
FGFWFC	Florida Game and Fresh Water Fish Commission
FNAI	Florida Natural Areas Inventory
fps	feet per second
FRP	Facilities Response Plan
ft	feet
ft/s	feet per second
FTS	Flight Termination System
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram
GaAs	gallium-arsenide
gal	gallon
GEM	Graphite Epoxy Motor
HCl	hydrogen chloride or hydrochloric acid
HCN	hydrogen cyanide
HCO_3	Bicarbonate
HGA	High Gain Antenna
HNO_3	nitric acid
HPF	Horizontal Processing Facility
HTPB	hydroxyl-terminated polybutediene
IDLH	Immediately Dangerous to Life or Health
IELV	Intermediate Expendable Launch Vehicle
IKI	Russian Space Research Institute
IMU	Inertial Measurements Unit
in	inch(es)
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
K	Kelvin, absolute temperature scale, -273.4 degrees Celsius = 0 K
KSC	Kennedy Space Center

kg	kilogram = 2.2 pounds
km	kilometer = 1 x 10^3 meters = 1,000 meters = 0.62 mile
km/s	kilometers per second
kPa	KiloPascals, unit of pressure
kph	kilometers per hour
l	liter
lb	pound(s)
LBS	Launch Base Support
LC-17	Launch Complex 17, CCAS
Ldnmr	onset-adjusted day-night sound Levels
LEO	Low Earth Orbit
LGA	Low Gain Antenna
LHP	Loop Heat Pipe
LMA	Lockheed Martin Astronautics
LV	launch vehicle
m	meter(s) = 39.37 in
MARCI	Mars Color Imager
MARDI	Mars Descent Imager
MAC	Maximum Allowable Concentration
MET	Meterorology Science Package
mg	milligram
mg/m^3	milligram per meter cubed (mass per volume)
mg/l	milligrams/liter
mg/m*l*	milligram/milliliter
MGA	Medium Gain Antenna
MGS	Mars Global Surveyor
MHz	Megahertz (1 x 10^6 cycles/second = 1 million cycles per second)
mi	mile(s)
mi/s	miles per second
mJ	milliJoule (.001 Joule), unit of energy
MLI	Multi Layer Insulation
MLV	Medium Launch Vehicle
MMP	Mars Microprobes
MOAs	Military Operations Areas
MOI	Mars Orbit Insertion
mph	miles per hour
MPPF	Multi Payload Processing Facility
m/s	meters per second
MSL	Mean Sea Level
MSP	Mars Surveyor Program
MSPSP	Missile System Pre-Launch Safety Plan
mW	milliWatt
mW/cm^2	milliWatt per square centimeter (power per unit area)

$\mu g/m^3$	micrograms per cubic meter (.000001 gram/meter^3)
μm	micron (or micrometer) = 1 X 10^{-6} meter = .000001 meter = 3.937 x 10^{-5} in
μs	microsecond, 1 x 10^{-6} second
N	Newton = 1 kg m/s^2, Nitrogen
N_2H_4	hydrazine
N_2O_4	nitrogen tetroxide
NAAQS	National Ambient Air Quality Standard
NaOH	sodium hydroxide
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCA	Noise Control Act
NCS	Nutation Control System
ND	not detected
NDMA	nitrosodimethylamine
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standard for Hazardous Air Pollutants
NH_3	ammonia
NHL	National Historic Landmark
NHO_3	nitric acid
Nm	nautical mile
NO_2	nitrogen dioxide
NO_x	nitrogen oxides (generic)
NRHP	National Register of Historic Places
NRC	National Research Council
NRCS	Natural Resource Conservation Service, U.S. Dept. of Agriculture
NRD	National Register District
NSI	NASA Standard Initiator
O	oxygen
O_3	ozone
OFW	Outstanding Florida Water
OSHA	Occupational Health and Safety Administration
PAF	Payload attach fitting
PAFB	Patrick Air Force Base
PAM	Payload Assist Module
Pb	lead
PEL	Permissible Exposure Level
pH	level of acidity or alkalinity relative to water
PHSF	Payload Hazardous Servicing Facility
PICA	Phenolic Impregnated Ceramic Ablator
PLF	Payload Fairing
PM-10	particulate matter less than10 microns in diameter
PMIRR	Pressure Modulator Infrared Radiometer
ppb	parts per billion

ppm	parts per million
PPE	Personal Protective Equipment
ppt	parts per thousand
PSD	Prevention of Significant Deterioration
psf	pounds per square foot
PVFD	Polyvinylidene Difluoride
RA	Robotic Arm
RAC	Robotic Arm Camera
RCRA	Resource Conservation and Recovery Act
RCS	Reaction Control System
REEDM	Rocket Exhaust Effluent Diffusion Model
RF	radio frequency
ROI	Region of Influence
RP-1	thermally stable kerosene fuel
RSA	Russian Space Agency
S&A	Safe & Arm
SAEF-2	Spacecraft Assembly and Encapsulation Facility-2
SC	Sample Canister
Si	silicon
SLA-561V	Super Lightweight Ablator
SO_2	sulfur dioxide
SOA	Supersonic Operating Area
SPCCP	Spills Prevention, Control, and Countermeasures Plan
SPEGL	Short-term Public Emergency Guidance Level
sq	square
SRM	Solid Rocket Motor
SRP	Safety Review Panel
SSEP	Solar System Exploration Program
SSI	Surface Stereo Imager
SSPA	Solid State Power Amplifier
SSTI	Small Spacecraft Technology Initiative
STEL	Short-term Exposure Level
STP	Sewage Treatment Plant
STS	Space Transportation System (Space Shuttle)
SU	Sensor Unit
SUTTR	South UTTR, includes Dugway Proving Grounds and Wendover Air Force Range
TBD	To be determined
TBR	To be revised
TCM	Trajectory Correction Maneuver
TEGA	Thermal and Evolved Gas Analyzer
TDL	Tunable Diode Laser
TDS	total dissolved solids
TEL	Telecommunications Subsystem

TLV	Threshold Limit Value
TMU	Telemetry Modulation Unit
TPS	Thermal Protection System
TRI	Toxic Chemical Release Inventory
TTU	Thermal Treatment Center
TWA	Time Weighted Average
TWEL	Time-weighted Exposure Limit
UDMH	Unsymmetrical Dimethyl Hydrazine
UHF	Ultra High Frequency
U.S.	United States
USAF	United States Air Force
U.S.C.	United States Code
UST	underground storage tank
UTTR	Utah Test and Training Range
WAFR	Wendover Air Force Range
WNW	West-North-West
WSA	Wilderness Study Area
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

PROPOSED ACTION

This environmental assessment addresses the proposed action to complete the integration and launch of two Mars Surveyor Program 1998 (MSP 98) spacecraft from Cape Canaveral Air Station (CCAS), Florida, during the launch window in December 1998 - to January 1999. The spacecraft would be assembled and tested at Lockheed Martin Astronautics in Denver, CO and shipped to Kennedy Space Center (KSC) for checkout and propellant loading. Each injection stage would be assembled and integrated with the spacecraft at KSC. The integrated spacecraft and their injection stages would then be transferred to Launch Complex 17 (LC-17) on Cape Canaveral Air Station.

The baseline Delta II 7425/PAM-D injection stage vehicles would be assembled in facilities at CCAS before being transferred to LC-17. The Delta II 7425 consists of a liquid bipropellant main engine, a liquid bipropellant second stage engine, and four graphite epoxy motor (GEM) strap-on solid rockets. While most of the check-out of the spacecraft and launch vehicle would be performed at individual integration buildings, operations completed at the launch site would include mating of the spacecraft and upper stage with the launch vehicle, integrated systems test and check-out, launch vehicle liquid propellant servicing, and ordnance installation.

PURPOSE AND NEED FOR THE ACTION

The Mars Surveyor 1998 missions are part of the Solar System Exploration Program (hereinafter the "Program") to the inner planets designed to maintain a sufficient level of scientific investigation and accomplishment so that the United States retains a leading position in solar system exploration well into the next century. The Program consists of a specific sequence of missions, based on technological readiness, launch opportunities, rapidity of data return, and a balance of scientific disciplines. The purpose of the MSP 98 mission would be to deliver one spacecraft platform to a low-altitude polar orbit around Mars, and another spacecraft to the surface, where they would collect observations of basic volatiles, including water, and climatological processes of the planet. Additionally, locales where rudimentary forms of life may have existed may be identified. To satisfy this purpose, the MSP 98 mission would support a scientific set of objectives.

Although significant insights into the evolution of Mars have resulted from previous explorations, large gaps in knowledge remain. Detailed global maps and the monitoring of global weather, collected by the orbiter over the period of one Martian year (about two Earth years), would help answer some of the questions about the evolution of Mars. Local lander observations of the polar environment and surface would help place global observations and previous landed observations in context. Such investigations would help scientists better understand the current state of water on Mars, the evolution of the planet's atmosphere, and the factors that led to major changes in the Martian climate. Data collected from this mission would provide insight into the evolution of both Earth and the solar system, as well as demonstrate technological approaches that could be applicable to future Mars missions.

MISSION DESCRIPTION

The two MSP 98 missions are part of the robotic exploration of Mars. The MSP 98 orbiter spacecraft, would be placed in a near-circular polar orbit via thruster maneuvering and through the use of aerobraking techniques designed to reduce the amount of propellant required for orbital insertion. The scientific instruments would be activated and begin to map the surface of Mars. The MSP 98 lander spacecraft would deploy two ballistic surface microprobes before entry. It would then enter the atmosphere and be slowed by a heatshield/parachute combination before a propulsive landing near the south pole. The lander science data would be transmitted up to the MSP 98 orbiter spacecraft. The microprobe data would be transmitted to the Mars Global Surveyor (MGS) spaceraft, which is already in orbit at Mars. Data would be downlinked from the two orbiter spacecraft to Earth via the Deep Space Network (DSN). After its mapping phase, the MSP 98 orbiter spacecraft would act as a relay for data from other spacecraft and landed vehicles.

ALTERNATIVES CONSIDERED

Alternatives to the proposed action that were considered included those that: (1) utilize an alternate launch vehicle/upper stage combination, or (2) eliminate the Mars Surveyor 1998 missions (the No-Action alternative).

Alternate Launch Vehicles

The most desirable launch vehicle for MSP 98 would meet, but not greatly exceed, the mission's minimum launch performance requirements. Other considerations in the selection of a launch vehicle include reliability, cost, and potential environmental impacts associated with the use of the vehicle. Of the several alternative US and foreign launch vehicles considered, the Delta II 7425 most closely matches the MSP 98 mission requirements:

- The mass performance of the Delta II 7425/PAM-D most closely matches the MSP 98 performance requirement.

- The Delta II 7425/PAM-D is the more reliable alternative launch system of those systems meeting the MSP 98 performance criteria.

- The Delta II 7425/PAM-D is the lowest cost launch system of those systems meeting the MSP 98 performance criteria.

- Of the reasonable alternative launch systems examined, all were approximately equal in their potential environmental impacts.

No-Action Alternative

The proposed action is to complete the integration and launch two MSP 98 spacecraft. An alternative to the proposed action is No-Action. This alternative would result in termination of the mission, which would disrupt the progress of NASA's Inner Solar System Exploration Program. For Mars, the Program calls for progressively more detailed reconnaissance by spacecraft and robotic explorers. The No-Action alternative would delay or prevent the demonstration of technologies critical to future exploration of Mars. While minimal environmental impacts would be avoided by cancellation of the two launches, the loss of the scientific knowledge and database that could lead to future technological advances would be significant.

SUMMARY OF ENVIRONMENTAL IMPACTS

The only expected environmental effects of the proposed action are associated with normal launch vehicle operation and are summarized below.

Air Quality

In a normal launch, exhaust products from a Delta II launch are distributed along the launch vehicle's path. The quantities of exhaust are greatest at ground level and decrease continuously as the vehicle gains altitude. The portion of the exhaust plume that persists longer than a few minutes (i.e., the ground cloud) is emitted during the first few seconds of flight and is concentrated near the pad area. The ground cloud resulting from a normal Delta II launch is predicted to have a radius of about 20 meters (m) (67 feet [ft]).

Hydrogen chloride (HCl) concentrations in the Delta II exhaust plume should not exceed 5 ppm beyond about 4.3 kilometers (km) (2.7 miles [mi]) in a downwind direction. The nearest uncontrolled area (i.e., general public) is about 4.8 km (3 mi) from LC-17. Appropriate safety measures would be taken to ensure that the permissible exposure limits defined by the Occupational Safety and Health Administration (OSHA) (5 parts per million [ppm] for an 8-hour time-weighted exposure limit) are not exceeded for personnel in the launch area.

To estimate the peak ground level concentrations of ground cloud pollutants, the US Air Force has exercised Delta II exhaust plume diffusion models. Based upon these studies and the distance to the nearest uncontrolled area, HCl concentrations are not expected to be high enough to be harmful to the general population. Although National Ambient Air Quality Standards (NAAQS) have not been adopted for HCl, the National Academy of Sciences (NAS) developed recommended limits for short-term exposure to HCl, ranging from 20 ppm for a 60-minute exposure to 100 ppm for a 10-minute exposure. The maximum level of HCl expected to reach uncontrolled areas during preparation and launch of the Delta II would be well below the NAS recommended limits.

The same predictive modeling techniques used for HCl were also applied to Carbon monoxide (CO) and aliminium oxide (Al_2O_3). CO concentrations are predicted to be less than 2 ppm except for brief periods during actual lift-off. During launch, gases are exhausted at temperatures ranging from 2,000 to 3,000 degrees. Most of the gases then immediately rise to an altitude of about 2,000 feet, where they are dispersed by the prevailing winds. Carbon monoxide gas is expected to rapidly oxidize to carbon dioxide (CO_2) in the atmosphere, and therefore, CO concentrations for Delta launches are not expected to exceed the NAAQS of 35 ppm (1-hour average) beyond the immediate vicinity of the launch complex.

Aluminum oxide (AL_2O_3) exists as a crystalline dust in solid rocket motor (SRM) exhaust clouds, but is inert chemically and is not toxic. However, since many of the dust particles are small enough to be retained by lungs, it is appropriate to abide by NAAQS for particulate matter smaller than 10 microns (PM-10). The maximum 24-hour Al_2O_3 concentration beyond the distance of the nearest CCAS property boundary predicted by the model for a Delta launch was 2.5 $\mu g/m^3$ [USAF 1996]. The NAAQS for emissions of particulate matter should not be exceeded by a Delta II launch due to the short nature of the launch event.

Nitrogen oxides (NO_x) may enter the atmosphere through propellant system venting, a procedure used to maintain proper operating pressures. Air emission control devices will be used to mitigate this small and infrequent pollutant source. First stage propellants will be carefully loaded using a system with redundant spill-prevention safeguards. Aerozine 50 vapors from second stage fuel loading will be processed to a level below analytical detection by a citric acid scrubber. Likewise, nitrogen tetroxide (N_2O_4) vapors from second stage oxidizer loading will be passed through a sodium hydroxide (NaOH) scrubber. These scrubber wastes will be disposed of by a certified hazardous waste contractor.

During the last 20 years there has been an increased concern about human activities that are affecting the upper atmosphere. Space vehicles that use SRMs have been studied concerning potential contribution to stratospheric ozone depletion because of their exhaust products, with the primary depleting component being Hcl. Based on the history of eight Delta II launches per year average for the past eight years, the cumulative stratospheric ozone depletion would be on the order of 2.1×10^{-4} percent (one in 5000) during a twelve-month period.

Since the ground cloud for a Delta II launch is very small (about 100 m or 330 ft) and concentrates around the launch pad, there whould be no substantial acid deposition beyond the near-pad area.

Land Resources

Overall, launching a Delta II vehicle would not be expected to have significant negative effects on the land forms surrounding LC-17. However, launch activities could have some small impacts near the launch pad associated with fire and acidic depositions. Minor brush fires are infrequent by-products of Delta launches, and are contained and limited to the ruderal vegetation within the launch complexes; past singeing has not permanently affected the vegetation near the pads. Wet deposition of HCl could damage or kill vegetation, but would not be expected to occur outside the pad fence perimeter.

Local Hydrology and Water Quality

Water, supplied by municipal sources, is used at LC-17 for fire suppression (deluge water), launch pad washdown, and potable water. The deluge water would be collected in the flume located directly beneath the launch vehicle and flow into a sealed concrete catchment basin, where it would then be disposed of in accordance with applicable federal and state regulations and permit programs. A concrete exhaust flume on each pad deflects exhaust gases away from the pad to reduce the noise and shock wave that result from ignition of solid rockets and the first stage of the launch vehicle. Most of the pad washdown and fire suppressant water would also be collected in a concrete catchment basin, and any propellant release would occur within sealed trenches and should not contaminate runoff. If the catchment basin water meets Federal discharge criteria, it would be discharged directly to grade at the launch site. If it fails to meet the criteria, it would be treated on site and disposed to grade or collected and disposed of by a certified contractor. [USAF 1988]

The primary surface water impacts from a normal Delta II launch involve HCl and Al_2O_3 deposition from the exhaust plume. The ground cloud would not persist or remain over any location for more than a few minutes. Depending on wind direction, most of the exhaust may drift over the Banana River or the Atlantic Ocean. A brief acidification of surface waters may result from HCl deposition. A normal Delta II launch would have no substantial impacts to the local water quality due to amount of water available for dilution.

Ocean Environment

In a normal launch, the first and second stages and the SRMs would impact the ocean. The trajectories of spent stages and SRMs would be programmed to impact at a safe distance from any US coastal area or other land mass. Toxic concentrations of metals would not be likely to occur due to the slow rate of corrosion in the deep ocean environment and the large quantity of water available for dilution.

Spent stages would have relatively small amounts of propellant. Concentrations in excess of the maximum allowable concentration (MAC) of these compounds for marine organisms would be limited to the immediate vicinity of the spent stage. No substantial impacts would be expected from the reentry and ocean impact of spent stages, since the amount of residual propellants is small when compared with the large volume of water available for dilution.

Biotic Resources

A normal Delta II launch would not be expected to substantially impact CCAS terrestrial, wetland, or aquatic biota. The elevated noise levels of a launch are of short duration and would not substantially affect wildlife populations. Wildlife encountering the launch-generated ground cloud could experience brief exposure to exhaust particles, but would not experience any substantial impacts. If the launch were to occur immediately before a rain shower, aquatic biota could experience acidified precipitation. This impact would be expected to be minimal due to the brevity of the small ground cloud and the high buffering ability of the surrounding surface waters to rapidly neutralize excess acidity.

Radioactive Materials

The proposed design of these spacecraft include no radioactive materials. Thus, there is no radiological risk to the health and safety of human life or the environment from these missions.

Threatened and Endangered Species

Any action that may affect Federally listed species or their critical habitats requires consultation with the US Federal Wildlife Service (FWS) under Section 7 of the Endangered Species Act of 1973 (as amended). The US FWS has reviewed those actions which would be associated with a Delta II launch from LC-17 and has determined that those actions would have no effect on state or federally listed threatened (or proposed for listing as threatened), endangered species residing on CCAS and in adjoining waters, or critical habitats.

Population and Socioeconomics

The MSP 98 missions would create negligible impact on local communities, since no additional permanent personnel would be expected beyond the current CCAS staff. Launch Complex 17 has been used exclusively for space launches since the late 1950s. The MSP 98 missions would cause no additional adverse impacts on community facilities, services, or existing land uses.

Safety and Noise Pollution

Normal operations at CCAS include preventative health measures for workers such as hearing protection, respiratory protection, and exclusion zones to minimize or prevent exposure to harmful noise levels or hazardous areas or materials.

The engine noise and sonic booms from a Delta II launch are typical of routine CCAS operations. In the history of USAF space-launch vehicle operations at CCAS, there have been no problems reported as a result of sonic booms. To the surrounding community, the noise from this activity appears, at worst, to be an infrequent nuisance rather than a health hazard.

Cultural Resources

Since no surface or subsurface areas would be disturbed, no archeological, historic, or other types of cultural sites would be expected to be affected by launching the MSP 98 missions.

POTENTIAL LAUNCH ACCIDENTS

Liquid Propellant Spill

The potential for an accidental release of liquid propellants will be minimized by strict adherence to established safety procedures. Post-fueling spills from the launch vehicle will be channeled into a sealed concrete catchment basin and disposed of according to the appropriate state and federal regulations.

The most severe propellant spill accident scenario would be releasing the entire launch vehicle load of N_2O_4 at the launch pad while conducting propellant transfer operations. This scenario would have the greatest potential impact on local air quality. Airborne NO_x levels from this scenario are expected to be reduced to 5 ppm within about 150 m (500 ft) and to 1 ppm within approximately 300 m (1,000 ft). Activating the launch pad water deluge system would substantially reduce the evaporation rate, limiting exposure to concentrations that are above federally established standards to the vicinity of the spill. Propellant transfer personnel would be outfitted with protective clothing and breathing equipment. Personnel not involved in transfer operations would be excluded from the area.[OPlan 32-3]

Launch Vehicle Destruction

In the unlikely event of a launch vehicle destruction, either on the pad or in-flight, the liquid propellant tanks and SRM cases would be ruptured. Due to their hypergolic (ignite on contact) nature, a launch failure would result in a spontaneous burning of most of the liquid propellants, and a somewhat slower burning of SRM propellant fragments. Any such release of pollutants would have only a short-term impact on the environment near the pad.

Launch failure impacts on water quality would stem from unburned liquid propellant being released into CCAS surface waters. For most launch failures, propellant release into surface waters would be substantially less than the full fuel load, primarily due to the reliability of the vehicle destruct system. However, if there were an early flight termination and failure of the vehicle destruct system, it is remotely possible that the entire Stage II propellant quantity could be released to the ocean. Impacts to ocean biotic systems would be localized, transient in nature, and these systems would be expected to recover rapidly, due to the large amount of ocean water available for dilution.

1. PURPOSE AND NEED

The National Aeronautics and Space Administration (NASA) has prepared this Environmental Assessment (EA) for the Proposed Action of preparing for and implementing the Mars Surveyor Program 1998 (MSP 98) missions, including integration of two MSP 98 spacecraft and their separate launches from Cape Canaveral Air Station (CCAS), Launch Complex 17 (LC-17), in December 1998 and January 1999. This EA discusses the mission objectives as well as potential environmental impacts. Possible alternatives to the proposed action are also examined. Among the possible effects that will be considered are air and water quality impacts, local land area contamination, adverse health and safety impacts, the disturbance of biotic resources, socioeconomic impacts, and adverse effects in wetland areas and areas containing historical sites. This document was completed in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321, et seq.), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and NASA's policy and procedures (14 CFR Subpart 1216.3).

1.1 PURPOSE OF THE PROPOSED ACTION

The National Aeronautics and Space Act of 1958, as amended (42 U.S.C. 2451(d)(1)(5)) establishes a mandate to conduct activities in space that contribute materially to "the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space", and to "the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere." In response to this mandate, NASA, in coordination with the National Academy of Sciences (NAS), has developed a prioritized set of science objectives to be met through a long-range program of planetary missions (i.e., the US Solar System Exploration Program). [NASA 1986] These missions are designed to be conducted in a specific sequence based on technological readiness, launch opportunities, timely data return, and a balanced representation of scientific disciplines.

NASA's strategy to carry out this sequence consists of an orderly progression from flyby-type reconnaissance missions, to investigation with orbiters and atmospheric probes, to intensive study involving landars, sample return, and human exploration. In addition, these three phases of planetary exploration are being applied to each of the three regions of the solar system: the inner solar system (terrestrial planets), the primitive bodies (comets and asteroids), and the outer solar system (the gas giants and Pluto). Emphasis in mission selection is on continuity, commonality, and cost-effectiveness.

In 1978, following the successful Viking Orbiter and Lander missions to Mars, the National Academy of Science's Committee on Planetary and Lunar Exploration identified a list of prioritized objectives for post-Viking Mars exploration. In 1983, the Solar System Exploration Committee of the NASA Advisory Council recognized that achieving the major objectives of a Mars exploration program would require establishing and operating long-lived science stations at diverse Martian locations to perform seismic, meteorological, and geoscience measurements. In order to fulfill these objectives in a cost-effective manner, it is imperative that detailed information on the surface and atmosphere of Mars be obtained. [NASA 1986]. Mars Observer was designed to address geoscience and climatology objectives by remote sensing from a near-polar orbit, but failed shortly before arrival at Mars. The MSP 98 orbiter would fly one of the two Mars Observer instruments not flown on the 1996 Mars Global Surveyor (MGS) mission. The MSP 98 lander would land at a different location on the planet than the 1996 Mars Pathfinder (MPF) mission.

The MSP 98 missions support two of the Solar System Exploration Program's primary objectives: (1) to understand the origin, evolution, and present state of the solar system; (2) to understand the Earth through comparative planetary studies. The purpose of the MSP 98 missions are: 1) to place a polar-orbiting spacecraft at Mars in 1997 in order to fulfill part of the remaining critical science objectives of the failed Mars Observer mission and 2) to place a lander near Mars' south pole. To satisfy this purpose, the MSP 98 orbiter would carry one instrument from the Mars Observer instrument payload, and would use that instrument in conjunction with a visible light camera to acquire Mars surface data for a full Martian year (approximately two Earth years). The landed mission would photograph and excavate the surface, examine surface volatiles for their composition and abundance, and monitor the weather for approximately 90 days in the mid-summer season. The lander would carry two deployable probes which would measure the soli characteristics at different landing sites. MSP 98 would provide significant data in support of possible future missions, including relay capability for surface science stations and landars. The instruments and objectives of the MSP 98 mission are described in Section 2 of this EA.

In February 1994, NASA directed the Jet Propulsion Laboratory (JPL) to "plan and implement an aggressive Mars exploration program called the Mars Surveyor Program" [NASA 1994A]. The broad science objectives of such a program are to characterize the Martian environment in terms of atmospheric structure, global atmospheric circulation, surface morphology and geology, surface geochemistry, surface elemental composition, internal planet structure, variations in the Martian gravitational field, and the planet's size and shape. The data obtained by MSP 98, as well as its relay capability, would aid the Mars Surveyor Program in meeting its objectives.

1.2. NEED FOR THE PROPOSED ACTION

Earth and Mars are related inner solar system planets composed of rocky silicate material and possessing substantial atmospheric cover. Mars was one of the first planetary bodies to be extensively studied by telescope; its distance from the earth ranges from 70 to 400 million km (44 to 249 million mi). Mars has a radius of only 3,394 km (2,121 mi), compared to Earth's 6,378 km (3,964 mi), and a weaker gravitational field (only 38 percent that of Earth's).

Previous robotic explorations of Mars have revealed an intriguing world of large mountains and deep canyons, and a surface etched by the erosion of wind and ancient floods. Part of its surface resembles the Earth's moon, and shows massive impact basins, cratered highland regions, and extensive flooding by lavas. Other surface regions resemble Earth's mountains, volcanoes, dried-up riverbeds, desert sand dunes, and seasonal polar caps. Based upon the science collected by these previous robotic missions, it is known that Mars has evolved to an advanced stage, approaching the development level of Earth and that its internal heat may still be producing volcanic activity and outgassing internal gases into the atmosphere.

Mars is the only other terrestrial planet known to have surface-accessible water. Like Earth, Mars has polar caps composed of frozen volatiles, including water. In addition, water may be locked up as ground ice and liquid water below the surface, and adsorbed on minerals or in surface rocks. Although liquid water is not stable under the current conditions on the Martian surface, there is evidence for what may have been large outflow channels across the surface in the past, as well as small, stream-like channels in the ancient crust that are suggestive of surface runoff resulting from rain. The scale of the Martian features has led planetary scientists to theorize that the water must have been recycled for long periods in a hydrologic cycle. Also, these ancient terrains give evidence of lakes or smaller standing bodies of water. Some researchers have suggested the presence of surface oceans on Mars that filled the northern lowlands of the planet, not unlike oceans on Earth. If true, Mars had a warmer and wetter past and has undergone major climatic changes during its history. Knowledge of the distribution, amount, and forms of water on Mars will lead to a greater understanding of the role that water has played in the various geologic processes that shaped its surface. Understanding what has happened to the water on Mars and its relation to major changes in climate thus may have a strong bearing on understanding major climatic fluctuations that have occurred on Earth, such as the ice ages.

Although both Mars and Earth have a long and varied history of mantle activity, there is no evidence of plate tectonics on Mars, and little is known of the chemical composition of its volcanic rocks and lavas. Mars' surface reveals evidence of volcanic, alluvial, glacial, eolian, and tectonic processes that have led to stratigraphic systems, structural relation, and landforms that are generally understandable from a terrestrial perspective.

Mars has an atmosphere with variable cloud patterns, but it is thin (only 1/100 as dense as Earth's), dry, and cold (the average minimum temperature at the equator is -100°C, or about -148°F), and provides little protection from solar ultraviolet radiation, rendering the planet's surface hostile to life as we know it. Mars experiences readily measurable seasonal changes due to the 25° tilt of its axis, which is almost identical to Earth's 23.5° tilt. However, its global atmospheric dynamics, the distribution and transport of vaporized materials during the Martian year, and the structure and photochemistry of the upper atmosphere are not well characterized. Even the existence and strength of an intrinsic Martian magnetic field remain poorly understood.

Every object in the solar system contains part of the record of planetary origin and evolution. These geologic records are in the form of chemical and isotopic 'fingerprints', as well as in the stratigraphic sequences, structural relationships, and morphology of land forms. The exploration of Mars has reinforced the opinion held by the scientific community that many planetary processes, including some that operate on Earth, may be universal.

Significant insights into the evolution of Mars have been gained from previous robotic explorations, but large gaps in scientific knowledge still remain. Detailed data on the Martian atmosphere and surface are needed to help answer some of the questions about the history and current state of water on Mars, the evolution of the planet's atmosphere, and the factors that led to major changes in the Martian climate. The MSP 98 missions would provide data that could possibly answer some of these questions, as well as provide a demonstration of technological approaches that could be applicable to future Mars missions.

The MSP 98 orbiter would obtain global maps of the water content of the Martian atmosphere. The maps could then be used in conjunction with those developed by the MGS mission to evaluate the distribution of water and other volatiles in relation to the age, morphology, emplacement mode, and weathering of the surface material. By focusing on water transport, the mission would make a substantial contribution to the development of a future exploration program. The MSP 98 lander and its probes would obtain local knowledge of the water and chemical content of the atmosphere and the soil at its landing site. Additionally the lander would provide local meteorology data which would allow enhanced interpretation of orbiter data. These could be combined with the local knowledge gained from the Viking landers and the Mars Pathfinder lander. Following the mapping phase of its mission, the MSP 98 orbiter would then be available to serve as a data relay station for signals from other future landed missions.

2. PROPOSED ACTION AND ALTERNATIVES

2.1. PROPOSED ACTION

This section describes the Proposed Action of preparing and implementing the Mars Surveyor 1998 missions, including integration of each of the two MSP '98 spacecraft with a Delta II 7425 launch vehicle, and launch from Launch Complex-17 at Cape Canaveral Air Station. Alternatives to this Proposed Action, including the No-Action alternative, are discussed in Section 2.2.

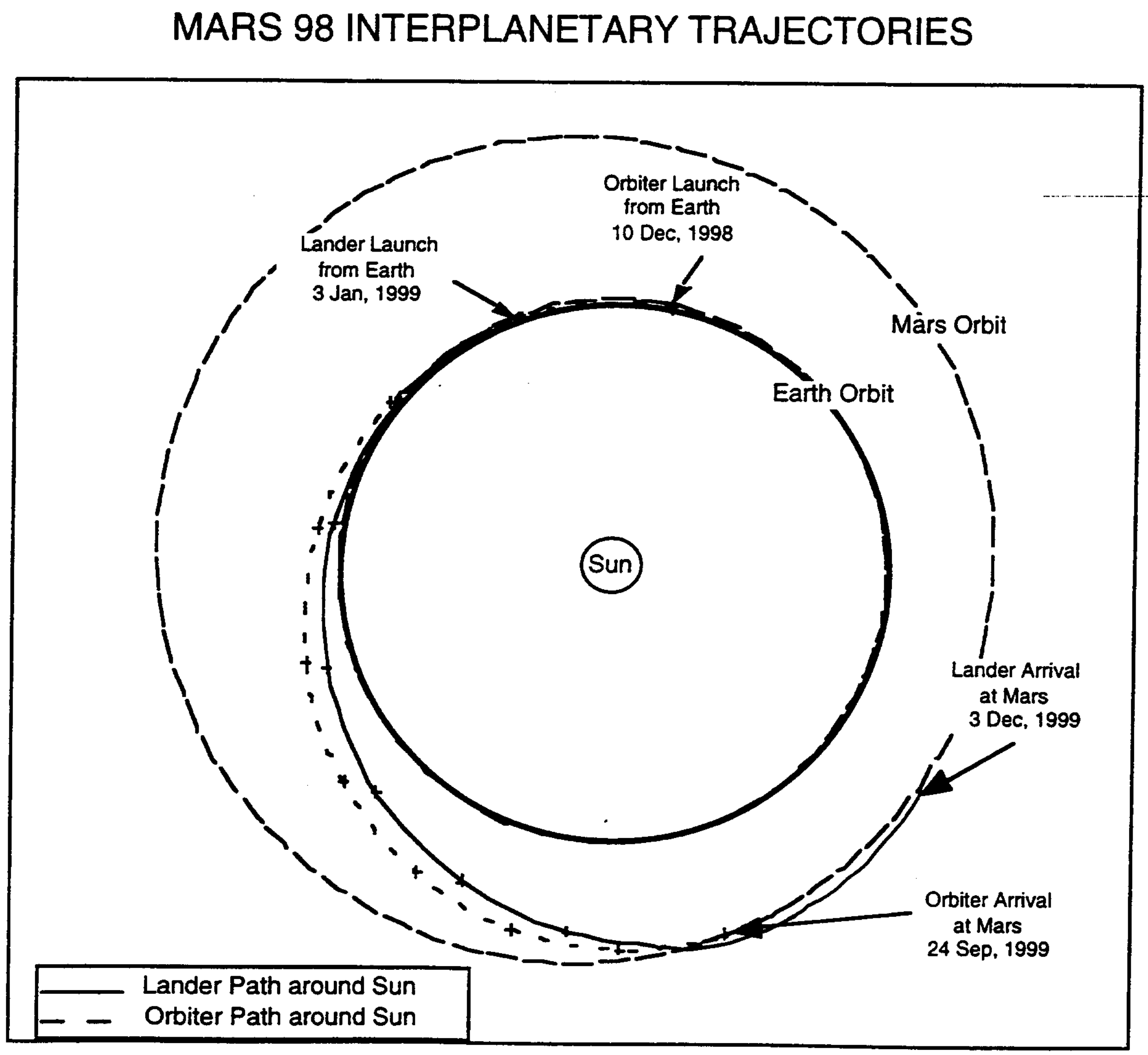


Figure 2-1 MSP '98 Earth-Mars Trajectories for Earliest Launch Date

2.1.1. PROGRAM OBJECTIVES

NASA has initiated a program of Mars exploration, the Mars Surveyor Program (MSP). The highest priority scientific objectives of this program are to:

- Search for evidence of past or present life;
- Understand the climate and volatile history of Mars;
- Assess the nature and inventory of resources on Mars.

The common thread of these objectives is water: past and present sources and sinks; exchanges between subsurface, surface and atmospheric reservoirs; and the change of volatiles over time.

The goal of the MSP is to carry out low-cost missions, each of which provides important, focused, scientific return, and which would in sum constitute a major element of the scientific exploration of Mars. The program would include launches to Mars in opportunities following the 1998 opportunity.

The Mars Surveyor 1998 Program consists of two launch of complementary space vehicles to Mars. The Orbiter and lander would be launched in the same interplanetary transfer window to Mars, as shown in figure 2-1. Following arrival, they would gather science at the same time, allowing the orbital and landed perspective to be be seen in the same physical phenomena. The orbiter would support the lander with a data relay function, without which the lander mission data return is reduced by 1000. The lander mission supports the orbiter mission by physically viewing potential sources for atmospheric water which is sensed by from orbit.

2.1.1.1. Mars Surveyor 1998 Science Strategy

The Mars Surveyor 1998 Missions would directly address the climate history and resource themes of the Mars Surveyor Program, while supporting the life-on-Mars theme through characterization of climate change and its evolving impact on the distribution of water. To accomplish this within the programmatic constraints of cost and affordable launch capabilities, the Mars Surveyor 1998 Orbiter and Lander Missions would utilize the following scientific strategy:

- Use seasonal and diurnal cycles of Dust, Water and Carbon Dioxide to understand <u>processes</u> of climate change over longer time scales;

- Characterize global atmospheric structure and circulation to elucidate roles of <u>atmospheric transport</u> of Volatiles and Dust;

- Land on, and explore, a site having physical evidence of ancient climates, atmospheric evolution and more recent, possibly periodic climate change;

- Locate surface volatile reservoirs and search for local sub-surface volatiles;

- Acquire data needed to validate and extend model simulations of climate processes and climate change;

- Emphasize comparative study of the climates of Earth and Mars and their potential implications for origin and development of life.

2.1.1.2. Mars Surveyor 1998 Science Objectives

Given the scientific strategy outlined above, the major scientific objectives for the Mars Surveyor Program 1998 Missions are to:

- Systematically observe the thermal structure and dynamics of the global atmosphere and the radiative balance of the polar regions, thereby providing a quantitative climatology of weather regimes and daily to seasonal processes;

- Determine the variations with time and space of the atmospheric abundance of dust and of volatile material (i.e., carbon dioxide and water, both vapor and ice) for one full Martian year;

- Identify surface reservoirs of volatile material & dust and observe their seasonal variations; characterize surface compositional boundaries and their changes with time; search for near-surface ground ice in the polar regions;

- Explore and quantify the climate processes of dust storm onset and decay, of atmospheric transport of volatiles and dust, and of mass exchange between the atmosphere, surface and subsurface;

- Search for evidence characterizing ancient climates and more recent periodic climate change.

2.1.1.3. Orbiter Mission Overview

The objective of the MSP Orbiter mission is to deliver a Pressure Modulator Infrared Radiometer (PMIRR) and a multispectral camera assembly, the Mars Color Imager (MARCI) into a low, near-circular, Sun-synchronous orbit around Mars. The Orbiter would also provide relay link support for the playback of MSP Lander science data following Orbiter aerobraking and attaining mapping orbit. The Orbiter would use the Delta II 7425 launch vehicle, and would be launched on a Type II transfer trajectory during the launch period that opens on December 10, 1998. Mars orbit insertion occurs on September 24, 1999, followed by 65 days of aerobraking to achieve the final mapping orbit. Mapping is conducted for a full Martian year (687 days). Landed data relay support will support the MSP98 lander during its approximately 90 day mission, and can be conducted for a total of 3 Earth years in order to support follow-on lander missions. The mapping orbit meets planetary protection requirements. [NASA 1994B]

2.1.1.4. Lander Mission Overview

The lander mission would deliver a payload to the surface of Mars near the south polar cap during the middle of the southern hemisphere summer. The proposed landing site is at 210° West, 77° south, which is a unique region of layered terrain. The mission would include imaging of the landing site during descent using a Mars Descent Imager (MARDI), and imaging of the terain after landing using a Surface Stereo Imager (SSI). A meterology mast (MET) would be deployed which measured wind speed, temperature, and atmospheric water content. A Thermal and Evolved Gas Analyzer (TEGA) would take delivery of soil samples delivered by the robotic arm (RA) and measure their chemical content. Additionally, the robotic arm has a camera which wil take close-up images of the soil structure. The lander mission would launch in a period beginning on 1/3/99, and arrive on 12/3/99. Following landing the mission would last until approximately 90 days, terminating when the polar cap begins to engulf the lander during the southern hemisphere autumn.

2.1.2. ORBITER SPACERAFT

The orbiter, shown in Figure 2.2 in its launch configuration, would be a 3-axis stabilized spacecraft in all mission phases following separation from the launch vehicle. The primary attitude determination uses a star camera and an inertial measurement unit, and is backed up by analog sun sensors. Reaction wheels provide primary attitude control during most mission phases, and are desaturated via Reaction Control System (RCS) thrusters. RCS thrusters also provide attitude control during maneuvers and safe mode. The orbiter Command & Data Handling Subsystem uses the RAD6000 processor. The X-band link with Earth employs Deep Space Transponders, 15 W RF solid state power amplifiers (SSPA's), one high gain antenna (HGA), one medium gain antenna (MGA), and a receive low gain antenna. A UHF system supports the 2-way link with the lander.

The single wing solar array uses GaAs/Ge solar cells and also functions as the primary drag brake during aerobraking. The batteries are NiH2 single pressure vessel batteries, while the electrical power electronics are based on the Smalll Spacecraft Technology Initiative (SSTI) heritage spacecraft electronics. The thermal control subsystem is passive, with louvers to control the temperature of the batteries and SSPA's and combinations of Multi-Layer Insulation

(MLI) and dedicated radiators for certain other components. The orbiter equipment module is a composite truss structure with titanium end fittings and two honeycomb panels with composite face sheets. The solar array and HGA track the Sun and Earth, respectively, with 2-axis gimbals. The propulsion subsystem is dual mode, employing an MGS heritage bipropellant main engine for Mars Orbit Insertion (MOI) and hydrazine Reaction Control System (RCS) hydrazine thrusters for all other propulsive events. Most subsystem components are redundant, with critical items cross strapped.

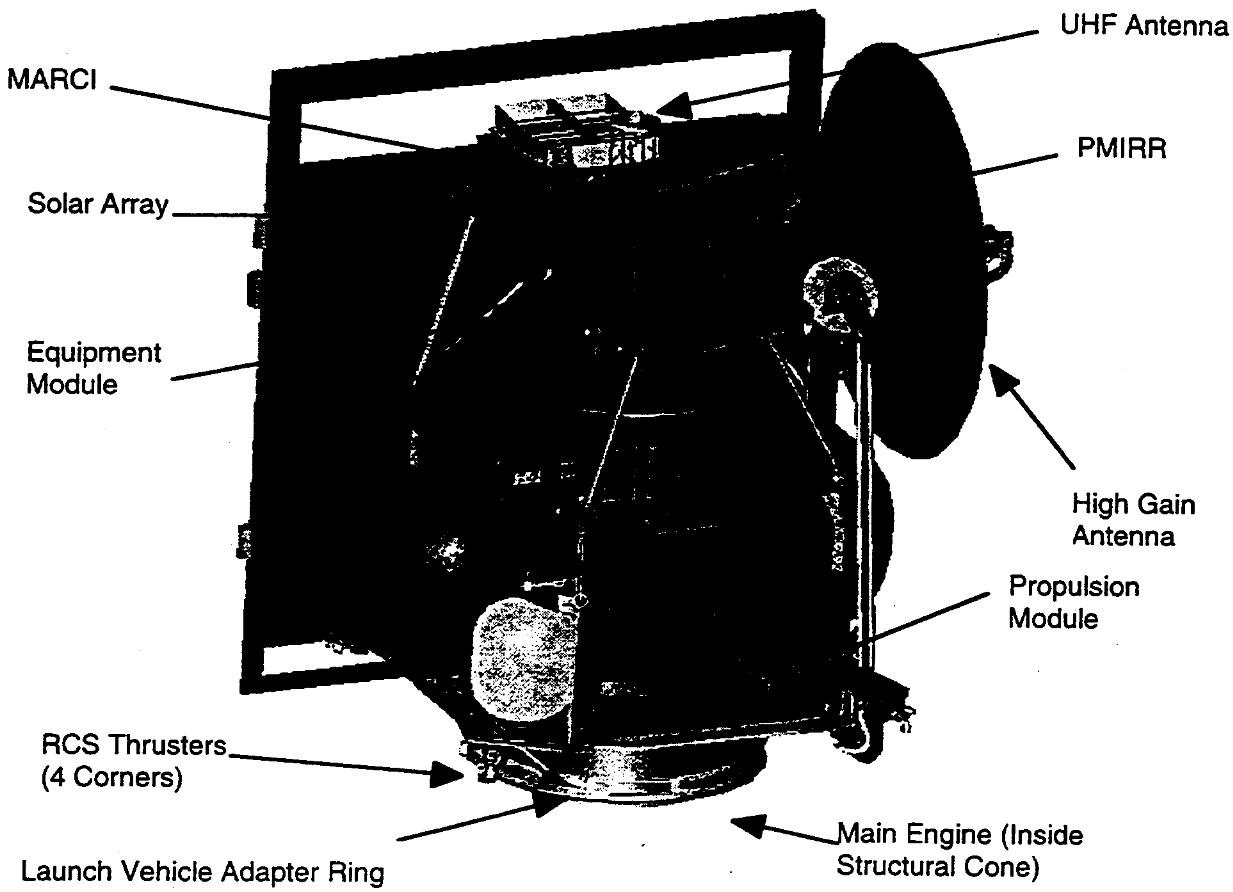


Figure 2-2 MSP '98 Orbiter Launch Configuration

The propulsion module interfaces to the launch vehicle with an adapter ring, and supports the equipment module, the stowed solar array, and the stowed HGA. The top deck of the equipment module is the science deck to which are mounted the fixed PMIRR, the MARCI science cameras, and UHF antennas. Not shown are the thermal blankets that enclose the equipment and propulsion modules.

The orbiter mapping/relay configuration is shown in Figure 2.3. The orbiter instruments and UHF antennas are oriented toward nadir. The instrument viewning axis which defines nadir is canted 5° out of the orbital plane, and 10° away from the HGA to balance the spaceraft. This PMIRR cant was required to accommodate its Field of view and the launch phase spin stability requirements simulaneously. Both the Solar Array and HGA are rotated via their 2-axis gimbals in order to remain Sun and Earth pointed, respectively. Both sets of gimbal are rewound during the eclipse phase. The PMIRR has a thermal radiator which is always on the anti-Sun side of the mapping orbit. The orbiter provides regulated +28 V and 10 V power and ±25 mrad attitude knowledge performance for the science instruments.

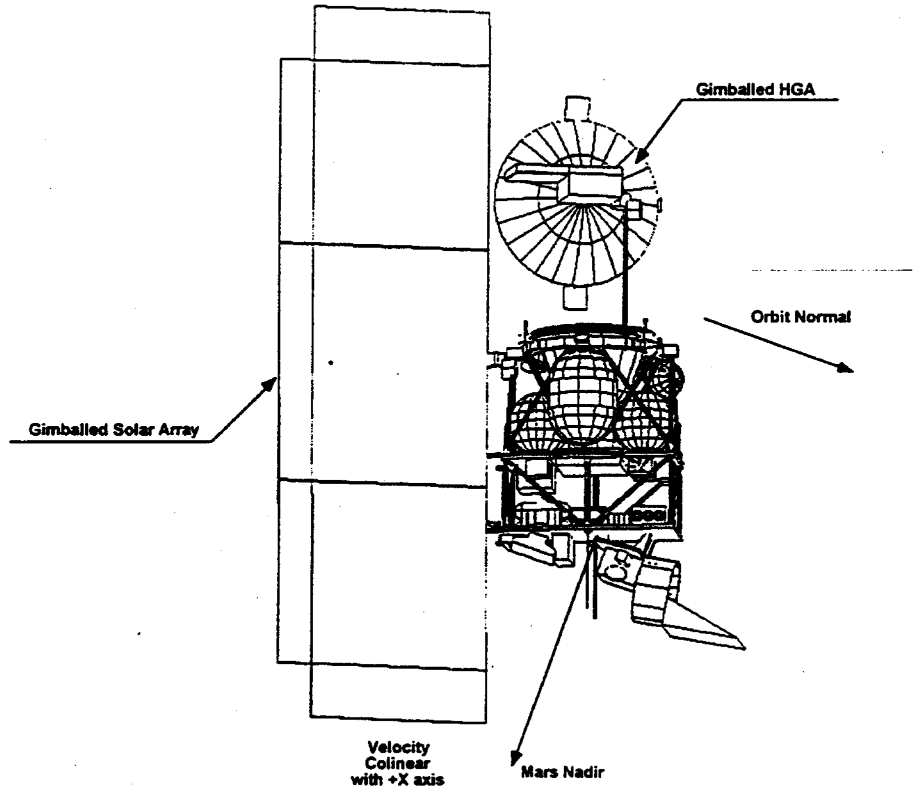


Figure 2-3 MSP '98 Orbiter Mapping Orbit Configuration

2.1.2.1. MSP'98 Orbiter Science Instruments

2.1.2.1.1. Pressure Modulator Infrared Radiometer (PMIRR)

PMIRR would be a nine-channel limb and nadir scanning atmospheric sounder designed to vertically profile atmospheric temperature, dust, water vapor and condensate clouds and to quantify surface radiative balance. PMIRR would observe in a broadband visible channel, calibrated by observations of a solar target mounted on the instrument, and in eight spectral intervals between 6 and 50 μm in the thermal infrared. High spectral discrimination in the 6.7 μm water vapor band and in two parts of the 15 μm carbon dioxide bands is achieved by employing pressure (density) modulation cells in front of selected spectral detectors. Adequate signal-to-noise in these channels is ensured through the placement of their detectors on a cold focal plane assembly cooled to 80 degrees Kelvin by a passive radiative cooler.

No PMIRR science observations would be taken prior to the Orbiter achieving its mapping orbit, when the PMIRR radiator door is fully opened. Once PMIRR is deployed in the mapping orbit, vertical profiles of atmospheric properties are constructed from observations in three fields-of-view (FOV) stepped across the limb and onto the planet using a two-axis scan mirror in front of the primary telescope. Nominally, PMIRR would view the aft limb, referenced to the spacecraft, except for the polar regions where it routinely views in and out of the plane of the spacecraft track to quantify the polar surface albedo by observing much of the bi-direction reflectance distribution function. PMIRR can also view to the side limb, acquiring observations characterized by different local times.

2.1.2.1.2. Mars Color Imager (MARCI)

MARCI would combine Wide Angle and Medium Angle cameras with individual optics but identical focal plane assemblies, data acquisition system electronics, and power supplies. Each camera is small in size (≈ 6 x 6 x 12 cm, including baffle) and mass (< 500 gm). Both cameras operate in a "pushframe" mode, with their CCD detectors overlain with spectral ("color") filter strips. The cameras are electronically shuttered at intervals timed so that the spacecraft motion spatially overlaps each filter strip view, thereby providing a "color" composite.

Near the end of the Orbiter's cruise phase, MARCI would acquire approach images of Mars. Once in the mapping orbit, MARCI provides daily global images of the Mars atmosphere and surface with the wide angle camera, and monitors surface changes with the medium angle camera during mission periods with high data rates.

The wide angle camera would have five spectral bands (including 250 and 330 nanometers, in addition to three conventional color settings) and has spatial resolutions on the planet better than 7.2 km/pixel, for nominal orbital altitude and downlink data rates. Kilometer-scale resolutions are possible, when data rates permit. Limb observations detail the atmospheric structure of clouds and hazes at ≈ 4 km resolution. The medium angle camera has a 6° FOV covering 40 km at 40 m/pixel (nadir) and accessing all areas of the planet (except the rotational poles due to the slight inclination of the spacecraft orbit). Ten spectral channels from 425 to 1000 nm provide the ability to discriminate both atmospheric and surface features on the basis of composition.

2.1.3. LANDER SPACECRAFT

The Mars Surveyor 1998 lander would provide a three-axis stabilized platform cruise and a stable platform for observations of Mars by the science payload. The design borrows for both from Viking and the Mars Pathfinder spacecraft.

The lander flight system would consist of a separable cruise stage with a V–band launch vehicle separation interface and propulsive lander. The configuration of the lander inside the Delta II 9.5 foot fairing is shown in Figure 2.4. The configuration during the cruise to Mars is the same as the launch configuration except for the separation of the fairing and the third stage. A cruise stage, which forms the interface to the PAM-D during launch, is jettisoned just prior to atmospheric entry at Mars. The cruise stage includes equipment needed only in cruise, thus reducing landing weight and increasing payload capability. Cruise stage operational components include redundant star cameras and sun sensors for attitude determination, two solar array wings for power generation, an X-Band medium gain transmit/receive horn antenna and two low gain receive patch antennas and a redundant pair of solid state power amplifiers for telecommunications during cruise. Three–axis attitude control during cruise is provided using a redundant Inertial Measurement Units and four cruise reaction engine modules located on the Lander. The lander structure would meet the planetary protection cleanliness requirements [NASA 1994B].

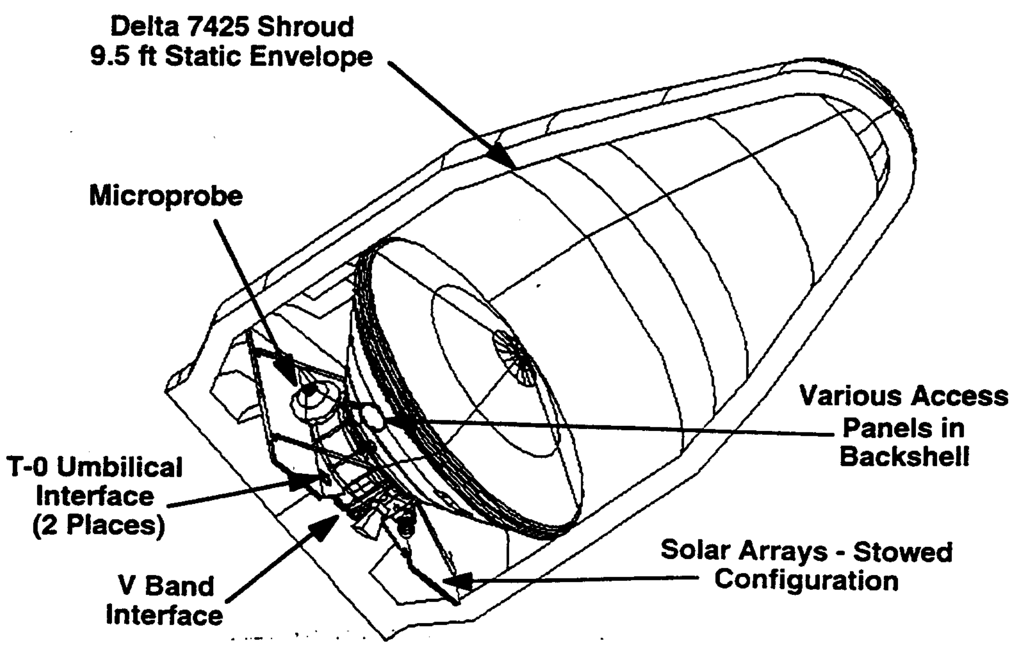


Figure 2-4 MSP '98 Lander Launch Configuration Inside the Delta II 7425 Payload Fairing

Two Mars Microprobes (MMP) would be attached to the cruise stage of the lander and enter the atmosphere separate from the lander itself. The probes would separate from the cruise stage of the 98 Lander shortly after the cruise stage separates from the Lander entry body. Powered exclusively by lithium batteries, the microprobes enter the Martian atmosphere and penetrate the surface of the planet. Over a period of a few days the microprobes relay their data back to Earth through the Mars Relay on the MGS spacecraft.

On impact, each microprobe would penetrate through its aeroshell and anywhere from 0.3 to 1.75 m (1-5.75 ft) into the surface. During penetration, each probe will separate into two sections: a surface (aftbody) module and a subsurface (forebody) module, connected by a 2 m (6.56 ft) flex interconnect cable. Instruments mounted within each probe will collect acceleration data during entry and at impact, atmospheric pressure data, soil water content data, and soil temperature data. A microtransceiver will relay the data to Earth via the 1996 MGS orbiter. The primary mission will last about 50 hours -- two full sols. Depending on the batteries' performance, an extended mission may last an additional 12 sols or more.

The lander 2.4 m diameter heatshield structure and ablator removes velocity upon contact with the martian atmosphere, allowing a parachute to be deployed at an atmospheric relative speed of approximately 500 m/s (1640 ft/s). The Viking-heritage parachute is deployed based on an on-board navigator velocity estimate. The parachute is mortar-deployed to ensure good separation for inflation in the freestream. After parachute deployment the heatshield is separated from the lander, 3 landing legs are deployed, the descent engines are warmed with short firing pulses, and the MARDI and MET experiments begin operating. After a short parachute ride the flight software attitude control algorithms determine the optimum time to release the lander from the backshell/parachute to begin the powered descent phase.

Two diaphragm propellant tanks contain the 64 kg (141 lb) of purified hydrazine propellant used for both cruise maneuvers and attitude control as well as for lander powered descent. This is a pressure-regulated system with serially-redundant pressure regulators utilizing helium gas pressurant. For final descent, a Doppler radar provides accurate altitude and 3–D velocity estimates. Descent control is provided by twelve 266 N retro–engines arranged in three groups of four engines each. As the lander descends to within 12 meters (39.4 ft) of the surface the spacecraft control system begins the 2.4 m/s (7.9 ft/s) constant velocity terminal descent phase.

Landing engines are cutoff when any one of the lander footpads touches the planet surface as shown in Figure 2.5. The lander legs each contain an aluminum honeycomb insert which crushes to soften the landing. The Attitude Control System subsystem controls the orientation of the lander on landing to within 5 degrees of the desired azimuth heading to maximize the solar array efficiency and minimize Direct To Earth antenna blockage. Descent flight software is based on the Viking design.

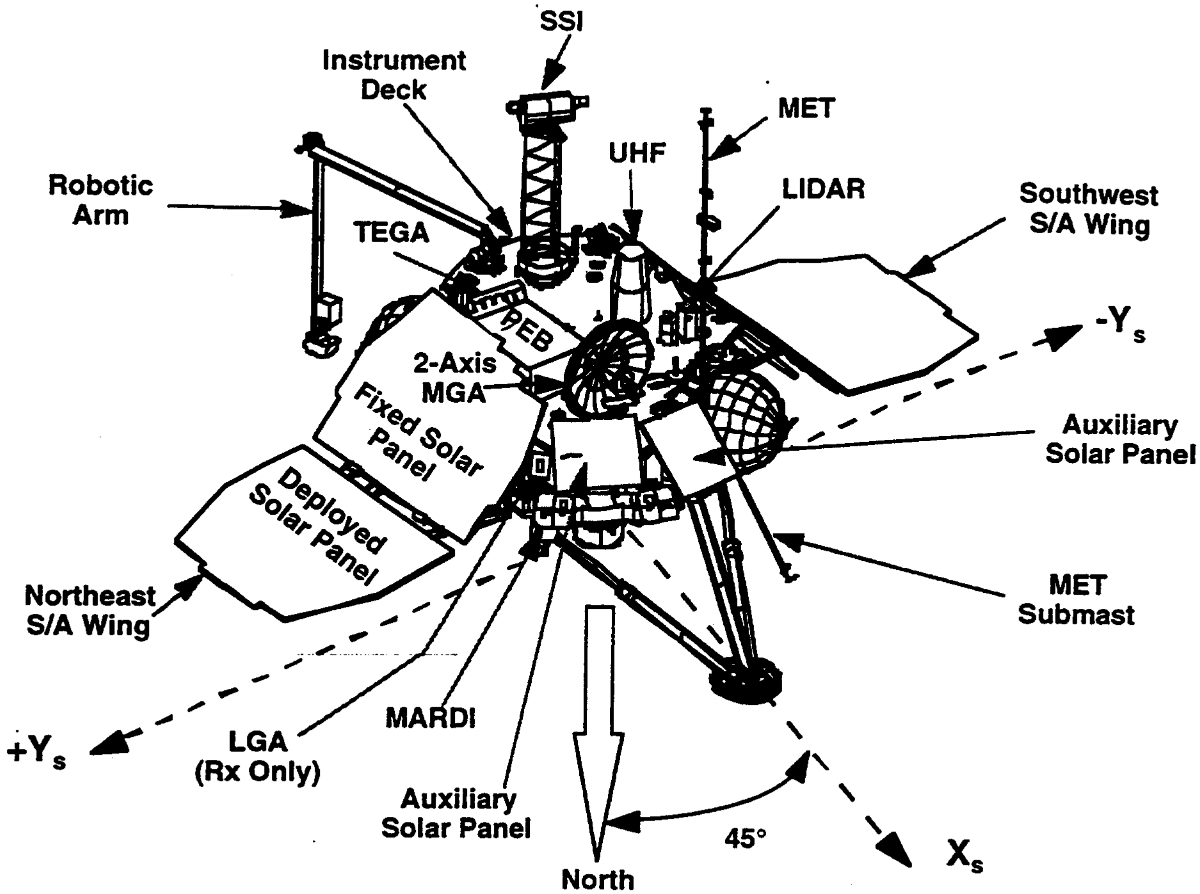


Figure 2-5 MSP '98 Lander Configuration on Mars

The Lander would be constructed using a composite material consisting of honeycomb aluminum core with graphite-epoxy facesheets bonded to each side. A thin aluminum sheet is bonded to the composite to provide a Faraday cage around the thermal enclosure. The design has a thermally isolated component deck inside of a central thermal enclosure to control the thermal environment for spacecraft and Payload electronics. Located within this enclosure is the Command and Data Handling electronics, the Power Distribution electronics, the Nickel-Hydrogen Common Pressure Vessel Batteries, the X-Band and UHF telecommunication electronics, and the Capillary Pump Loop Heat Pipe (LHP) components. Imbedded within the component deck are the LHP evaporators which transfer heat from the aluminum facesheets of the component deck to the LHP radiators located outside of the thermal enclosure. Components used only during Entry are mounted external to the enclosure to maximize volume inside the thermal enclosure for on–surface functions. For the landing footprint of 75° to 78° South latitudes the sun does not go below the nominal horizon for the season of the approximately 90 day prime mission.

A 10° terrain mask is assumed for power analyses and results in a defined day and night interval when the sun goes below the horizon mask. The solar array provides power during the daytime for payload operations and recharges the batteries which provide nighttime heater power for the thermal enclosure. The electronics have a low-power sleep mode to reduce energy consumption at night. The lander lifetime is limited by the size of the batteries. As the nights get longer and colder late in the summer the heater power required at night increases until the demand can no longer be satisfied by the 16 A-hr batteries. The batteries then freeze and the mission ends.

Daytime operations are limited by the size of the arrays and the amount of power required to recharge the batteries. Payload operations are allocated 25 Watts continuous power when operating. The duration of the payload and spacecraft daytime operations varies from approximately 9 hours to less than 2 hours as the summer season ends

The primary telecom link for science data and spacecraft commanding is the daily UHF relay link to the MSP 1998 orbiter. A backup UHF link to the Mars Global Surveyor orbiter is also available. Up to six UHF communication passes above 20° effective terrain mask can occur with both orbiters. An X–band, Direct-To-Earth link with a steerable dish is provided as a transmit/receive backup. The maximum duration of an X-Band transmit event is limited to one hour by the capability of the Loop Heat Pipe to transfer the heat energy from the X-Band Solid State Amplifier out of the thermal enclosure. The number of UHF and X-Band use cycles is limited by the amount of daytime power available.

2.1.3.1. MSP'98 Lander Science Instruments

2.1.3.1.1. Mars Descent Imager (MARDI)

MARDI would include a single camera head consisting of optics, focal plane assembly and support electronics, and housing. Using a megapixel, electronically shuttered CCD, MARDI provides panchromatic images of the landing site for the last 80 seconds prior to landing with a resolution of 1.25 mrad/pixel. Images are taken following jettison of the aeroshell and parachute deployment until landing, a duration of 2 minutes. Under nominal circumstances ten 1000 x 1000 pixel images would be acquired. Taken at altitudes less than 8 km (4.97 mi) above the surface, these images cover areas from 9 km to 9 m (5.6 mi to 29.5 ft) across and at resolutions of 7.5 m to 9 mm (24.6 ft to 0.35 in) per pixel pair

2.1.3.1.2. Stereo Surface Imager (SSI)

The mast-mounted SSI would provide panoramas of the Lander site, characterize the general environment at the landing site, and provide imaging support for other payload elements, especially operations of the RA and TEGA, and for the spacecraft, as needed. The SSI would be essentially a clone of the Mars Pathfinder imager; it is a multi-spectral imager accessing several wavelengths between 0.4 and 1.1 microns. This multi-spectral capability, together with onboard calibration targets, provides true color images. SSI also images magnetic targets on the Lander deck to characterize the magnetic properties of surface material. Narrow-band imaging of the sun provides line-of-sight optical depths of atmospheric aerosols and (slant column) water vapor abundances. Stereo imaging is provided by the dual optical lens systems focusing onto a single CCD.

2.1.3.1.3. Robotic Arm (RA); Robotic Arm Camera (RAC)

A two-meter RA with an articulated end member would be used to dig trenches at the site, to acquire samples of surface and subsurface materials, and to support operations of an attached RA Camera. The RAC would image the surface and subsurface at close range to reveal fine-scale layering if present and to characterize the fine-scale texture of the samples and trench sides. The light-weight RA would also support a probe for measuring surface and subsurface temperatures.

2.1.3.1.4. Meteorological Package (MET)

Mounted on a 1.2-m (3.9 ft) mast, the MET package would include a wind (speed and direction) sensor, several temperature sensors, and Tunable Diode Lasers which measure water vapor amounts and specific isotopes of water and carbon dioxide. A secondary mast (0.9 m in length) is attached to the main MET mast, and supports a wind speed and two temperature sensors near the surface saltation layer. Pressure sensors are mounted within the spacecraft. During descent of the Lander to the surface, the MET sensors are read following parachute deployment and aeroshell release. Once on the surface the MET sensors are read at periodic intervals, as power permits.

2.1.3.1.5. Thermal and Evolved Gas Analyzer (TEGA)

TEGA would use differential scanning calorimetry combined with gas-specific sensors to determine the concentrations of ices, adsorbed volatiles and volatile-bearing minerals in surface and subsurface samples acquired and imaged by the Robotic Arm (RA). The RA deposits the sample on a grated screen over a chute which fills the sample receptacle. This receptacle is then mated with a cover to form the oven in which the sample is heated; a paired (empty) oven provides a calibration for the heating run. Evolved gases are wafted to sensors which quantify the rate of discharge of oxygen, carbon dioxide and water vapor. Once used, the ovens cannot be used again. TEGA is designed to receive eight surface (soil) samples during the Lander mission.

2.1.3.1.6. LIDAR

The LIDAR would be an upward viewing laser mounted on the Lander deck. It would consist of a sensor assembly, an electronics assembly, and the interconnecting cable assembly. The LIDAR would be provided by the Space Research Institute (IKI) of the Russian Academy of Science, under the sponsorship of the Russian Space Agency (RSA).

The LIDAR transmitter would use a pulsed GaAlAs laser diode which emits 400 nJ energy in 100 nsec pulses at a rate of 2.5 kHz and at 0.88 μm wavelength. The LIDAR would have two sounding modes. During active sounding, light pulses are emitted and their return timed in order to locate and characterize ice and dust hazes in the lowest few kilometers (< 2-3 km) of the atmosphere. During passive sounding, sunlight at 0.88 μm is detected and used to characterize optical properties of atmospheric particulates.

2.1.3.1.7. Mars Microprobes (MMP)

The instrument package for the Mars Microprobe Mission is designed to demonstrate valid scientific measurements of both Mars atmospheric conditions and the subsurface soil characteristics obtained by a probe. The instrumentation includes a descent accelerometer to measure atmospheric drag forces on the aeroshell during entry, a high-g tri-axial accelerometer to measure the deceleration of the microprobe forebody upon impact with the surface, an aftbody mounted pressure sensor to record the surface atmospheric pressure, a pair of forebody temperature sensors to measure the rate of cooling of the microprobe after impact, and an experiment to collect a subsurface sample of Martian soil and test for the presence of water.

During the descent of the Microprobe to the surface, the deceleration profile will be used to determine the atmospheric drag forces on the aeroshell. A dual axis accelerometer, on an axis aligned with the penetrator forebody Z axis and the other axis normal to the Z axis, will be sampled at regular intervals and the measurements stored for transmission during the first communications link with Mars Relay orbiter. On impact the deceleration force profile is integrated to provide an estimate of the depth of penetration. A subsurface soil sample will be collected after impact and heated to release any water vapor that may be present. The vapor would flow into a tunable diode laser (TDL) with nominal output wavelength close to a strong water absorption line at 1.37mm (0.53 in). The atmospheric pressure will be measured once every hour for the span of the mission after impact. The pressure sensor is a micro-machined Si membrane with an implanted piezo-resitive bridge. The cool down rate of the forebody after impact provides information on the. Two platinum resistor temperature sensors mounted on the inner metal surface of the probe forebody would be sampled to record the cool down profile.

2.1.4. LINK BETWEEN MSP'98 ORBITER/LANDER SCIENCE PAYLOADS AND MISSION SCIENCE OBJECTIVES

Systematically observe the thermal structure and dynamics of the global atmosphere and the radiative balance of the polar regions, thereby providing a quantitative climatology of weather regimes and daily to seasonal processes

PMIRR provides vertical profiles of temperature and the distributions of the radiatively important dust and ice in the atmosphere and of water vapor. MARCI provides images of cloud morphology and the distributions of dust and ice hazes. Atmospheric waves and weather systems are characterized by observing their distinctive thermal signatures (PMIRR) and, when present, by viewing cloud features (MARCI) and changes in the dust (PMIRR, MARCI), ozone (MARCI) and water vapor (PMIRR) distributions. Atmospheric winds can be derived from the global temperature fields; winds can also be estimated by monitoring changes in the cloud, water vapor or dust fields, when there are distinctive features to be tracked; data assimilation techniques can exploit both data sets to provide an optimum estimate of winds.

PMIRR and MARCI data, separately and in combination, provide key constraints on wavelength-dependent optical properties of the dust and ice hazes, important to computing heating and cooling of the atmosphere and to modelling the resulting circulation. Weather regimes in the south polar region are monitored during late southern spring and summer by the MET in situ measurements at a single surface site of pressure, temperature, wind and water vapor variations; optical depths, haze altitudes, and local saturation state are also quantified by MET, SSI, and LIDAR at this Lander high-latitude site.

Seasonal variations in the polar cap are monitored using the MARCI cameras at their different spatial resolutions and in ultraviolet to visible channels. The radiative energy balance of the polar caps is quantified by the visible band and infrared radiances measured by PMIRR.

Determine the variations with time and space of the atmospheric abundance of dust and of volatile material (i.e., carbon dioxide and water, both vapor and ice) for one full Martian year;

PMIRR provides daily global maps of the vertical variations of temperature, dust and water vapor; MARCI images clouds, dust and ice hazes and ozone (anti-correlated with water). Radiative balance measurements by PMIRR quantify the seasonal variation of carbon dioxide, while images of surface frosts by MARCI elucidate spatial changes. MET, SSI, and LIDAR measurements quantify local changes of atmospheric dust and water vapor at the Lander site for the period from late southern spring into southern summer (no seasonal carbon dioxide frost is expected at this site during this period).

Identify surface reservoirs of volatile material & dust and observe their seasonal variations; characterize surface compositional boundaries and their changes with time; search for near-surface ground ice in the polar regions

MARCI would image surface frost deposits; PMIRR temperature measurements would indicate composition (H_2O or CO_2). MARCI would monitor surface compositional boundaries using the ten spectral channels and medium spatial resolution of its medium-angle camera. PMIRR daily global water vapor measurements and MARCI cloud images may reveal local surface sources of water.

The RA would trench the upper 0.5-1.0 meter (1.64 - 3.28 ft) of the polar layered terrain at the Lander site searching for ground ice or volatile-rich material. Quantitative estimates of the amount of water in the samples acquired by the Robotic Arm is provided by the Thermal/Evolved Gas Analyzer (TEGA).

Explore and quantify the climate processes of dust storm onset and decay, of atmospheric transport of volatiles and dust, and of mass exchange between the atmosphere, surface and subsurface

Imaging the onset of regional and planet-encircling dust storms by MARCI and characterization of the thermal environment before and during dust storms by PMIRR would elucidate the processes of dust storm onset and the environmental conditions which cause them to occur. Transport regionally or over the globe during major dust storms is monitored by mapping the evolution of the dust, and potentially the water vapor, distribution. Near-surface meteorological conditions during dust storms can be monitored by the MET package during the nominal Lander mission, a seasonal period when both local and global dust storms have occurred.

In more clear periods transport of water vapor can be estimated by monitoring the evolving distribution of water vapor (PMIRR), of ice hazes (PMIRR, MARCI), and of temperature (i.e., the saturation state; PMIRR). Exchange of water vapor between the atmosphere, surface and subsurface would be explored in detail at the Lander site by the MET water vapor, temperature, wind and dust measurements for a period when atmospheric water vapor is known to vary rapidly with season. Condensation of water in the atmosphere or at the surface would be observed and quantified using the SSI imaging and LIDAR vertical ranging systems. Temperatures of water frost deposits and subsurface soil would be made by RA using a thermal probe mounted on the Robotic Arm. The abundance of adsorbed water and carbon dioxide in the surface (soil) samples would be determined by the TEGA.

Search for evidence characterizing ancient climates and more recent periodic climate change

The RA would dig a trench at the Lander's site on the south polar layered terrain. The Robotic Arm Camera would image the sides of the trench to determine if the layering seen from orbit (at a best resolution of tens of meters) continues down to the centimeter or even micron (i.e., the suspected annual) scale. The TEGA would analyze surface (soil) samples acquired by the Robotic Arm to detect the presence of volatile-bearing minerals (e.g., carbonates) which may indicate the ancient presence of liquid water.

Tunable Diode Laser systems in the MET package and in its TEGA to analyze concentrations of carbon dioxide and water vapor isotopes in the atmosphere and in gases evolved from the surface samples, respectively, and to elucidate thereby the evolution over time of the Mars climate.

MARDI descent images would yield a detailed geophysical context of the landing site area, on the geologically young polar layered terrains, providing a known and detailed link between orbiter imaging (e.g., MARCI) and landed panoramas (provided by the Stereo Surface Imager). Geomorphic structures and surface textures may reveal erosional or depositional features indicating climatic conditions in the recent past.

2.1.5. LAUNCH VEHICLE [MDSSC 1992]

The Delta II 7425 would be the baseline launch vehicle for the MSP '98 mission. The Delta II launch vehicle (Figure 2.6) consists of a payload fairing (PLF), the first and second stage propulsion systems with four graphite epoxy motors (GEMs) used as strap-on boosters to the first stage, and a Payload Assist Module-Delta (PAM-D) upper stage. The upper stage consists of the third stage motor and and the Payload Attach Fitting (PAF) which is the interface to the spacecraft.

2.1.5.1. Payload Fairing

During ascent, the MSP '98 spacecraft/PAM-D upper stage combination would be protected from aerodynamic forces by a 2.9 m (9.5 ft) payload fairing. The PLF would be jettisoned from the launch vehicle during second stage powered flight at an altitude of at least 111 km (69 mi).

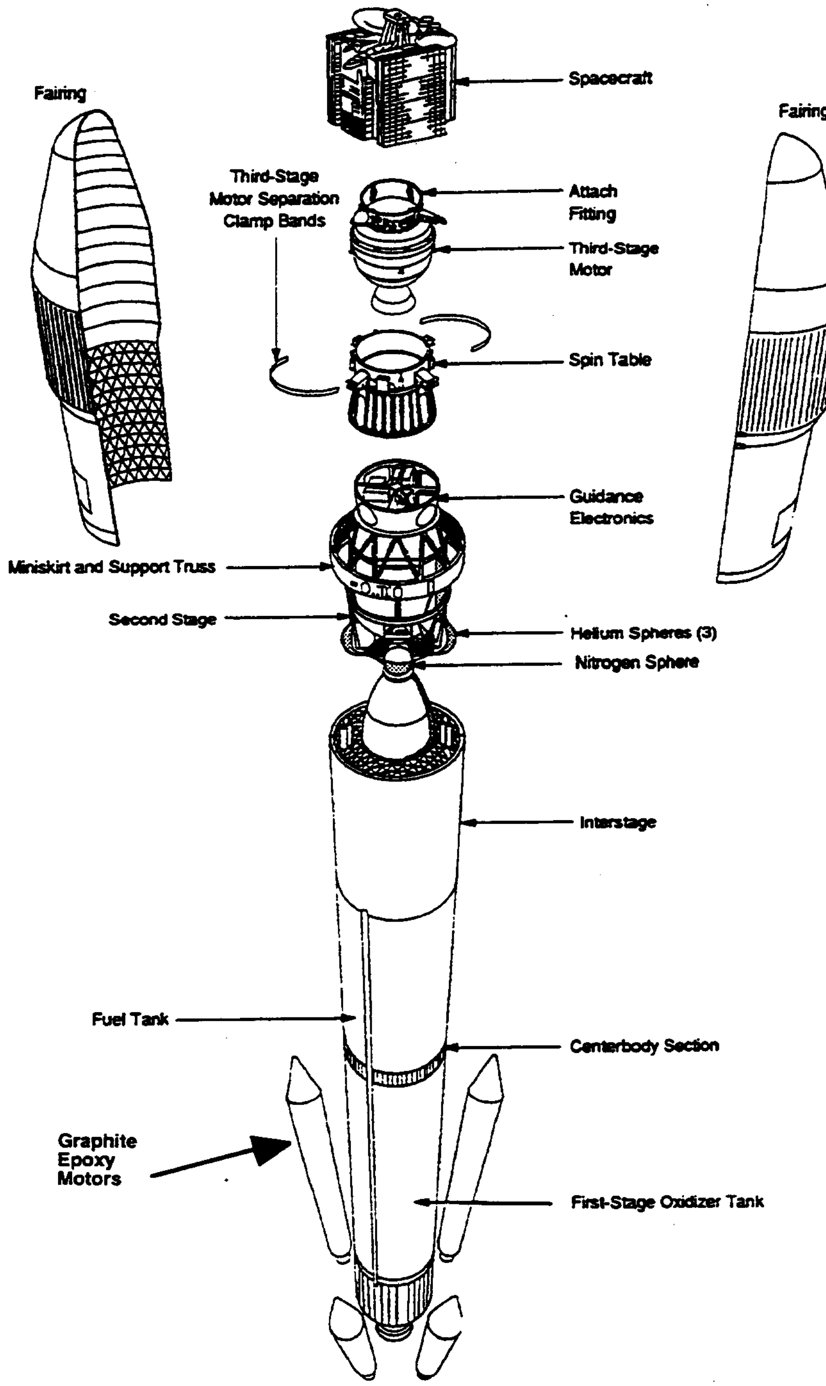


Figure 2-6 Delta II 7425 Launch Configuration (with representative spacecraft)

2.1.5.2. Delta II First and Second Stage

The first stage of the Delta II is powered by a liquid bipropellant main engine and two vernier engines. The first stage propellant load consists of approximately 96,243 kg (211,735 lb) of

RP-1 fuel (thermally stable kerosene) and liquid oxygen as an oxidizer. First stage thrust is augmented by four GEMs, each fueled with 11,870 kg (26,114 lb) of Hydroxyl-Terminated PolyButediene (HTPB) solid propellant. The main engine, vernier engines, and the GEMs are ignited at liftoff. The GEMs are jettisoned after burnout of the solid propellant.

The Delta II second stage propulsion system has a bipropellant engine that uses Aerozine 50 (a 50/50 mix of hydrazine and unsymmetrical dimethyl hydrazine) as fuel and nitrogen tetroxide (N_2O_4) as oxidizer. The second stage has a total propellant load of 6,019 kg (13,242 lb).

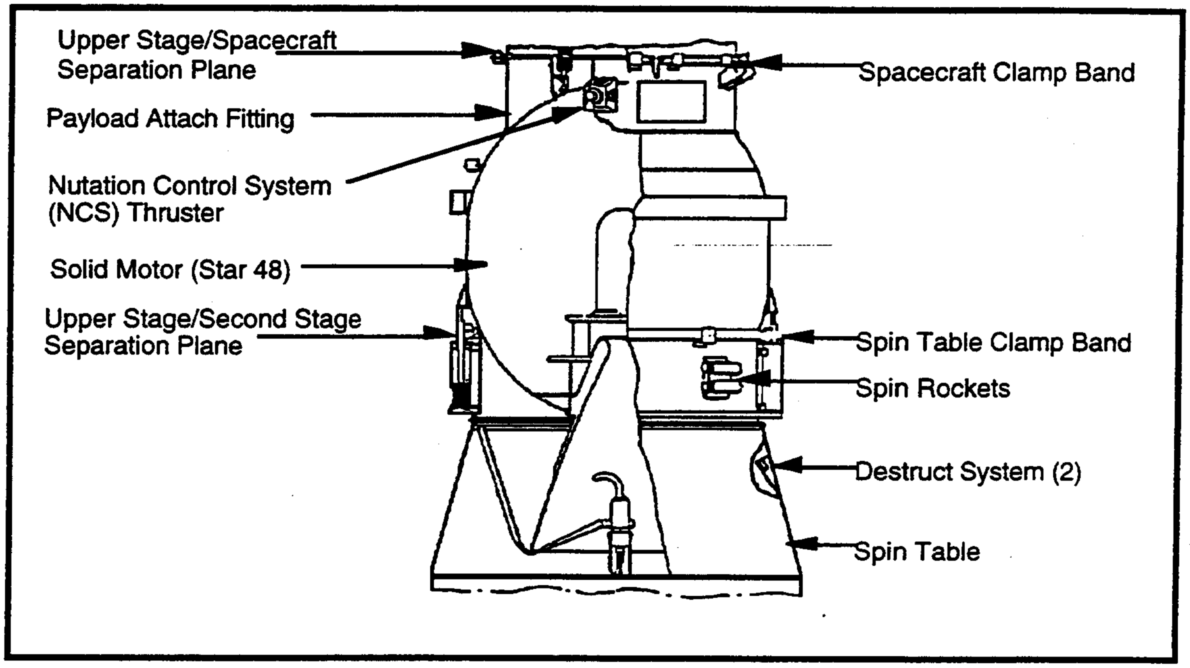


Figure 2-7 Payload Assist Module-Delta (PAM-D) Upper Stage

2.1.5.3. PAM-D Upper Stage

The PAM-D is the third stage of the launch vehicle and provides the final velocity required to insert the MSP '98 spacecraft onto the trajectory to Mars. The PAM-D upper stage (Figure 2.7) consists of: (1) a spin table to support, rotate, and stabilize the MSP '98 spacecraft/PAM-D combination before separation from the second stage, (2) a Star 48B solid rocket motor for propulsion, (3) an active Nutation Control System (NCS) to provide stability after spin-up of the spacecraft/PAM-D stack, and (4) a payload attach fitting to mount the Star 48B motor to the spacecraft. The Star 48B is fueled with 2,010 kg (4,422 lb) of solid propellant. The payload attach fitting, spacecraft separation system, and cabling between the PAM-D and the spacecraft do not remain with the spacecraft after its separation from the upper stage.

2.1.5.4. Flight Termination System

The Eastern Range (ER) Range Safety Office would establish flight safety limits for the trajectory of the MSP '98 launch vehicle. These limits are established to ensure that errant launch vehicles (or debris resulting from a launch failure) do not pose a danger to human life or property. These flight safety limits are determined before launch by calculating the range of possible flight azimuths using predicted values for winds, explosively produced fragment velocities, human reaction time, data delay time, and other pertinent data. During a launch, if the vehicle trajectory indicates that these limits would be exceeded, the ER Range Safety Officer would take appropriate action, including destruction of the vehicle. [EWR 127-1]

As specified by Range Safety requirements, the MSP '98 launch vehicle would be equipped with a Flight Termination System (FTS). This system would be capable of destroying the vehicle based on commands sent from the ER Range Safety Officer. In the event of an unplanned separation of the first and second stages, the FTS would automatically issue a destruct command. This function would be activated when electrical paths between stages are interrupted and stage separation commands have not been issued by the flight computer.

An electromechanical Safe and Arm (S&A) device would be located on each of the first and second stages. Upon activation of the FTS, either by a Range Safety destruct command or by sensing vehicle breakup, the S&A device would enable the power and sequence box to trigger the destruction of the vehicle. The first stage S&A device would be connected to several strands of explosive detonating cord, which is attached to the propellant tanks. When activated, these detonations would rupture the tanks, initiating the rapid burning and dispersion of propellants before the vehicle impacts the ground. The second stage S&A device would be connected to a linear shape charge designed to sever the second stage propellant tanks. This device would also be designed to activate the PAM-D FTS by detonating a set of conical shape charges to rupture the motor and render it non-propulsive. [MDSSC 1991]

2.1.5.5. Launch Vehicle Debris

Delta launch vehicles use containment devices to mitigate the spread of debris generated during staging. Once separated, the Delta II payload fairing, first stage, and GEMs would not achieve Earth orbit. The first stage and GEMs would burn to depletion to avoid potential tank rupture and breakup from over-pressurization caused by solar heating. They would then fall into the Atlantic Ocean. Although the second stage would achieve orbit, its orbital decay time would fall below the limit NASA has set for orbital debris consideration. The second stage is expected to break apart and burn up upon reentry, however, in the event that it does not completely incinerate, its footprint is less thatn NASA's requirement (less than $8m^2$ total footprint) for uncontrolled reentry. After third stage separation, the second stage propellants would burn to depletion. The second stage would then remain in low Earth orbit (LEO) until its orbit eventually decayed. The MSP '98 Project has followed the NASA guidelines regarding orbital debris and limiting the risk of human casualty for uncontrolled reentry into the Earth's atmosphere. [NASA 1997, NASA 1995A] The MSP '98 spacecraft/PAM-D upper stage would be "parked" in LEO for less than one hour before departing on a hyperbolic trajectory to Mars.

2.1.6. CAPE CANAVERAL AIR STATION OPERATIONS (CCAS)

Nearly 200 Delta launches have occurred from CCAS Launch Complex 17 since May of 1960. During this long period of Federally sponsored activities, launch preparation procedures have been well documented, standardized, and continuously reviewed. The MSP '98 launch would be performed by veteran McDonnell Douglas personnel, and the spacecraft supporting personnel would be trained to follow established procedures.

Safe hardware and support equipment would be used to ensure safety for both personnel and equipment during all phases of fabrication, test, and operation. A Missile System Pre-Launch Safety Package (MSPSP) would be prepared in accordance with KSC and Air Force ER Range Safety Office requirements. A Safety Review Panel (SRP) High-Performance Work Team, as specified by Eastern Range Regulation (ERR) 127-1, would be convened and meet as required to review and guide the resolution of safety issues. The SRP would also provide recommended dispositions for the MSPSPs, which would be submitted to the Air Force.

2.1.6.1. Launch Vehicle Processing

The Delta II first and second stages would be initially received, inspected, and stored at Hangar M (Figure 2.8). They would then be moved to the Delta Mission Check-Out (DMCO) Building next to Hangar M for hardware integration and systems testing. The first stage would then be transferred to the Horizontal Processing Facility (HPF) at Complex 17 for installation of the destruct ordnance package, and prepared for erection at the launch site. The second stage would depart the DMCO Building for the LC 17 Area 55 Second Stage Check-Out Building for verification of hydraulic and propulsion systems and destruct ordnance package installation. Both the first and second stages would then be transported to the launch pad for integration and testing. The GEM solid rocket motors would receive all prelaunch processing at Solid Motor Buildup Area 57 (at LC17) before being transported to the launch pad and attached to the first stage. [MDA 1993]

2.1.6.2. Spacecraft Processing

2.1.6.2.1. Planetary Protection Requirements

NASA follows established policy for the protection of planetary environments from contamination by spacecraft, and has obtained international acceptance of this policy through the Committee on Space Research of the International Council of Scientific Unions (NASA 1994B). NASA implements this policy by establishing planetary protection requirements for each applicable mission. The Space Studies Board of the National Research Council has recommended to NASA that spacecraft targeted to Mars without life-detection instrumentation be subject to assembly in an environment with no more than 100,000 particles greater than 5.0 microns in size per cubic foot (3,500 per liter) of air (Class 100,000 Clean Room) to reduce the potential organic contaminants. The MSP '98 Project would comply with all planetary protection policies and requirements specified by NASA and would document compliance in the Mars Surveyor 1998 Planetary Protection Plan.

2.1.6.2.2. Spacecraft Component Assembly and Test Operations

The MSP '98 orbiter and lander spacecraft would be transported separately via escorted surface carrier from Lockheed Martin Astronautics in Denver to KSC enclosed in a reusable shipping container. The solar panels, batteries, and thermal blankets would be transferred under escort separately in an air-ride moving van. The orbiter and its support equipment would arrive at KSC for final assembly in September 1998, and similarly the lander would arrive in October. At KSC's SAEF-2, the component systems and subsystems would undergo testing to verify proper operation prior to loading of the spacecraft propellant tanks. The spacecraft would then be mated to their PAM-D upper stages. The following major component assembly activities would occur in the SAEF-2:

- Electronic ground support equipment check-out
- System test complex check-out
- Spacecraft baseline test to ensure that power, telemetry, science systems, etc., were not damaged in shipping
- Spacecraft propellant loading
- Spacecraft ordnance installation and check-out
- Spacecraft mating with the PAM-D third stage

In late November 1998, the orbiter and its upper stage would be transferred to CCAS LC-17 via the McDonnell Douglas Payload Transport Trailer, mated to the Delta launch vehicle, and final integrated tests with the launch vehicle would be conducted in preparation for the December 1998 launch. The lander would follow the same procedure in late December for an early January 1999 launch.

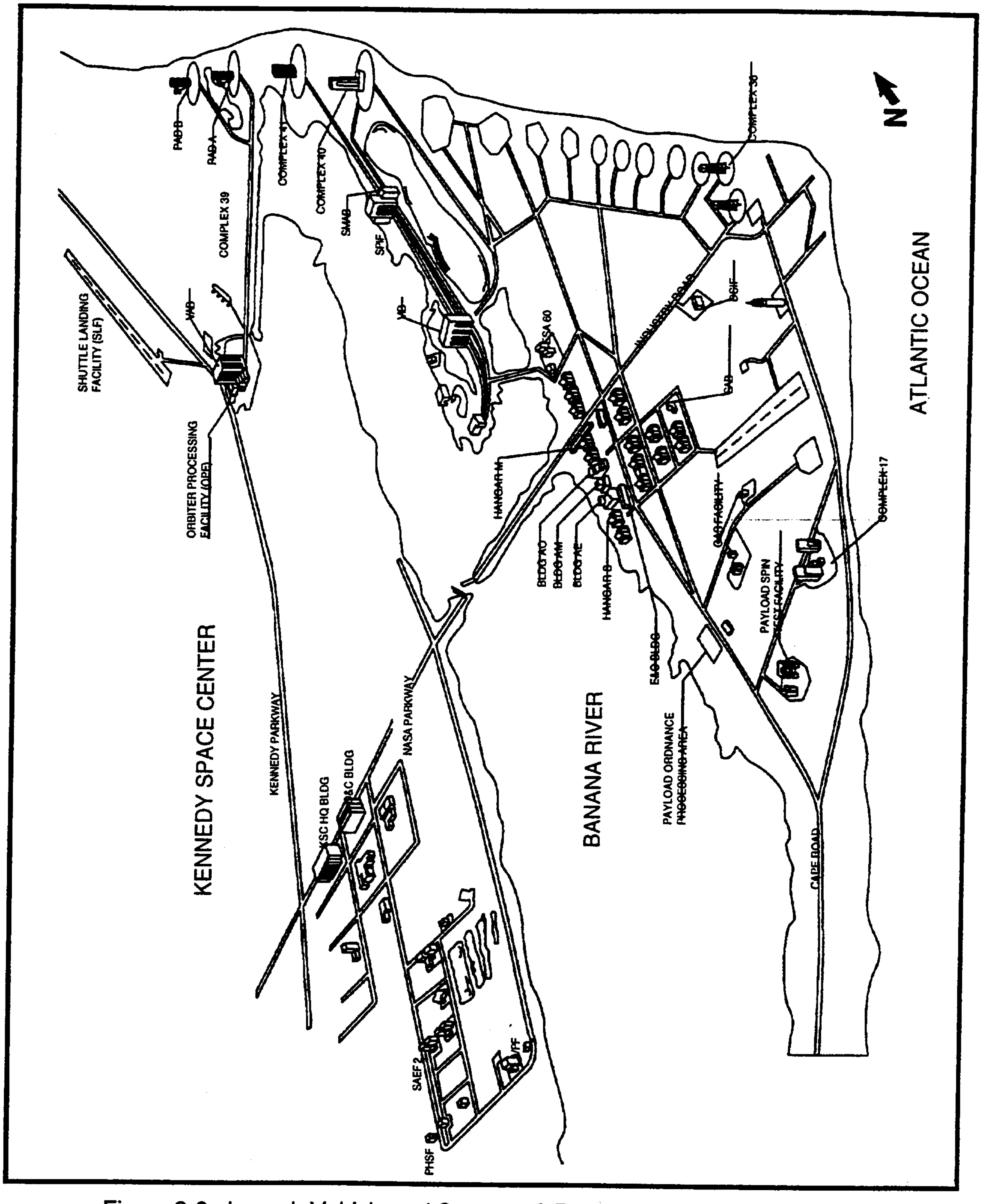


Figure 2-8 Launch Vehicle and Spacecraft Processing Areas, KSC/CCAS

The spacecraft would arrive at the base of the pad , be hoisted to the top of the launch tower payload level, and mated to the launch vehicle. Once mated to the launch vehicle, interface verifications with the launch vehicle, launch rehearsals, and power on/off stray voltage checks would be performed to verify spacecraft compatibility with the launch vehicle. Integrated operations at the pad would also include electrically mating the PAM-D upper stage/spacecraft structure to the Delta II 7425 launch vehicle and final spacecraft functional tests.

2.2. ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to the proposed action that were considered included those that: (1) utilize an alternate launch vehicle/upper stage combination, and (2) cancel the MSP '98 missions (the No-Action alternative).

2.2.1. ALTERNATE LAUNCH SYSTEMS

2.2.1.1. Selection Criteria

Selecting a launch vehicle/upper stage combination (launch system) for a planetary mission largely depends on matching the payload mass and the energy required to achieve the desired trajectory to the capabilities of the prospective launch system. The more massive the payload and the more energy required to achieve the trajectory, the more powerful the launch system required. The most desirable launch system would meet, but would not greatly exceed, the mission's minimum launch performance requirements.

For the MSP '98 mission, constraints on launch system performance are the MSP '98 launch mass of approximately 630 kg (1386 lb) and an injection energy (C_3) of 11.2 km^2/s^2 (4.4 mi^2/s^2). Other considerations which must be addressed in selection of the launch system include reliability, cost, and potential environmental impacts associated with use of the launch system.

Feasible alternative MSP '98 launch systems are potentially available from both foreign and domestic manufacturers. Potential alternative launch systems from foreign manufacturers include the European Ariane and the Russian Molniya and Proton. Potential alternative U.S. launch systems include the Space Transportation System (STS) and various Atlas, Delta, and Titan configurations. [JPL 1993]

2.2.1.2. Foreign Launch Systems

Of the foreign launch systems that are potentially available for the Mars Surveyor 1998 mission, the Ariane 44L and the Russian Proton most closely match the MSP '98 requirements for performance and injection energy. However, both of these vehicles exceed by a wide margin the MSP '98 mission requirements. Therefore, these foreign launch systems are not considered to be reasonable alternatives. The Russian Molniya meets the mission requirements, but current U.S. government policy prohibits the launch of U.S. government-sponsored spacecraft on foreign launch systems.

2.2.1.3. US Launch Systems

2.2.1.3.1. Space Transportation System

The STS greatly exceeds the Mars Surveyor 1998 mission requirements and would not be considered a reasonable alternative launch system.

2.2.1.3.2. Expendable Launch Systems

Potential alternative U.S. expendable launch systems include the Delta II 7325/Star 48, Delta II 7326/Star37, Delta II 7426/Star37, Delta II 7925/PAM-D, and Atlas II/Centaur.

- Neither the Delta II 7325/Star 48, the Delta II 7326/Star37, nor the DeltaII7426/Star37 meet the minimum mass performance criteria, and are not considered as reasonable alternatives.

- The Atlas II/Centaur launch system meets the minimum Mars Surveyor 1998 mission requirements. However, the Delta II 7425/PAM-D system costs approximately 25 million (FY '92) dollars less than the Atlas II/Centaur and has a higher reliability than the Atlas II launch system.

2.2.1.4. Summary

Of the launch systems examined, the Delta II 7425/PAM-D combination is the best-suited for the Mars Surveyor 1998 mission, for the reasons listed below:

- The mass performance of the Delta II 7425/PAM-D most closely matches the MSP '98 performance requirement. [JPL 1993]

- The Delta II 7425/PAM-D is the most reliable alternative launch system of those systems meeting the MSP '98 performance criteria.

- The Delta II 7425/PAM-D is the lowest cost alternative launch system of those systems meeting the performance criteria. [JPL 1993]

- Of the reasonable alternative launch systems examined, all were approximately equal in their potential environmental impacts. [DOT 1986]

2.2.2. NO-ACTION ALTERNATIVE

The No-Action alternative would result in termination of the mission, which would disrupt the progress of NASA's Inner Solar System Exploration Program. For Mars, the Program calls for progressively more detailed reconnaissance by spacecraft and robotic explorers. The No-Action alternative would delay or prevent the demonstration of technologies critical to future exploration of Mars. While minimal environmental impacts would be avoided by cancellation of the two launches, the loss of the scientific knowledge and database that could lead to future technological advances would be significant.

3. GENERAL ENVIRONMENTAL CHARACTERISTICS OF CAPE CANAVERAL AIR STATION AND SURROUNDING AREA

The information provided in this section is summarized from the reference documents cited in the text. Refer to those references for more complete information and maps of environmental resources.

3.1. REGIONAL AND LOCAL ENVIRONMENT

For the purposes of this document, the region of interest (Figure 3-1) consists of the six county area of Volusia, Seminole, Lake, Orange, Osceola, and Brevard counties.

The Cape Canaveral Air Station is located in Brevard County on the eastern coast of Florida, near the city of Cocoa Beach and 75 km (45 mi) east of Orlando. The station occupies nearly 65 square (sq) km (25 sq mi) of the barrier island that contains Cape Canaveral, and is adjacent to the NASA Kennedy Space Center, Merritt Island, Florida. CCAS is bounded by KSC on the north, the Atlantic Ocean on the east, the city of Cape Canaveral on the south, and the Banana River and KSC/Merritt Island National Wildlife refuge on the west (Figure 3-2).

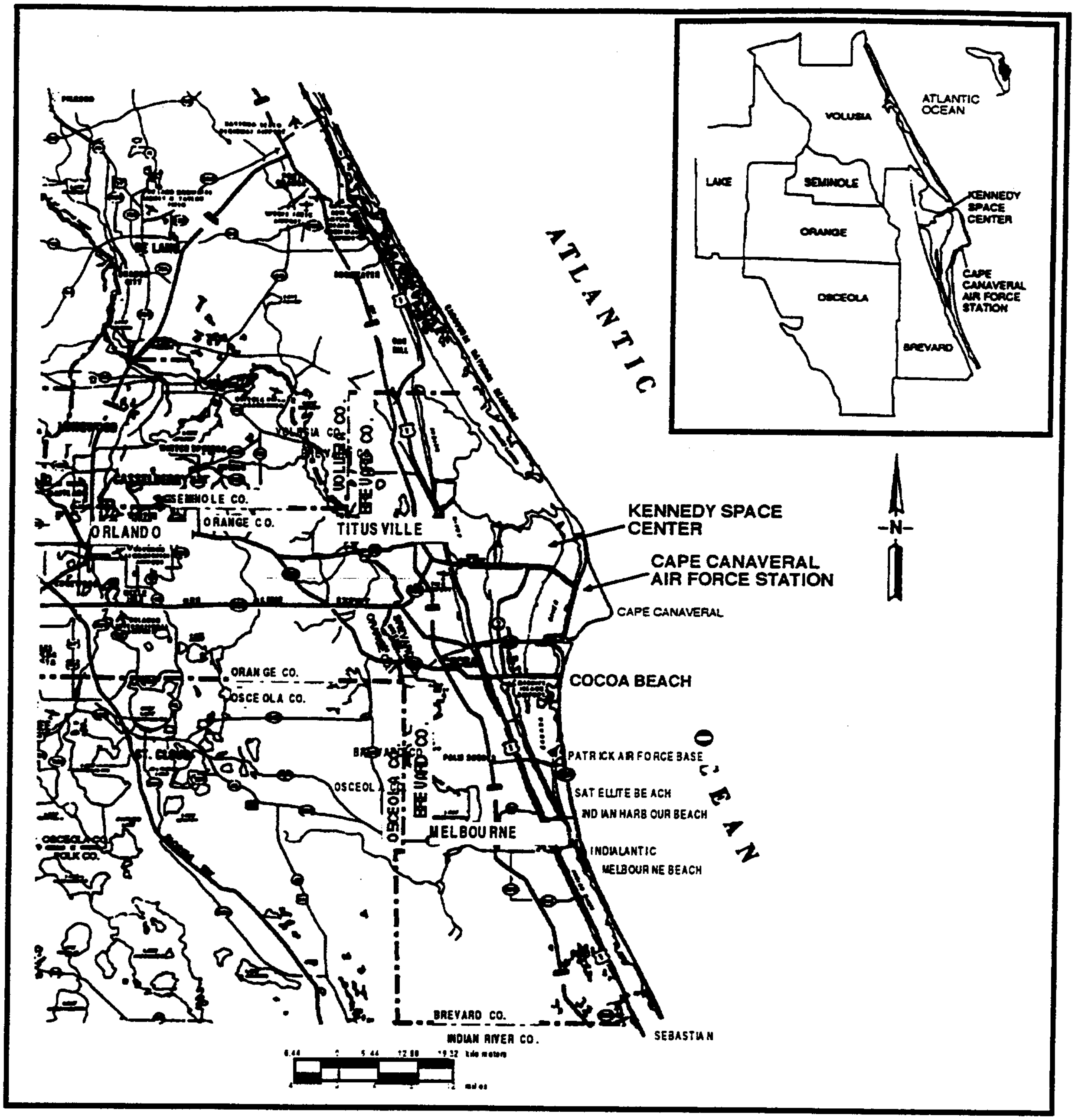
3.1.1. POPULATION DISTRIBUTION

Prior to 1950 the population of Brevard County was predominantly rural. Activation of the CCAS in the 1950s brought military personnel into the county. For the last forty years, the population and economy of Brevard County has been closely linked to the growth of the space program. There was a constant influx of aerospace contractors and military personnel from the early 1950s through the mid-1960s. Employment levels dropped in the late-1960s, reflecting major cutbacks in NASA operations. The local aerospace economy recovered after 1979 due to a renewed national emphasis on launch activities.

CCAS has a work force of approximately 7,500 people, most of whom are employed by companies involved in launch vehicle testing and space launch operation. About 95 percent of the installation's military and civilian contractor personnel live in Brevard County, with the remainder residing in the surrounding counties. Major population centers includes Titusville (20 km [12 mi] northwest), Cocoa Beach (13 km [8 mi] south), Cocoa (12 km [7 mi] southwest), Melbourne (48 km [30 mi], and Cape Canaveral (0.8 km [0.5 mi] south). All military personnel serving at the station are assigned to Patrick Air Force Base (PAFB), about 25 km (15 mi) to the south of CCAS. [USAF 1990]

In the 1990 census, Brevard County's population was 398,978. The population growth rate for Brevard County has been projected at 3.2 percent annually through 1995; this would imply a population of about 473,000 by that year and 504,263 by the year 2000. The greatest increase is expected to occur in southern Brevard County and the lowest in the central portion of the county. [USAF 1990] Economic sectors providing significant employment include services, with 301,300 employees (34.9 percent of total non-agricultural employment); retail trade, with 183,900 (21.3 percent); government, with 113,800 (13.1 percent); manufacturing, with 94,200 (10.9 percent); construction, with 48,300 (5.6 percent); finance and real estate, with 43,000 (5.0 percent); wholesale trade, with 41,200 (4.8 percent); and transportation and public utilities, with 38,000 (4.4 percent). [NASA 1995B] In addition to resident employees, many people commute from surrounding areas to work in the county.

At the beginning of 1991, 984,434 people were employed in the region (863,800 non-agricultural and 120,634 agricultural). A total of 593,796 people were employed in Orange, Seminole, and Osceola Counties, 180,491 in Brevard, 153,720 in Volusia, and 56,427 in Lake. The unemployment rate for the region at the beginning of 1991 was 6.6 percent. The 1990 median annual household income across the six-county region ranged from $7,237 to $76,232, with both ends of the range occurring in Orange County. Within 32 km (20 mi) of the launch complexes, the median income ranged from $10,940 to $55,66 with most of the census tracts within this area recording median incomes in excess of $25,000. At the nearest uncontrolled population area (16 km [10 mi]) from the launch complexes, the median income was $34,000. [NASA 1995B]



Source: [NASA 1986]

Figure 3-1. Regional Area of Interest

3.1.2. LAND USE

Only about 8 percent, or 1,327.42 sq km (510 sq mi), of the total region (17,000 sq km; 6,534.8 sq mi) is urbanized [ECFRPC 1992], with the largest concentrations of people occurring in three metropolitan areas:

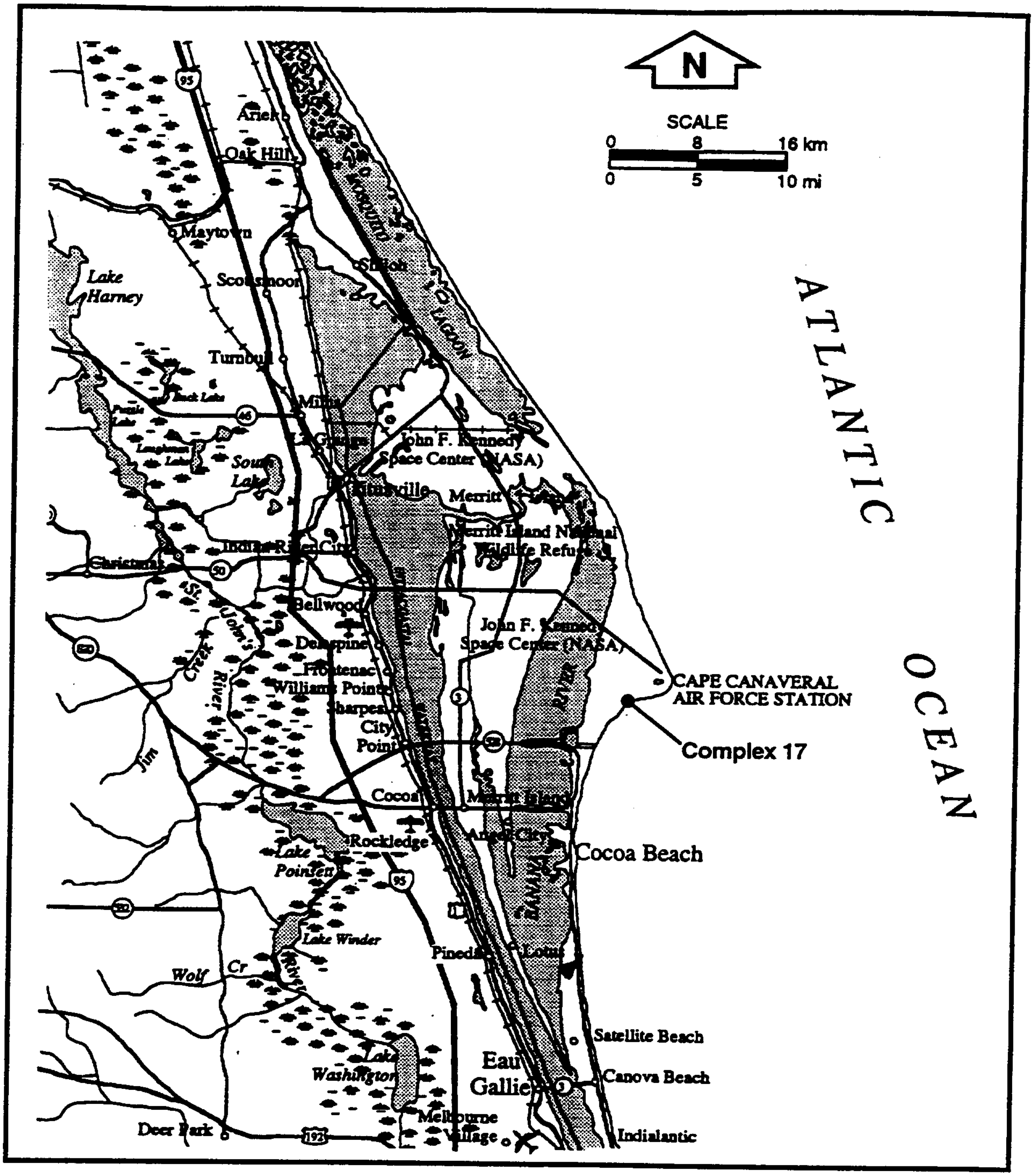
- Orlando, in Orange County, expanding into the Lake Mary and Sanford areas of Seminole County to the north, and into the Kissimmee and St. Cloud areas of Osceola County to the south,
- the coastal area of Volusia County, including Daytona Beach, Port Orange, Ormond Beach, and New Smyrna Beach, and
- along the Indian River Lagoon and coastal areas of Brevard County, specifically the cities of Titusville, Melbourne, and Palm Bay.

Approximately 85 percent of the region's population lives in urban areas.

The majority of the region is considered rural, which includes agricultural lands and their associated trade and service areas, conservation and recreation lands, and undeveloped areas. About 35 percent of the regional area is devoted to agriculture, including more than 5,000 farms, nurseries, and ranches. Agricultural areas include citrus groves, winter vegetable farms, pasture land and livestock, foliage nurseries, sod farms, and dairy land.

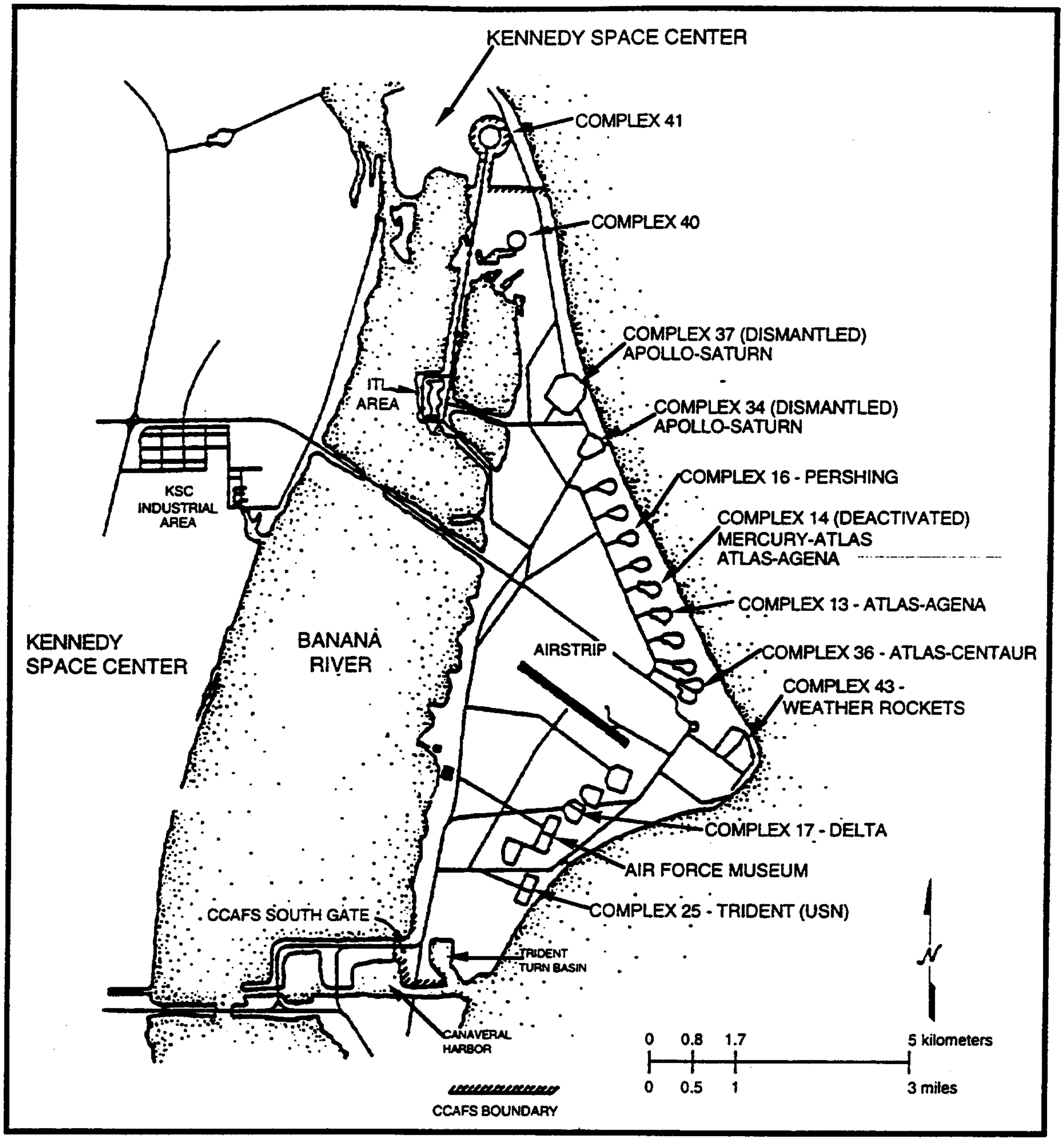
In Brevard County, approximately 68 percent of the developed land use is agricultural, 12 percent is residential, 2 percent is commercial, 1 percent industrial, and 1 percent institutional. The remaining 16 percent is comprised of various other uses. The developed land areas are clustered in three areas in a north-south pattern along the coast and the banks of the Indian and Banana Rivers. [USAF 1990]

Approximately 30 percent of the CCAS (about 18.8 sq km; 7.3 sq mi) is developed, and consists of launch complexes and support facilities (Figure 3-3). The remaining 70 percent is comprised of unimproved land. The CCAS also contains a small industrial area, the Air Force Space Museum, a turning basin for the docking of submarines, and an airstrip that was initially constructed for research and development in recovery operations for missile launches. Many of the hangars located on the station are used for missile assembly and testing. Future land use patterns are expected to remain similar to current conditions. The Kennedy Space Center occupies almost 560 sq km (about 216 sq mi), about 5 percent of which is developed land. Nearly 40 percent of the KSC consists of open water areas, such as portions of the Indian and Banana Rivers, Mosquito Lagoon, and all of Banana Creek. [USAF 1990]



Source: [NASA 1986]

Figure 3-2. Location of CCAS Relative to the Region of Interest



Source: [USAF 1986]

Figure 3-3. Land Use at CCAS

LC-17 (Figure 3-4) is located in the southern portion of the CCAS, approximately 0.8 km (0.5 mi) west of the Atlantic Ocean, 2.5 km (1.5 mi) east of the Banana River, and roughly 5.7 km (3.4 mi) from the station's South Gate. The complex consists of two launch pads, 17A and 17B, each with its own Mobile Service Tower, Fixed Umbilical Tower, cable runs, and Fuel Storage Area. [USAF 1990]

A concrete exhaust flume on each pad deflects exhaust gases away from the pad to reduce the noise and shock wave that result from ignition of solid rockets and the first stage of the launch vehicle. The noise levels of a Delta II 7425/PAM-D launch do not require a water deluge system acoustic mitigation measure. [JPL 1995A]

The two launch pads share common gas storage facilities, located in bunkers between the pads, and are monitored from a common blockhouse, located at a distance from the launch pads. Other miscellaneous support and service facilities are shared between them, as well. LC-17 was renovated in the late 1980s to support an upgraded version of the Delta launch vehicle.

3.1.3. ECONOMIC BASE [NASA 1990]

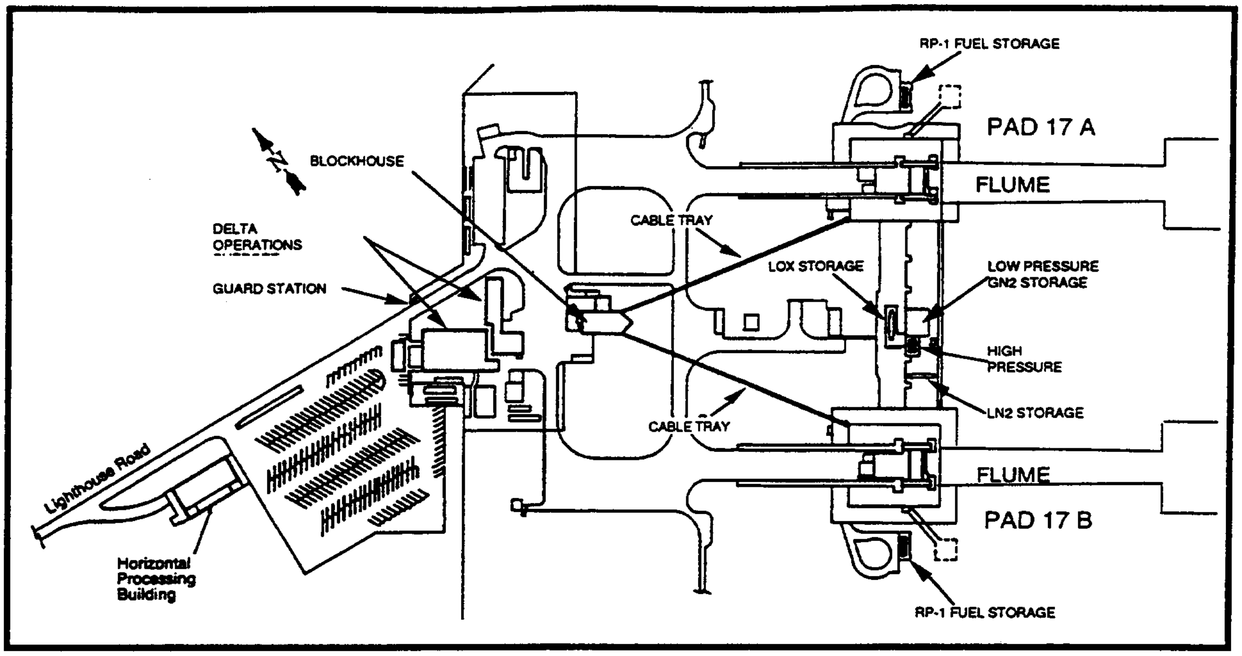
The region's economic base is tourism and manufacturing. Tourism-related employment includes most jobs in amusement parks, hotels, motels, and campgrounds, as well as many occupations in the retail trade and various types of services. Manufacturing jobs, while probably outnumbered by tourism jobs, may provide more monetary benefits to the region because of higher average wages and a larger multiplier effect.

The region's agricultural activities include citrus groves, winter vegetable farms, pastures, foliage nurseries, sod, livestock, and dairy production. In the central region, 30 percent of the land is forested and supports silviculture, including harvesting of yellow pine, cypress, sweetgum, maple, and bay trees. In Osceola County, large cattle ranches occupy almost all of the rural land. Agricultural employment declined in 1986 to just 2.2 percent of the region's employment base.

Commercial fisheries in the two counties bordering the ocean (Brevard and Volusia) landed a total of approximately 9,727 metric tons (about 21.4 million pounds) of finfish, shrimp and other invertebrates in 1988. Brevard and Volusia Counties ranked third and fourth, respectively, among the East Coast counties of Florida in total 1988 finfish landings.

3.1.4. PUBLIC FACILITIES AND EMERGENCY SERVICES [USAF 1990]

The city of Cocoa provides potable water, drawn from the Floridan Aquifer, to the central portion of Brevard County. The maximum capacity is 152 million liters (ℓ) (40 million gallons [gal]) per day, and average daily consumption is about 99 million ℓ (26 million gal) per day.



Source: [USAF 1988]

Figure 3-4. Launch Complex 17

The cities of Cocoa, Cape Canaveral, Cocoa Beach, and Rockledge are each served by their own municipal sewer systems. Unincorporated areas are accommodated by several plants, some of which have reached capacity. Municipal plants in Cape Canaveral, Cocoa Beach, and Cocoa have been expanded and plans are in the works for expansion of the Rockledge system.

Florida Power and Light supplies electricity to Brevard County. Police departments in the five municipalities of the central Brevard area have an average of one officer per 631 people, and fire protection has one full-time officer per 936 people. Health care within the area is available at 28 general hospitals, three psychiatric hospitals, and two specialized hospitals.

Rail transportation for Brevard County is provided by Florida East Coast Railway. A main line traverses the cities of Titusville, Cocoa, and Melbourne, and spur lines provide access to other parts of the county. [USAF 1986]

3.1.5. CCAS FACILITIES AND SERVICES

CCAS receives its water supply from the city of Cocoa, and uses roughly 11.4 million ℓ (3 million gal) per day. To support launch facility deluge systems, the distribution system at CCAS was constructed to provide up to 114,000 ℓ (30,000 gal) per minute for up to ten minutes. [USAF 1990]

The CCAS provides for its own sewage disposal with on-site package sewage treatment plants (STPs). The LC-17 STP has a capacity of 57,000 ℓ (15,000 gal) per day and is permitted by the Florida Department of Environmental Protection (FDEP). [USAF 1988] Current CCAS plans call for a consolidated Waste Water Treatment Plant (WWTP) to be operational in late 1996. [JPL 1995-A]

All nonhazardous solid waste goes to the Brevard County Landfill. Hazardous wastes are accumulated at a number of locations throughout CCAS pending disposal. Wastes are collected for up to 90 days at the accumulation sites before transfer to one of three CCAS hazardous waste storage facilities, where they are stored for eventual shipment to a licensed hazardous waste treatment/disposal facility. [USAF 1986] CCAS has a Resource Conservation and Recovery Act (RCRA) permitted Explosive Ordnance Disposal (EOD) facility which supports disposal of CCAS- & KSC-generated wastes, such as shavings from SRMs. All hazardous wastes generated at CCAS are managed acccording to the CCAS Petroleum Products and Hazardous Waste Management Plan (OPlan 19-14).

To prevent oil or petroleum discharges into U.S. waters, a Spills Prevention, Control, and Countermeasures Plan (SPCCP) is required by the EPA's oil pollution prevention regulation. A SPCCP has been integrated into the CCAS Oil and Hazardous Substance Pollution Contingency Plan (OPlan 19-1). Spills of oil or petroleum products that are Federally listed hazardous materials will be collected and removed for proper disposal by a certified contractor according to this plan. All spills/releases will be reported to the host installation per OPlan 19-1.

The Launch Base Support (LBS) Contractor conducts all police services on CCAS. A mutual agreement for fire protection services exists between the city of Cape Canaveral, KSC, and the LBS Contractor at CCAS. The station is equipped with a dispensary under contract to NASA. The dispensary normally works on a forty-hour week basis. If medical services cannot be provided by the dispensary, hospitals at PAFB and in Cocoa, Titusville, and Melbourne are used. [USAF 1986]

NASA will comply with Toxic Release Inventory requirements, Emergency Planning and Community Right-To-Know responsibilities, and State and Local Right-to-Know and Pollution Prevention requirements. NASA will support the Local Emergency Planning Committee as requested and will make available all Pollution Prevention and Community Right-To-Know information to the public upon request. [NASA 1995-B]

3.1.6. CULTURAL RESOURCES

Within the region, there are 81 sites that are listed in the National Register of Historic Places (NRHP) [DOI 1991], and 2 in the National Register of Historic Landmarks.

In 1982, an archeological/historical survey of CCAS was conducted that consisted of literature and background searches and field surveys. The survey located 32 prehistoric and historic sites and several uninvestigated historic localities. Results of the field survey indicated that many of the archeological resources had been severely damaged by the construction of roads, launch complexes, power lines, drainage ditches, and other excavation. The survey recommended 21 sites for further evaluation to determine eligibility for the NRHP. [USAF 1994, RAI 1982] CCAS is a National Historic Landmark (NHL) District, and LC-17 has been identified as potentially eligible for listing in the NRHP.

The protection and interpretation of significant resources associated with the space program are underway by the Department of the Interior, National Park Service, and USAF. Areas at CCAS designated as landmark sites include the Mission Control Center and launch complexes 5, 6, 13, 14, 19, 26, and 34, which were used during the Mercury, Gemini, and early Apollo manned space flights. [USAF 1988] [45 AMDS/SGPB]

3.2. NATURAL ENVIRONMENT

3.2.1. METEOROLOGY AND AIR QUALITY

3.2.1.1. Meteorology

The climate of the region is subtropical with two distinct seasons: long, warm, humid summers and short, mild, and dry winters. [USAF 1994] Rainfall amounts vary both seasonally and yearly. Average rainfall is 128 centimeters (cm) (51 inches[in]), with about 70 percent falling during the wet season (May to October). Temperature is less variable — prolonged cold spells and heat waves rarely occur. Tropical storms, tropical depressions, and hurricanes occasionally strike the region, generally in the period starting in August and ending in mid-November. The probability of winds reaching hurricane force in Brevard County in any given year is approximately 1 in 20. [USAF 1986] Tornadoes may occur, but are very scarce. Hail falls occasionally during thunderstorms, but hailstones are usually small and seldom cause much damage. Snow in the region is rare.

Summer weather typically lasts about nine months of the year, starting in April. Afternoon thundershowers are common and usually result in lower temperatures and an ocean breeze. Occasional cool days occur as early as November, but winter weather generally commences in January and extends through March. [NASA 1994]

At CCAS, winds typically come from the north/northwest from December through February, from the southeast from March through May, and from the south from June through August. Sea breeze and land breeze phenomena occur commonly over any given 24-hour period due to unequal heating of the air over the land and ocean. Land breeze (toward the sea) occurs at night when air over land has cooled to a lower temperature than that over the sea; sea breeze (toward the land) occurs during the day when air temperatures over the water are lower. The sea breeze and land breeze phenomena occur frequently during the summer months, less frequently during the winter. [USAF 1986]

3.2.1.2. Air Quality

Air quality at CCAS is considered good, primarily because of the distance of the station from major sources of pollution. There are no Class I or nonattainment areas for criteria pollutants (ozone [O_3], nitrogen dioxides [NO_2], sulfur dioxide [SO_2], lead [Pb], carbon monoxide [CO], and particulates (PM-10) within about 96 km (60 mi) of CCAS. Orange County was a nonattainment area for ozone until 1987, when it was redesignated as an ozone attainment maintenance area. [DC 1995]

The station and its vicinity are considered to be "in attainment" or "unclassifiable" with respect to National Ambient Air Quality Standards (NAAQS) for criteria pollutants. [USAF 1990] The criteria pollutants and the Federal and State standards are listed in Table 3-1. NAAQ primary and secondary standards apply to continuously emitting sources, while a launch is considered to be a one-time, short-term moving source; however, the standards will be used for comparative purposes throughout this EA to provide a reference, since no other more appropriate standards exist.

The daily air quality at CCAS is chiefly influenced by a combination of vehicle traffic, maintenance activities, utilities fuel combustion, and incinerator operations. Space launches influence air quality only episodically. Two regional power plants are located within 20 km (12 mi) of the station and are believed to be the primary source of occasional elevations in nitrogen dioxide and sulfur dioxide levels. Ozone has been CCAS's most consistently elevated pollutant. However, since January 1992, the primary standard for ozone has not been exceeded. [DC 1995]

3.2.2. NOISE [USAF 1996A]

The primary noise generators at CCAS prelaunch processing sites are support equipment, vehicles, and air conditioners. Occasionally, increased noise levels are experienced on a short-term basis when launches occur at one of the launch complexes. Ambient conditions in the prelaunch processing areas are typical of those for an urban commercial business or light industrial area. On the whole, day-to-day operations at CCAS would most likely approximate that of any urban industrial area, reaching levels of 60 to 80 decibels (dBA), but with a 24-hour average ambient noise level that is somewhat lower than the EPA-recommended upper level of 70 dBA. [USAF 1990, NASA 1994]

Table 3-1. State and Federal Air Quality Standards

Pollutant	Averaging Time	State of Florida Standard	Federal Primary Standard	Federal Secondary Standard
Carbon Monoxide (CO)	8-hour *	10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)	none
	1-hour *	40 mg/m^3 (35 ppm)	40 mg/m^3 (35 ppm)	none
Lead (Pb)	Quarterly Arithmetic Mean	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	same as primary
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	100 $\mu g/m^3$ (0.05 ppm)	100 $\mu g/m^3$ (0.05 ppm)	same as primary
Ozone (O_3)	1-hour +	235 $\mu g/m^3$ (0.12 ppm)	235 $\mu g/m^3$ (0.12 ppm)	same as primary
Sulfur Dioxide (SO_2)	Annual Arithmetic Mean	60 $\mu g/m^3$ (0.02 ppm)	80 $\mu g/m^3$ (0.03 ppm)	none
	24-hour *	260 $\mu g/m^3$ (0.1 ppm)	365 $\mu g/m^3$ (0.14 ppm)	none
	3-hour *	1300 $\mu g/m^3$ (0.5 ppm)	none	1300 $\mu g/m^3$ (0.5 ppm)
Particulate Matter 10 (PM-10)	Annual Arithmetic Mean	50 $\mu g/m^3$	50 $\mu g/m^3$	same as primary
	24-hour *	150 $\mu g/m^3$	150 $\mu g/m^3$	same as primary

Source: [NASA 1994]

NOTE: mg/m^3 = milligrams per cubic meter

$\mu g/m^3$ = micrograms per cubic meter

ppm = parts per million

* Not to be exceeded more than once per year

\+ The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is less than or equal to one.

Occasionally, increased noise levels are experienced on a short-term basis when launches occur at one of the launch complexes. Noise is generated from the following sources: combustion noise emanating from the rocket chamber; jet noise generated by the

Occasionally, increased noise levels are experienced on a short-term basis when launches occur at one of the launch complexes. Noise is generated from the following sources: combustion noise emanating from the rocket chamber; jet noise generated by the interaction of the exhaust jet with the atmosphere; combustion noise resulting from the postburning of the fuel-rich combustion products in the atmosphere; and sonic booms. The major noise source in the immediate vicinity of the launch pad is the combination of these noises. The nature of the noise may be described as intense, of relatively short duration, composed predominantly of low frequencies, and occurring infrequently. This noise is usually perceived by the surrounding communities as a distant rumble. A concrete exhaust flume on each pad deflects exhaust gases away from the pad to reduce the noise and shock wave that result from ignition of solid rockets and the first stage of the launch vehicle. [USAF 1988, JPL 1995B]

Space launches also generate sonic booms during vehicle ascent and stage reentry. Launch-generated sonic booms are directed upward and in front of the vehicle and occur over the Atlantic Ocean. Stage reentry sonic booms also occur over the open ocean and do not impact developed coastal areas. [USAF 1996A] Some launch vehicle related noise levels measured at KSC are shown in Table 3-2.

Peak noise levels created by industrial and construction activities — mechanical equipment, such as diesel locomotives, cranes, and rail cars — could range from about 90 to 111 dBA. Vehicular traffic noise ranges from around 85 dBA for a passenger auto to about 100 dBA for a motorcycle. [NASA 1994]

Table 3-2. Launch Noise Levels at Kennedy Space Center

SOURCE	DISTANCE FROM LAUNCH PAD	NOISE LEVEL (dBA)	REMARKS
Titan IIIC	9,388 m (5.82 mi)	93.7	21 October 1965
Saturn I	9,034 m (5.60 mi)	89.2	Average of 3 launches
Saturn V	9,384 m (5.82 mi)	91.0	15 April 1969
Atlas	4,816 m (2.99 mi)	96.0	Comstar
Space Shuttle	9,384 m (5.82 mi)	89.6	Estimated
Delta II*	6,452 m (4.00 mi)	98.0	Extrapolated from Measured Values

Source: [NASA 1994, *USAF 1994]

*Launch Noise Level at CCAS [USAF 1994]

3.2.3. LAND RESOURCES

3.2.3.1. Geology

The region is underlain by a series of limestone formations, with a total thickness of several thousand feet. The lower formations contain the Upper Floridan Aquifer, which is under artesian pressure in the vicinity of the station. At CCAS, the Upper Floridan Aquifer commences at a depth of about 80 m (260 ft) and is about 110 m (360 ft) thick. [USAF 1990] Beds of sandy clay, shells, and clays of the Hawthorn formation overlay the Floridan Aquifer, isolating the Floridan Aquifer from other, more shallow aquifers. The Hawthorn formation lies at a depth of about 30 m (100 ft) at CCAS and is about 50 m (160 ft) thick. Overlying the Hawthorne formation are upper Miocene, Pliocene, Pleistocene, and recent age deposits, which form secondary, semi-confined aquifers and the Surficial Aquifer, which lay at depths up to about 30 m (100 ft).

CCAS lies on a barrier island composed of relict beach ridges formed by wind and wave action. This island, approximately 7.5 km (4.5 mi) wide at the widest point, parallels the Florida shoreline and separates the Atlantic Ocean from the Indian River, Indian River Lagoon, and Banana River. The land surface elevation ranges from sea level to about 6 m (20 ft) above sea level at its highest point. LC-17 is located near the southeastern shore of the station. This area is designated as above the 500-year floodplain. [USAF 1990]

3.2.3.2. Soils

Soils on CCAS have been mapped by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS). Soil types that have been identified by the NRCS in the vicinity of LC-17 are Canaveral Complex, Palm Beach Sand, Urban Land, and Canaveral-Urban Land Complex. These native soils are composed of highly permeable, fine-grained sediments typical of beach and dune deposits. None of these soil types are considered prime farmland. Based on examination of well and soil borings from CCAS, the near-surface stratigraphy is fairly uniform, consisting of Pleistocene age sand deposits that underlie the installation to depths of approximately 30 m (100 ft). [USAF 1988]

3.2.4. HYDROLOGY AND WATER QUALITY

3.2.4.1. Surface Waters

The station is located on a barrier island that separates the Banana River from the Atlantic Ocean. As is typical of barrier islands, the drainage divide is the dune line just inland from the ocean. Little runoff is naturally conveyed toward the ocean; most runoff percolates or flows westward toward the Banana River. The majority of storm drainage from CCAS is collected in manmade ditches and canals and is directed toward the Banana River.

Major inland water bodies in the CCAS area are the Indian River, Banana River, and Mosquito Lagoon. These water bodies tend to be shallow except for those areas maintained as part of the Intracoastal Waterway. The Indian and Banana Rivers connect adjacent to Port Canaveral by the Barge Canal, which bisects Merritt Island; they have a combined area of 600 sq km (2.32 sq mi) in Brevard County and an average depth of 1.8 m (6 ft). This area receives drainage from 2,160 sq km (834 sq mi) of surrounding terrain.

Predominant ocean currents in the vicinity of CCAS are north of the area. From the Cape Canaveral region to 26 km (16 mi) offshore, the average ocean current speed is 1.7 to 5 km per hour (1 to 3 mi per hour). Beyond about 26 km, the system of currents becomes known as the Florida Current of the Gulf Stream. The central axis of the Gulf Stream is located approximately 83 km (50 mi) off the coast of Florida at Cape Canaveral.

3.2.4.2. Surface Water Quality

Surface water quality near CCAS and KSC is monitored at 11 long-term monitoring stations that are maintained by NASA. It is also monitored by the Air Force Bioenvironmental Engineering Services on a quarterly basis at 7 sites. Other monitoring stations in the general area are maintained by Brevard County, the U.S. Fish and Wildlife Service, and the Florida Department of Environmental Protection (FDEP). [NASA 1994] In general, the water quality in the monitored surface waters has been characterized as good. Both the northern and southern segments of the Banana River tend to be brackish to saline (15 to 36 parts per thousand [ppt]) at NASA Causeway East. [USAF 1990] Water quality monitoring data for the southern segment of the Banana River is summarized in Table 3-3.

The Banana River is designated a Class III surface water, as described by the Federal Clean Water Act of 1977. Class III standards are intended to maintain a level of water quality suitable for recreation and the production of fish and wildlife communities. The Banana River is also designated an Outstanding Florida Water (OFW) by the FDEP. An OFW is provided the highest degree of protection of any Florida surface waters. [NASA 1994]

3.2.4.3. Ground Waters [USAF 1988]

Ground water at the station occurs under both confined (artesian) and unconfined (nonartesian) conditions. Confined ground water is located in the Floridan Aquifer, which serves as the primary ground water source in the coastal lowlands. Recharge to the Floridan Aquifer occurs primarily in northern and central Florida.

Table 3-3. Summary of Water Quality Monitoring Data for South Banana River

Parameter	Average Value	Range of Values	State FDEP Class III Standards
Conductivity (μmhos/cm)	33,300	12,470 - 50,500	Varies
Total Suspended Solids (mg/ℓ)	32	1 - 143	No standard
Turbidity NTU	2.09	0.76 - 5.0	29 NTU above background
Oil and Grease (mg/ℓ)	0.8	<0.2 - 3.9	≤5.0; no taste or odor
Phenols (μg/ℓ)	128	32 - 364	< 300
Alkalinity (mg/ℓ)	130	109 - 168	≥20 (fresh water)
pH	8.6	7.4 - 9.2	6.5 - 8.5 (marine water)
Total Kjedahl Nitrogen (mg/ℓ)	1.96	0.23 - 15.00	No standard
Nitrate Nitrogen (mg/ℓ)	0.02	<0.02 - 0.06	No standard
Ortho Phosphate (mg/ℓ)	0.032	<0.025 - 0.08	No standard (marine)
Chlorophyll A (mg/m^3)	5.0	<0.5 - 74.7	No standard
Biological Oxygen Demand (mg/ℓ)	2.5	<1 - 7	No standard
Chemical Oxygen Demand (mg/ℓ)	712	478 - 1361	No standard
Dissolved Oxygen (mg/ℓ)	6.6	2.1 - 10.2	≥ 4 mg/l (marine water)
Total Organic Carbons (mg/ℓ)	5.41	2.23 - 13.00	No standard
Aluminum (mg/ℓ)	0.62	< 0.10 - 8.47	≤ 1.5 (marine water)
Cadmium (μg/ℓ)	0.56	<0.01 - 2.86	≤ 0.3
Chromium (mg/ℓ)	0.020	<0.001 - 0.05	0.5 Cr^{+6})
Iron (mg/ℓ)	0.075	<0.040 - 0.178	0.3 (marine water)
Zinc (mg/ℓ)	0.023	< 0.01 - 0.234	86 (fresh water)
Silver (μg/ℓ)	17.88	≤ 0.05 - 31.3	≤ 0.05 (marine water)

Source: [NASA 1994]

NOTE: mg/ℓ = milligram per liter
μg/ℓ = microgram per liter
μmhos/cm = micromhos per centimeter
NTU = Nephelometric Turbidity Units

Although good quality water may be obtained from the Floridan Aquifer throughout much of the state, water from this formation on CCAS is highly mineralized and is not used for domestic or commercial purposes. Water for domestic and commercial purposes in this area is generally retrieved from the city of Cocoa. The water is pumped from wells in east Orange County that extract water from the Floridian Aquifer.

This unconfined surficial aquifer, or water table, is composed of recent and Pleistocene age surface deposits, and is usually found up to 1.5 m (5 ft) or so below land surface. It is recharged by rainfall along the coastal ridges and dunes. The unconfined aquifer formation at CCAS ranges in depth from about 15 m (50 ft) at the coastal ridge to less than 6 m (20 ft) in the vicinity of the St. Johns River. The unconfined aquifer beneath LC-17 is not used as a water source, except for residential irrigation.

3.2.4.4. Ground Water Quality

Two aquifer systems underlie CCAS: the surface aquifer and the Floridan aquifer. The surface aquifer system, which is composed generally of sand and marl. The water table in the surface aquifer is generally located a few feet below the ground surface and is principally recharged by precipitation. Ground water of the Floridan Aquifer at CCAS is not used as a domestic or commercial water source. Table 3-4 summarizes the water quality characteristics of a sample collected from the Floridan Aquifer underlying the west-central portion of the station. The sample exceeded national drinking water standards for sodium, chloride, and total dissolved solids (TDS). [NASA 1994]

Table 3-4. Ground Water Quality for the Floridan Aquifer at CCAS

Parameter	Average Value (mg/ℓ)	Drinking Water Standards (mg/ℓ)
Nitrates (as Nitrogen)	< 0.01	10 (primary standard)
Chlorides	540	250 (secondary standard)
Copper	<0.01	1.0 (secondary standard)
Iron	0.02	0.3 (secondary standard)
Manganese	<0.001	0.05 (secondary standard)
Sodium	1400	160 (primary standard)
Sulfate	85	250 (secondary standard)
Total Dissolved Solids	1,425	250 (secondary standard)
pH	7.6	6.5 - 8.5(secondary standard)
Zinc	<0.01	5.0 (secondary standard)
Arsenic	<0.01	0.05 (primary standard)
Barium	0.02	1.0 (primary standard)
Cadmium	<0.001	0.01 (primary standard)
Chromium	0.001	0.05 (primary standard)
Lead	<0.001	0.05 (primary standard)
Mercury	0.0005	0.002 (primary standard)
Selenium	0.006	0.01 (primary standard)

Source: [USAF 1988]

NOTE: mg/ℓ = milligrams per liter
primary standard = National Interim Primary Drinking Water Regulations
secondary standard = National Secondary Drinking Water Regulations

Overall, water in the unconfined aquifer in the vicinity of KSC and CCAS is of good quality and meets the State of Florida Class G-II (suitable for potable water use; total dissolved solids less than 10,000 milligrams per liter [mg/l]) and national drinking water quality standards for all parameters, with the exception of iron, and/or total dissolved solids. [NASA 1994, USAF 1990] There are no potable water wells located at LC-17 or in its vicinity.

Ground water quality in five monitoring wells at LC-17 is generally good, with some detectable quantities of trace metals and organic compounds reported in one well, and detectable zinc concentrations in another. [MDC 1990] These results suggest that soil contaminants detected by earlier studies.[USAF 1988] may be relatively non-mobile under the present soil conditions, and sampling data to confirm is currently being taken by the Air Force [USAF 1997C].

3.2.5. BIOTIC RESOURCES

The station is located in east-central Florida on the Cape Canaveral peninsula. Ecological resources at CCAS are influenced by the Atlantic Ocean on the east and the Banana River on the west. Relic dunes on CCAS have created inner-dunal swales that have been classified by the U.S. Fish and Wildlife Service as freshwater wetlands. There is also a naturally occurring pond and wetlands in the vicinity of LC-17. Vegetation communities and related wildlife habitats are representative of barrier island resources of the region. Major community types at CCAS include beach, coastal strand and dunes, coastal scrub, lagoons, brackish marsh, and freshwater systems in the form of canals and borrow pits.

The restrictive nature of CCAS and KSC activities has allowed large areas of land to remain relatively undisturbed. In addition to communities found at CCAS, coastal hammocks and pine flatwoods are found on KSC to the northwest and increase the ecological diversity and richness of the area. [USAF 1988] A majority of the 65 sq km (25 sq mi) complex consists of coastal scrub, woodland, strand, and dune vegetation. Coastal scrub and coastal woodland provide excellent cover for resident wildlife. Coastal strand occurs immediately inland of the coastal dunes and is composed of dense, woody shrubs. Coastal dune vegetation (a single layer of grass, herbs, and dwarf shrubs) exists from the high tide point to between the primary and secondary dune crest. Wetlands represent only a minor percentage (less than 4 percent) of the total land area and include freshwater marsh, mangrove swamp, and salt swamp. Known hammocks are small, total less than 0.8 sq km (0.3 sq mi), and are characterized by closed canopies of tree, shrub, and herb vegetation. Most of the wildlife species resident at the station can be found in each of these vegetation communities. No federally designated threatened or endangered flora are known to exist at CCAS. [USAF 1991, USAF 1996A]

3.2.5.1. Terrestrial Biota [USAF 1988, USAF 1994]

Natural upland vegetation communities found on CCAS are coastal dune, coastal strand, coastal scrub, and hammock. Wetlands found on-site include both marshes and swamps.

The coastal dune community extends from the coastal strand system to the high tide line, and within the salt-spray zone. Dune systems develop on poorly consolidated, excessively drained sands that are exposed to constant winds and salt spray. This zone is delineated by the interior limit of sea oats (Uniola paniculata) growth, which has been listed as a state species of special concern. Florida Statute 370.41 prohibits the disturbance or removal of sea oats.

LC-17 is surrounded by coastal scrub vegetation. As a result of a recent study by the Nature Conservancy, the overgrown oak scrub has now been classified as maritime hammock. The coastal scrub community covers approximately 37.6 sq km (14.5 sq mi), or about 78 percent of the undeveloped land on CCAS. This community is distributed on excessively drained, nutrient-deficient marine sands.

Coastal strand vegetation occurs between the coastal dune and scrub communities and lies just east of LC-17. Coastal strand communities exist on sandy, excessively drained soils dominated by shrubs and often are nearly devoid of ground cover vegetation.

CCAS beaches are nonvegetated, but provide significant wildlife resources. The tidal zone supports a large number of marine invertebrates, as well as small fish that are food for various shorebirds. CCAS and KSC beaches are also important nesting areas for several varieties of sea turtles. Sea turtles and turtle hatchlings are affected by exterior lights. To minimize impacts to sea turtles, CCAS has implemented a lighting policy for management of exterior lights at the installation. The policy requires the use of low-pressure sodium lights unless prohibited by safety or security purposes.

Coastal hammocks are characterized by closed canopies of cabbage palm. Hammocks are shaded from intense insolation, and therefore retain higher levels of soil moisture than the previously described habitats. No hammocks occur in the immediate vicinity of LC-17, the nearest one being about 3 km (1.8 mi) west of the site, adjacent to the Banana River.

Wetlands within CCAS and surrounding station facilities are important wildlife resources; there are four isolated emergent wetlands and a major east-west drainage canal. Wetland types that are found in the area include fresh water ponds and canals, brackish impoundments, tidal lagoons, bays, rivers, vegetated marshes, and mangrove swamps. No marsh or swamp systems occur near LC-17. These soils are not suitable for cultivation, yet do contain swamp plants that support migratory and wading birds. [USAF 1990] The wetlands support a wide variety of aquatic plants and animals, including the American alligator, a threatened species. The four isolated wetlands are vegetated primarily by cattails with Carolina-plains willow, wax myrtle, and groundsel bush along the edge of the system. The systems are small and appear to have originated as borrow areas for adjacent construction sites. [USAF 1994] Species of plant and animal life observed or likely to occur on CCAS are listed in references USAF 1988 and USAF 1994.

3.2.5.2. Aquatic Biota [USAF 1988]

The northern Indian River lagoon ecosystem is a shallow system with limited ocean access, limited tidal flux, and generally mesohaline salinities. The aquatic environment is subject to wide fluctuations in temperature and salinity due to the shallowness of the system.

Sea grasses are present in the Indian River system, generally found in patches in shoal areas less than 1 m (3 ft) deep and surrounded by open, sandy terrain. Benthic invertebrates found in the northern Indian and Banana Rivers include marine worms, mollusks, and crustaceans, typical of estuarine systems. Epibenthic invertebrates collected from the area included horseshoe crabs, blue crabs, and penaid shrimp.

The area is not considered an important nursery area for commercially important shrimp species. Mosquito Lagoon, north of the complex, has been considered an important shrimp nursery area. Blue crabs were determined to spawn in the area.

Few freshwater fish species inhabit the area. Many of the area's freshwater fish species are believed to have been introduced by man. Primary reasons for the low diversity in fish species are considered to be latitude, climate, low habitat diversity, and limited ocean access.

3.2.5.3. Launch Complex 17

A potential Region of Influence (ROI) has been identified for the proposed launches as a one-mile radius surrounding the launch complex, based on previous launch vehicle assessments at CCAS. Threatened or endangered species potentially occurring within the ROI are listed in Table 3-5. Preliminary review of existing vegetation mapping in the vicinity of the launch complex identified the dominant vegetation as coastal scrub community and coastal woodland community. The distinction between the two systems as previously described is a difference in the height of the vegetation and the openness of the canopy. The western portion of the ROI consists primarily of coastal woodland whereas the eastern portion of the ROI up to Pier Road supports a more open coastal scrub community. This portion of the ROI also displays signs of being recently burned. Controlled burns are implemented throughout much of CCAS using prescribed schedules in accordance with the control burning plan. These burns are important for improving and preserving wildlife habitat as well as for reducing the occurrence of uncontrolled fires and enhancing security visibility. The vegetation on the east side of Pier Road is characterized as coastal strand with dune vegetation along the beach interface.

The vegetative communities are partitioned into discrete units by the presence of line-of-site clear zones, roads, and widely dispersed industrial complexes. These clear zones provide an ecotone effect between the adjacent scrub/woodland community and a predominantly herbaceous grassy community. An ecotone is a transition area between the adjacent ecological communities usually containing species from both communities. Bahia grass was the dominant species bordering the road shoulder vegetation and the industrial buildings. The transition zone between the grassy community and the forested community includes wax myrtle, stoppers, groundsel, and Brazilian pepper. These species provide a nearly impenetrable shrub/scrub layer.

Table 3-5. Listed and Proposed Threatened and Endangered Animal Species and Candidate Animal Species In Brevard County and Their Status On CCAS

SPECIES	Potential Occurrence[a]	STATUS[b]			
Threatened/Endangered Species	LC-17	Federal USFWS	State FGFWFC	Other[c] FCREPA	Cape Canaveral
REPTILES/AMPHIBIANS					
American Alligator (*Alligator mississippiensis*)	X	FT (S/A)	SSC	SSC	O
Atlantic loggerhead turtle (*Caretta caretta caretta*)		FT	T	T	O
Atlantic green turtle (*Chelonia mydas mydas*)		FE	E	E	O
Leatherback turtle (*Dermochelys coriacea*)		FE	E	R	O
Eastern indigo snake (*Drymarchon corais couperi*)	X	FT	T	SSC	O
Atlantic ridley turtle (*Lepidochelys kempi*)		FE	E		Offshore
Hawksbill sea turtle (*Eretmochelys imbricata imbricata*)		FE	E	E	Offshore
BIRDS					
Florida scrub jay (*Aphelocoma coerulescens coerulescen*)	X	FT	T	T	O
Piping plover (*Charadrius melodus*)		FT	T	SSC	O
Arctic peregrine falcon (*Falco peregrinus tundrius*)		FT	T	E	O
Southeastern American kestrel (*Falco Sparverius paulus*)	X	UR2	T	T	O
Bald eagle (*Haliaeetus leucocephalus*)		FE	T	T	Visitor
Wood stork (*Mycteria americana*)		FE	E	E	O
Least tern (*Sterna antillarum*)			T		O
PLANTS					
Giant leather fern (*Acroatichum danaeifolium*)				T-FDA	O
Curtis milkweed (*Asclepias curtissii*)				E-FDA	O
Coconut palm (*Cocoa nuvifera*)				T-FDA	O
Mosquito fern (*Azolla caroliniana*)				T-FDA	O
Beach creeper (*Ernodea littoratis*)				T-FDA	O
Wild coco (*Elophia alta*)				T-FDA	O
Prickly pear cactus (*Opuntia compressa*)	X			T-FDA	N/O
Prickly pear cactus (*Opuntia stricta*)	X			T-FDA	O
Beach star (*Remirea maritima*)				E-FDA,FNAI	O
Scaevola (*Scaevola plumeria*)				T-FDA	O
Wildpine; air plant (*Tillandsia simulata*)				T-FDA	N/O
MAMMALS					
Southeastern beach mouse (*Peromyscus polionotus niveiventris*)		FT	T		O
West Indian manatee (*Trichechus manuatus latriostris*)		FE	E	T	O
Florida panther (*Felis concolor coryii*)		FE			N/O

Table 3-5. Listed and Proposed Threatened and Endangered Animal Species and Candidate Animal Species In Brevard County and Their Status On CCAS, cont.

SPECIES Candidate Species	Potential Occurrence[a] LC-17	STATUS[b] Federal USFWS	State FGFWFC	Other[c] FCREPA	Cape Canaveral
REPTILES/AMPHIBIANS					
Gopher tortoise (*Gopherus polyphemus*)	X	UR2	SSC	T	O
Gopher frog (*Rana areolata*)		UR2	SSC		N/O
BIRDS					
Roseate spoonbill (*Ajaia ajaja*)			SSC		O
Snowy egret (*Egretta thula*)			SSC		O
Louisiana heron (*Egretta tricolor*)	X		SSC		O
Little blue heron (*Florida oaerules*)	X		SSC		O
American oyster catcher (*Haematopus palliatus*)			SSC		O
Osprey (*Pandion haliaetus*)			SSC		O
Brown pelican (*Pelecanus occidentalis*)			SSC		O
Reddish egret (*Egretta rufescens*)		F	SSC	R	O
PLANTS					
Broad-leaved spiderlily (*Hymenocallis latifolia*)		UR2		UR2-FNAI	O
Royal fern (*Osmuda regalis var. spectabilis*)				C-FDA	N/O
Giant wildpine; giant air plant (*Tillandsia utriculata*)				C-FDA	O
MAMMALS					
Florida mouse (*Peromyscus floridanus*)		UR2	SSC	T	O
Round-tailed muskrat (*Neofiber alleni*)		F		SSC	N/O
Other species of interest					
Finback whale (*Balaenoptera physalus*)		FE			Offshore
Humpback whale (*Megaptera novaeangliae*)		FE			Offshore
Right whale (*Eubalaena glacialis*)		FE			Offshore
Sperm whale (*Physeter macrocephalus*)		FE			Offshore
Sei whale (*Balaenoptera borealis*)		FE			Offshore

Source: Adapted from [JPL 1995A], [USAF 1994] and [NASA 1994]

[a] X = potential occurrence near LC-17

[b] FE = federally listed as endangered; FT = federally listed as threatened; S/A = similarity of appearance; UR2 = under review, but substantial evidence of biological vulnerability and or threat is lacking; F = federal species of concern (former Category 2 Candidate species) - Such species are the pool from which future candidates for listing will be drawn [Federal register Vol. 61 No. 40, PP. 7457-7463, 2/28/96]. E = state listed as endangered; T = state listed as threatened; R = rare; SSC = species of special concern; C = commercially exploited; O = observed; N/O = not observed

USFWS = U.S. Fish and Wildlife Service; FGFWFC = Florida Game and Fresh Water Fish Commission; FCREPA = Florida Commission on Rare and Endangered Plants and Animals; FDA = Florida Department of Agriculture and Consumer Services; FNAI = Florida Natural Areas Inventory

[c] listing agencies other than FCREPA are noted next to species designation

3.2.5.4. Threatened and Endangered Species

The U.S. Fish and Wildlife Service (FWS), the Florida Game and Fresh Water Fish Commission (FGFWFC), and the Florida Commission on Rare and Endangered Plants and

Animals (FCREPA) protect a number of wildlife species listed as endangered or threatened under Federal or State of Florida law. The presence, or potential for occurrence, of such species on CCAS was determined from consultations with FWS, FGFWFC, and CCAS and KSC environmental staff, and from a literature survey. Table 3-5 lists those endangered or threatened species in Brevard County residing or seasonally occurring on CCAS and adjoining waters.

A review of the list indicates that only six species (American alligator, eastern indigo snake, southeastern kestrel, Florida scrub jay, and two species of prickly pear cactus) potentially occur in the immediate vicinity of LC-17. Three additional species may occasionally occur in wetlands on CCAS. West Indian manatees, green turtles, and loggerhead turtles are known to occur in the Banana River, Mosquito Lagoon, and along Atlantic Ocean beaches. The red-cockaded woodpecker is not known to occur in the vicinity of LC-17.

4. ENVIRONMENTAL IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

The activities associated with completing the preparations of the Mars Surveyor '98 spacecraft primarily involve refining the spacecraft and mission designs at JPL, and spacecraft fabrication, assembly, and testing at Lockheed Martin. While such fabrication activities may generate small quantities of effluents normally associated with tooling or cleaning operations, these are well within the scope of normal activities at the fabrication/testing facilities and will produce no substantial adverse environmental consequences.

Pre-launch activities (i.e., those activities occurring at the launch site) would involve integration and testing with the launch vehicle and final launch preparations, such as spacecraft and launch vehicle fueling operations, and would culminate in a successful nominal launch of the MSP '98 spacecraft.

The following sections summarize the environmental effects of a normal Delta II 7425/PAM-D launch and flight, and the effects of possible abnormal spacecraft operations or flight conditions for the launch of the MSP '98 spacecraft.

4.1. ENVIRONMENTAL IMPACTS OF A NORMAL DELTA II 7425 LAUNCH

4.1.1. AIR QUALITY

4.1.1.1. Emissions

Airborne emissions will be generated by prelaunch, launch, and post-launch operations. The majority of emissions will be produced by the graphite epoxy motor solid rockets (4 GEMs on the Delta II 7425 vehicle) and the liquid first stage of the Delta II vehicle during launch. The Four GEMs and the first stage of the Delta II will be ignited during lift-off. The primary products of GEM combustion will be carbon monoxide (CO), carbon dioxide (CO_2), hydrochloric acid (HCl), aluminum oxide (Al_2O_3) in soluble and insoluble forms, nitrogen oxides (NO_X), and water. Combustion products of the GEM are listed in Table 4-1. Major exhaust products of the Delta II first stage will be CO, CO_2, and water. Exhaust products from the Delta II first stage are given in Table 4-2.

Other emissions resulting from Delta II operations include fuel and oxidant vapors which may escape to the atmosphere during prelaunch or post-launch operations. The first stage of the Delta II uses RP-1 as a fuel and liquid oxygen as an oxidizer. The vehicle's second stage employs Aerozine 50 as a fuel and nitrogen tetroxide (N_2O_4) as an oxidizer. Both stages will be loaded while the vehicle is on the launch pad.

Table 4-1. Combustion Products for the GEM Solid Rocket

Combustion Product	Product Mass Fraction	Product Mass per GEM		Product Mass for 4 GEMs	
		kg	lb	kg	lb
AlCl	0.0002	2	5	8	20
$AlCl_2$	0.0002	2	5	8	20
$AlCl_3$	0.0001	1	3	4	12
AlClO	0.0001	1	3	4	12
Al_2O_3 (soluble)	0.2959	3,512	7,727	14,048	30,908
Al_2O_3 (insoluble)	0.0628	745	1,640	2980	6,560
CO	0.2208	2,621	5,766	10,484	23,064
CO_2	0.0235	279	614	1116	2456
Cl	0.0027	32	71	128	284
H	0.0002	2	5	8	20
HCl	0.2109	2,503	5,507	10,012	22,028
H_2	0.0228	271	595	1084	2380
H_2O	0.0773	918	2,019	3672	8,076
N_2	0.0823	977	2,149	3908	8,596
OH	0.0002	2	5	8	20

Source: Adapted from [USAF 1996A]

Table 4-2. Exhaust Products for the Delta II 7425 First Stage

Combustion Product	Mass Fraction	Product Mass	
		kilograms	pounds
CO	0.4278	41,173	90,580
CO_2	0.2972	28,603	62,928
H	0.0001	10	21
H_2	0.0139	1,338	2,943
H_2O	0.2609	25,110	55,242
OH	0.0002	19	42

Source: Adapted from [USAF 1996A]

Typically, RP-1 and liquid oxygen would be loaded into the first stage of the launch vehicle twice during the normal sequence of prelaunch operations. Minor amounts of fuel and oxidizer are loaded approximately two weeks prior to launch to test the fuel system's integrity. Following testing, the tanks are cleaned, and then loaded to full capacity within several hours before launch. Any fuel spillage that occurs during the loading process are collected in sealed trenches leading from the RP-1 storage tanks to the launch pad, and the RP-1 is then evacuated from these trenches into sealed 55 gallon drums for subsequent disposal by a certified subcontractor. Vapor losses during first stage loading are minimal, due to the low volatility of RP-1.

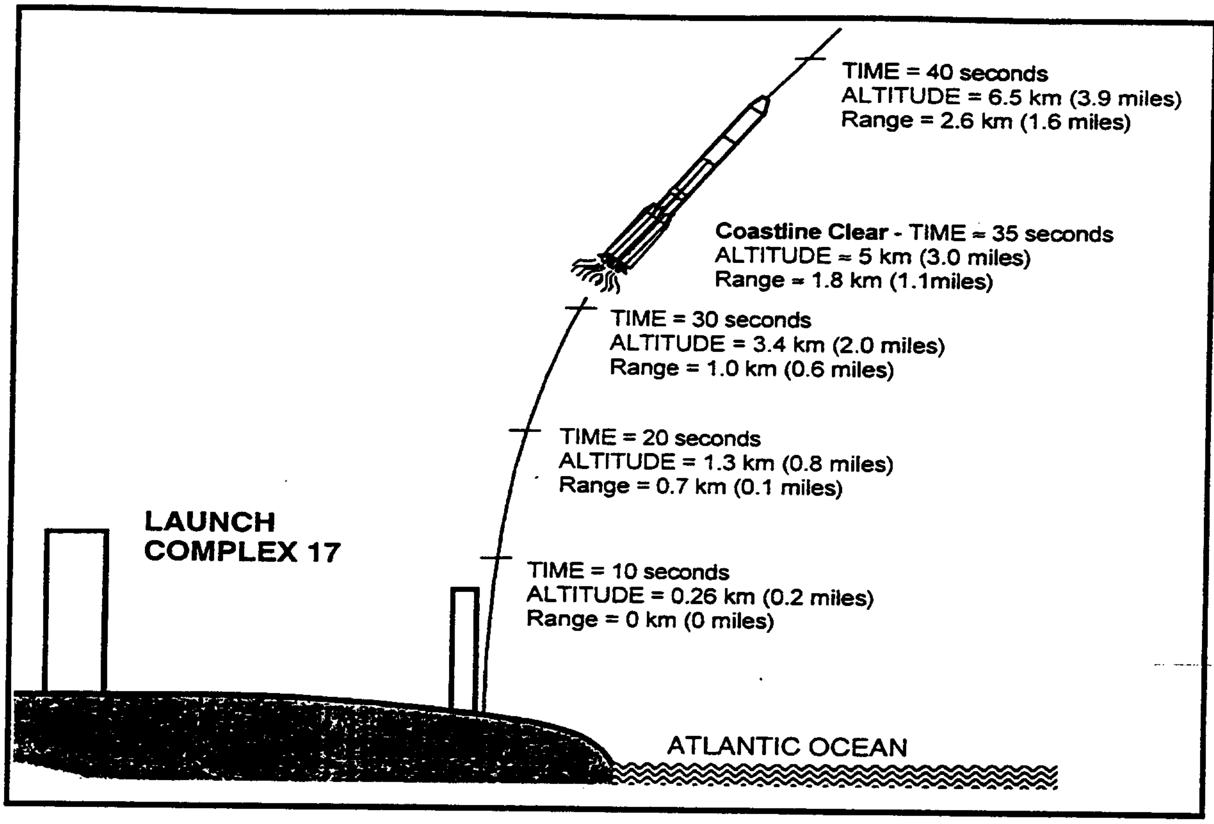
Aerozine 50 and N_2O_4 would be loaded into the second stage 3 days prior to the scheduled launch date. Pollution control devices are utilized to control emissions resulting from fuel and oxidizer handling operations. Chemical scrubbers are used to remove pollutants from the vapors; the scrubber solutions are then released into drums for disposal by a certified subcontractor. Spillage of Aerozine 50 or N_2O_4, although not expected, would be in accordance with OPlan 19-1.

Emergency release could occur during the rupture of a part of the propellant loading system, mainly as a result of over pressurization of the system. Redundant flow meters and automatic shutdown devices on the propellant loading system would prevent overfilling of the propellant tanks. Automatic pressure monitoring devices on the tanks and feed system are designed to prevent over pressurization.

In the unlikely event of a vehicle destruction on the pad, failure in flight, or a command destruct action, liquid propellant tanks and GEM casings are ruptured. Under these circumstances, most of the released liquid propellants would ignite and burn. Rupture of the GEM casings creates a sudden reduction in chamber pressure, which acts to extinguish most of the solid propellants, so that only a portion may continue to burn.

4.1.1.2. Impacts

In a normal launch, exhaust products from the Delta II 7425 (Tables 4-1 and 4-2) are distributed along the launch vehicle's path (Figure 4-1). The quantities of exhaust emitted per unit length of the trajectory are greatest at ground level and decrease continuously. The portion of the exhaust plume that persists longer than a few minutes (the ground cloud) is emitted during the first few seconds of flight and is concentrated near the pad area. Prior to launch all non-essential personnel are evacuated from the launch site to areas a minimal distance outside the facility perimeter. Necessary personnel remain inside the complex blockhouse until the area has been monitored and declared clear.



Source: Adapted from [MDA 1993]

Figure 4-1. Delta II 7425 Launch Area Flight Profile

The Air Force uses the Rocket Exhaust Effluent Diffusion Model (REEDM) to determine the concentration and areal extent of launch cloud emission dispersion from LVs. For this assessment, Air Force personnel from 45 SW/SESL ran REEDM for the Delta II 7425 LV nominal launch case (normal launch mode) in two different weather scenarios (2 runs). The model was also run for two failure modes (conflagration and deflagration) in two credible weather scenarios (4 runs). (A credible weather scenario is one in which launch would proceed.) A total of 6 runs were performed. The two weather scenarios include a high over the eastern US, producing easterly winds which could cause adverse inland toxic hazard corridors, and the second weather case is for a cold front over southern Florida, producing northerly wind components and inversions which could also cause an adverse toxic hazard corridor toward the closest and densest population center at Port Canaveral. Selected output from the model runs is included in Appendix A.

For the nominal launch scenario the launch cloud was assumed to be 100 m in diameter at ground level. The area directly impacted by flame from the rocket exhaust would be approximately 80 meters (262 ft) in diameter. [USAF 1994] The cloud height was calculated to be a minimum of 672 meters (2204 ft) above the ground, with a minimum time of rise of about 450 seconds. [USAF 1996]

Because the cloud rises so rapidly, surface exposure to the cloud immediately after launch is assumed to occur for approximately two minutes for this analysis. The model predicted that the cloud would stabilize approximately 4 km (2.5 mi) from LC-17. Concentrations for CO, CO_2, Cl, Al_2O_3, and HCl were considered. The exhaust cloud is predicted to stabilize at about 5 km (3 mi) downwind of the launch pad; the first concentration given below relates to this stabilization point. The second distance given relates to the position where the peak concentration is predicted to occur. For all species considered, the distance range between stabilization and peak concentration is from 5 km to 13 km (3 to 8 miles) downwind of LC-17 for the first weather scenario and 5 to 8 km (3 to 5 miles) downwind in the second weather scenario. REEDM outputs predict that the 60-minute average concentrations would be less than 0.05 ppm for all species considered for a normal launch in either of the two weather scenarios.

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for HCl is 5 ppm for an 8-hour time-weighted average. Although National Ambient Air Quality Standards have not been adopted for HCl, NAS developed recommended short-term exposure limits for HCl of 20 ppm for a 60-minute exposure, 50 ppm for a 30-minute exposure, and 100 ppm for a 10-minute exposure. Maximum concentrations for HCl are predicted to range from 0.03 to a maximum of 0.65 ppm. The maximum one-hour average concentration for HCl was predicted by REEDM to be 0.018 ppm at 14 km (8.7 miles) downwind of LC-17.

Since the nearest uncontrolled area (i.e., general public) is approximately 4.8 km (3 mi) from LC-17, HCl concentrations are not expected to be high enough to be harmful to the general population. The maximum level of HCl expected to reach uncontrolled areas during preparation and launch of the Delta II would be well below the NAS recommended limits. Appropriate safety measures would also be taken to ensure that the permissible exposure limits defined by the OSHA are not exceeded for personnel in the launch area.

During the last twenty years there has been an increased concern about human activities that are affecting the upper atmosphere. Space vehicles that use SRMs have been studied concerning potential contribution to stratospheric ozone depletion because of their exhaust products, with the primary depleting component being HCl. The average global depletion rates for the types of chemicals emitted were calculated as a percent O_3 reduction per ton of exhaust emissions. The relevant depletion rates are 1.9×10^{-5} percent reduction for each ton of Cl emitted and 1.0×10^{-8} for each ton of nitrogen oxides (NO_x). [USAF 1994] There are 22,318 lb of Cl and HCl emitted by the four GEMS during launch, which means that each launch would contribute an estimated 2.1×10^{-4} percent consequent global reduction in stratospheric ozone. Based on the history of eight Delta II launches per year average for the past eight years, launching eight Delta II 7425s with four GEMs in a twelve-month period is extrapolated to result in a cumulative net stratospheric ozone depletion on the order of 0.0017 percent, due to the Cl. The Delta II second stage is estimated to release 6 tons of NO_2, which would contribute 6×10^{-8} percent consequent global reduction in stratospheric ozone. Launching eight Delta IIs in a twelve month period would result in a cumulative net stratospheric ozone depletion on the order of 4.8×10^{-7} percent due to NO_x. The cumulative net stratospheric ozone depletion caused by both rocket exhaust effluents would be on the order of 2.1×10^{-4} percent for eight launches during a twelve-month period.

In addition to the near-pad acidic deposition that could occur during a launch, there is a possibility of acid precipitation from naturally-occurring rain showers falling through the ground cloud shortly after launch. Since the ground cloud for a Delta II launch is predicted to be very small (radius of about 100 m or 330 ft), concentrates around the launch pad, and disperses quickly, there should be no significant acid rain beyond the near-pad area.

During launch, gases are exhausted at temperatures ranging from 2,000 to 3,000 degrees F. Most of the gases then immediately rise to an altitude of about 2,000 feet (609 m), where they are dispersed by the prevailing winds. Unprotected individuals within 100 meters (328 ft) of the launch pad during a normal launch would likely be killed or injured due to heat and high levels of HCl. Prior to launch, a 6,500-foot (1981 m) clear zone is established by Range Safety around the launch pad. Prior to, during, and for about twenty minutes after launch, the area within the perimeter is cleared of personnel in accordance with Range Safety practices. The only personnel within the clear zone would be in the protected and sealed blockhouse at LC-17. Additionally, a 2,780-foot (847 m) blast danger zone is established. In the event of a catastrophic launch failure, no personnel would be in the blast area except those in the blockhouse, which was designed to protect personnel in such a circumstance.

Launch cloud CO concentrations predicted by REEDM for nominal launch mode range from 0.01 to a maximum of 1.4 ppm; CO_2 concentrations range from 0.02 to a maximum of 0.3 ppm; and, Cl concentrations range from 0.3 to a maximum of 8.6 parts per billion (ppb). The maximum one-hour average concentrations for these exhaust effluents were predicted to be 0.085 for CO, 0.018 for CO_2, and 0.001 for Cl. All maximums occurred approximately 10 km (6.2 miles) downwind of LC-17. The CO gas is expected to rapidly oxidize into CO_2 in the atmosphere, and therefore, CO concentrations for Delta launches are not expected to exceed the NAAQS of 35 ppm (one-hour average) beyond the immediate vicinity of LC-17.

Aluminum oxide exists as a crystalline dust in solid rocket motor (SRM) exhaust clouds, but is inert chemically and is not toxic. However, since many of the dust particles are small enough to be retained by lungs, it is appropriate to abide by NAAQS for particulate matter smaller than 10 microns (PM-10). Concentrations for Al_2O_3 range from 0.3 to a maximum of 2.5 $\mu g/m^3$. The maximum 24-hour Al_2O_3 concentration beyond the distance of the nearest CCAS property boundary predicted by the Rocket Effluent Exhaust Dispersion Model (REEDM) for a Delta II 7425 launch, was 2.5 $\mu g/m^3$, which is well below the 24-hour average PM-10 NAAQS for PM-10 of 150 $\mu g/m^3$. [USAF 1990] The NAAQS for continuous emitters of particulate matter should not be exceeded by a Delta II launch due to the short nature of the launch event.

Nitrogen oxides (NO_x) may enter the atmosphere through propellant system venting, a procedure used to maintain proper operating pressures. Air emission control devices will be used to mitigate this small and infrequent pollutant source. First stage propellants will be carefully loaded using a system with redundant spill-prevention safeguards. Aerozine 50 vapors from second stage fuel loading will be processed to a level below analytical detection by a citric acid scrubber. Likewise, N_2O_4 vapors from second stage oxidizer loading will be passed through a sodium hydroxide (NaOH) scrubber. These scrubber wastes will be disposed of by a certified hazardous waste contractor according to the CCAS Petroleum Products and Hazardous Waste Management Plan. [OPlan 19-14] The scrubber operation is a FDEP permitted activity. Air emissions monitoring is conducted in accordance with the FDEP permit.

4.1.2. LAND RESOURCES

Overall, launching a Delta II vehicle is expected to have negligible negative effects on the land forms surrounding LC-17. [USAF 1988] However, launch activities could have some small impacts near the launch pad associated with fire and acidic depositions. Minor brush fires are infrequent by-products of Delta launches, and are contained and limited to the ruderal vegetation within the launch complexes; past singeing has not permanently affected the vegetation near the pads. Wet deposition of HCl, caused by rain falling through the ground cloud or SRM exhaust, could damage or kill vegetation. Wet deposition is not expected to occur outside the pad fence perimeter, due to the small size of the ground cloud and the rapid dissipation of both the ground cloud and SRM exhaust plume. [USAF 1990]

4.1.3. LOCAL HYDROLOGY AND WATER QUALITY

Water, supplied by municipal sources, is used at LC-17 for deluge water (for fire suppression), launch pad washdown, and potable water. Most of the deluge and launch pad washdown water is collected in a concrete catchment basin; however, minor amounts may drain directly to grade. The only potential contaminants used on the launch pad are fuel and oxidizer, and the only release of these substances would occur within sealed trenches and should not contaminate runoff. Any accidental or emergency release of propellants from the Delta vehicle after fueling would be collected in the flume located directly beneath the launch vehicle and channeled to a sealed concrete catchment basin. If the catchment basin water meets the criteria set forth in the FDEP industrial wastewater discharge permit, it is discharged directly to grade at the launch site. If it fails to meet the criteria, it is treated on site and disposed to grade or collected and disposed of by a certified contractor. No discharges of contaminated water are expected to result from medium launch vehicle operations at LC-17. To ensure this, the groundwater in the discharge area is monitored quarterly by Air Force Bioenvironmental Engineering Services.

The primary surface water impacts from a normal Delta II launch involve HCl and Al_2O_3 deposition from the ground cloud. The cloud will not persist or remain over any location for more than a few minutes. Depending on wind direction, most of the exhaust may drift over the Banana River or the Atlantic Ocean, resulting in a brief acidification of surface waters from HCl. Aluminum oxide is relatively insoluble at the pH of local surface waters and is not expected to cause elevated aluminum levels or significant acidification of surface waters. The relatively large volume of the two bodies of water compared to the amount of exhaust released is a major factor working to prevent a deep pH drop and fish kills associated with such a drop. There have been no fish kills recorded in the Atlantic Ocean or Banana River as a result of HCl and Al_2O_3 deposition during a normal launch. [45 AMDS/SGPB] A normal Delta II launch will have no substantial impacts to the local water quality.

4.1.4. OCEAN ENVIRONMENT

In a normal launch, the first stage and GEMS will impact the ocean. The trajectories of spent first stage and GEMs would be programmed to impact a safe distance from any U.S. coastal area or other land mass. Toxic concentrations of metals are not likely to occur due to the slow rate of corrosion in the deep ocean environment and the large quantity of water available for dilution.

Since the first stage and GEMS will be burned to depletion in-flight, there would be relatively small amounts of propellant. The release of solid propellants into the water column would be slow, with potentially toxic concentrations occurring only in the immediate vicinity of the propellant. Insoluble fractions of the first stage propellant would spread rapidly to form a localized surface film that will evaporate in several hours. Second stage propellants are soluble and should also disperse rapidly.

Concentrations in excess of the maximum allowable concentration (MAC) of these compounds for marine organisms would be limited to the immediate vicinity of the spent stage. No substantial impacts are expected from the reentry and ocean impact of spent stages, due to the small amount of residual propellants and the large volume of water available for dilution. [USAF 1988]

4.1.5. BIOTIC RESOURCES

A normal Delta II launch is not expected to substantially impact CCAS terrestrial, wetland, or aquatic biota. The elevated noise levels of launch are of short duration and would not substantially affect wildlife populations. Wildlife encountering the launch-generated ground cloud may experience brief exposure to exhaust particles, but would not experience any significant impacts. Aquatic biota may experience acidified precipitation, if the launch occurs immediately after a rain shower. This impact is expected to be insignificant due to the brevity of the ground cloud and the high buffering ability of the surrounding surface waters to rapidly neutralize excess acidity.

4.1.6. THREATENED AND ENDANGERED SPECIES

Any action that may affect federally listed species or their critical habitats requires consultation with the U.S. Fish and Wildlife Service (FWS) under Section 7 of the Endangered Species Act of 1973 (as amended). The FWS has reviewed the actions which would be associated with a Delta II launch from LC-17 and has determined that those actions would have no effect on state or federally listed threatened (or proposed for listing as threatened) or endangered species residing on CCAS and adjoining waters or ctitical habitat. [USAF 1988] [NASA 1994]

4.1.7. DEVELOPED ENVIRONMENT

4.1.7.1. Population and Socioeconomics

Launching the Mars Surveyor '98 mission will have a negligible impact on local communities, since no additional permanent personnel are expected beyond the current CCAS staff. LC-17 has been used exclusively for space launches since the late 1950s. The MSP '98 mission would cause no additional adverse impacts on community facilities, services, or existing land uses.

4.1.7.2. Safety and Noise Pollution

The "Medium Launch Vehicle Accident Risk Assessment Report" [MDSSC 1986] describes the launch safety aspects of the Delta II vehicle, support equipment, and LC-17 facilities. The report identifies design and operating limits that would be imposed on system elements to preclude or minimize accidents resulting in damage or injury. Normal operations at CCAS include preventative health measures for workers such as hearing protection, respiratory protection, and exclusion zones to minimize or prevent exposure to harmful noise levels or hazardous areas or materials.

The engine noise and sonic booms from a Delta II launch are typical of routine CCAS operations. To the surrounding community, noise from launch-related activity appears, at worst, to be an infrequent nuisance rather than a health hazard. In the history of the USAF space-launch vehicle operations from CCAS, there have been no problems reported as a result of sonic booms, most probably because the ascent track of all vehicles and the planned reentry of spent suborbital stages are over open ocean, thus placing sonic booms away from land areas. Shipping in the area likely to be affected is warned of the impending launches as a matter of routine, so that all sonic booms are expected and of no practical consequence. [USAF 1988]

4.1.7.3. Cultural Resources

Since no surface or subsurface areas would be disturbed, no properties listed or eligible for listing in the National Register of Historic Places are expected to be affected by launching the MSP '98 spacecraft.

4.1.7.4. Pollution Prevention

4.1.7.4.1. NASA

In compliance with Executive Order (EO) 12856, "Pollution Prevention and Community Right-to-Know," NASA has developed a comprehensive agency program to prevent adverse environmental impacts by: 1) Moving ahead of environmental compliance; 2) Emphasizing pollution source elimination and waste reduction; and, 3) Involving communities in NASA decision processes.

By December 31, 1999, NASA will have achieved a 50 percent reduction (1994 baseline) in releases of toxic chemicals to the environment and off-site transfers of such chemicals for treatment and disposal as reported on Toxic Chemical Release Inventory (TRI), Form R. NASA will have a system in place to transfer Pollution Prevention technologies both in and out of its operations. Specifications and Standards used by NASA will no longer require the use of extremely hazardous substances and toxic chemicals, within safety and reliability constraints. Each NASA Center will submit annual Pollution Prevention progress reports to NASA Headquarters, describing the progress the Center has made in complying with EO 12856.

4.1.7.4.2. USAF

By December 31, 1999, the USAF will have achieved a 50 percent reduction (1994 baseline) in total releases and off-site transfers of TRI Chemicals. Purchases of Environmental Protection Agency (EPA) 17 Industrial Toxic Pollutants, and hazardous waste disposal will be reduced by 50 percent (1992 baseline) by December 31, 1996, and 1999, respectively. Environmentally preferable products will be purchased, so that one-hundred percent of all products purchased each year in each of EPA's "Guideline Item" categories shall contain recycled materials. [USAF 1995]

4.1.7.4.3. Environmental Justice

EO 12898 directs Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on low-income populations and minority populations. Given the launch direction and trajectories of the MSP 98 missions, analysis indicates little or no potential of substantial environmental effects on any human populations outside CCAS boundaries.

4.2. ACCIDENTS AND LAUNCH FAILURES

4.2.1. LIQUID PROPELLANT SPILL

The potential for an accidental release of liquid propellants will be minimized by strict adherence to established safety procedures. First stage propellants, RP-1 and liquid oxygen, will be stored in tanks near the launch pad within cement containment basins designed to retain 110 percent of the storage tank volumes. Post-fueling spills from the launch vehicle would be channeled into a sealed concrete catchment basin and disposed of in accordance with OPlan 19 –1. Second stage propellants, Aerozine 50 and N_2O_4, are not stored at LC-17 and would be transported to the launch site by specialized vehicles.

The most severe propellant spill accident scenario would be releasing the entire launch vehicle load of N_2O_4 at the launch pad while conducting propellant transfer operations. This scenario would have the greatest potential impact on local air quality. Using Titan IV REEDM results and scaling for the Delta propellant loading, airborne NO_x levels from this scenario should be reduced to 5 ppm within about 150 m (500 ft) and to 1 ppm within 300 m (984 ft). Activating the launch pad water deluge system would substantially reduce the evaporation rate, limiting exposure concentrations in the vicinity of the spill that are above Federally established standards. Propellant transfer personnel would be outfitted with protective clothing and breathing equipment. Personnel not involved in transfer operations would be excluded from the area during such operations. [OPlan 32-3]

4.2.2. LAUNCH FAILURES

In the unlikely event of a launch vehicle destruction, either on the pad or in-flight, the liquid propellant tanks and SRM cases would be ruptured. Due to their hypergolic (ignite on contact) nature, a launch failure would result in a spontaneous burning of most of the liquid propellants, and a somewhat slower burning of SRM propellant fragments. Tables 4-3 and

4-4 define the combustion products of a GEM SRM failure (conflagration) and the REEDM predictions for chemical species concentrations, respectively. These maximum concentrations are predicted to occur approximately 8 km (5 mi) downwind of LC-17. The maximum 60-minute mean concentrations are predicted to occur approximately 7 km (4.5 mi) downwind. Tables 4-5 and 4-6 define the combustion products of a catastrophic launch pad failure (deflagration), wherein there is burning of the hypergolic propellants, and the REEDM predictions for chemical species concentrations resulting

Table 4-3. Combustion Products for Delta II 7425 GEM Failure Scenario (Conflagration)

Combustion Product	Product Mass Fraction	Total Propellant Mass of 47,480 kg	
		kg	lb
Al_2O_3	0.1759	8352	18374
Ar	0.0064	304	669
C	0.0143	679	1494
CH_4	0.0000	0	0
CO_2	0.1329	6310	13882
Cl_2	0.0000	0	0
HCl	0.1071	5085	11187
H_2O (liquid)	0.1274	5888	12953
H_2O (gaseous)	0.0136	646	1421
N_2	0.4188	19885	43746
O_2	0.0000	0	0

Source: Adapted from [MDSSC 1992]

from the deflagration, respectively. Although much of the solid and hypergolic propellants would be burned in either failure mode, emissions would include the constituents from a normal launch and dispersed propellants, including N_2H_4, and UDMH. Any N_2O_4 which does not react with other propellants is predicted by REEDM to convert to NO_2 in the fireball chemical reactions. The health hazard quantities of these chemicals are summarized in Table 4-7. The 24-hour average of Al_2O_3 resulting from this failure mode would be 4.5 $\mu g/m^3$, which is well below the 150$\mu g/m^3$ 24-hour average federal and Florida state primary standards. This release of pollutants would have only a short-term impact on the environment near LC-17.

Table 4-4 REEDM Predictions for Conflagration Chemical Species Concentrations

Chemical Species	Peak Concentration (ppm)	Maximum 60-Minute Mean Concentration (ppm)
CO	1.80	0.13
CO_2	0.15	0.01
Cl	0.062	0.004
HCl	0.70	0.05

Source: [USAF 1996]

Table 4-5. Combustion Products for Delta II 7425 Catastrophic Failure Scenario (Deflagration)

Combustion Product	Product Mass Fraction	Total Propellant Mass of 154,168 kg	
		kg	lb
Al_2O_3	0.0926	14276	31407
Ar	0.0064	987	2171
C	0.0191	2945	6478
CO_2	0.2514	38758	85267
Cl_2	0.0000	0	0
HCl	0.0551	8495	18688
H_2O (liquid)	0.1556	23989	52775
H_2O (gaseous)	0.0141	2174	4782
N_2	0.4051	62453	137398
O_2	0.0000	0	0

Source: Adapted from [MDSSC 1992]

Table 4-6 REEDM Predictions for Deflagration Chemical Species Concentrations

Chemical Species	Peak Concentration (ppm)	Maximum 60-Minute Mean Concentration (ppm)
CO	12.14	0.27
HCl	0.19	0.004
Al_2O_3 (A)	0.015	0.003
UDMH	0.070	0.001
NO_2	1.0	0.022
NH_3	0.39	0.009
N_2H_4	0.024	0.001
HNO_3	0.002	none

Source: [USAF 1996]

For a deflagration scenario, additional species such as UDMH, Nitrogen Dioxide (NO_2), Ammonia (NH_3), N_2H_4, nitrosodimethlyamine (NDMA), Formaldehyde (FDH), and nitric acid (NHO_3) were considered. The maximum concentrations and 60-minute mean concentrations predicted by REEDM for the deflagration mode in the worst credible weather scenario are shown in Table 4-6. These peak concentrations were predicted to occur approximately 7 km downwind from LC-17. Maximum 60-minute mean concentrations resulting from deflagration are predicted to occur approximately 8 km downwind. REEDM predicted that there would be no FDH and NDMA found in the ground cloud.

Launch failure impacts on water quality would stem from unburned liquid propellant being released into CCAS surface waters. For most launch failures, propellant release into surface waters would be substantially less than the full fuel load, primarily due to the reliability of the vehicle destruct system.

If there was an early flight termination and failure of the vehicle destruct system, it is remotely possible that the entire launch vehicle liquid propellant load could be released to the ocean. Shallow or confined surface water systems, such as aquifers, ponds, etc., would receive most of the impact. The release of the total first stage RP-1 fuel load in this near-pad intact vehicle impact scenario would form a very thin film (less than 0.003 cm, or 0.001 in) covering a water surface area less than 4.4 sq km (1.7 sq mi). This film would be expected to dissipate within a few hours. Release of the entire stage 2 propellants (Aerozine 50 and N_2O_4) could exceed allowable concentrations for an approximate radius of 241 m (800 ft) in water depths exceeding 3 m (9 ft) deep. However, even given this maximum impact scenario, the impacts to ocean systems would be localized and/or transient in nature, and expected to recover rapidly due to dilution in such a large amount of ocean water for dilution and buffering. [USAF 1988]

Under normal or catastrophic launch scenarios, concentrations would not be hazardous except in the immediate vicinity of the launch pad for approximately two minutes after launch or near the centroid of the launch cloud for a short time after the launch. The launch cloud would be several hundred meters above ground level, depending on weather conditions. These hazardous concentrations near the centroid of the launch cloud would persist for an estimated ten minutes, but could occur for shorter or longer periods depending on meteorological conditions. Airplanes are not allowed near the CCAS area during launches. Prior to launch personnel are cleared from the areas where potentially hazardous concentrations would occur, and there should be no hazard to humans associated with exhaust effluents.

For the propellants that would be dispersed to the air in the event of a catastrophic launch failure, hazardous concentrations would not occur except in the immediate vicinity of the launch complex. Since personnel will be cleared from form the area prior to launch, except for those in the sealed and protected blockhouse, there should be no hazard to humans from dispersed propellants in the event of a catastrophic launch failure.

Since Immediately Danger to Life or Health standards (IDLHs), Permissible Exposure Limits (PELs), Short Term Exposure Limits (STELs), and Threshold Limit Values (TLVs) are established considering potential exposure of workers, they should not be used for evaluating the potential health significance of accidental release which may impact the general population. They are, however, included here since personnel at CCAS will be transferring and loading fuel at the pad prior to launch. The recommended guidelines used to determine safe exposure limits for the general population are the Emergency Response Planning Guidelines (ERPGs), developed by the American Industrial Hygiene Association (AIHA). The endpoint for a toxic substance is its ERPG level 2 (ERPG-2), developed by the AIHA (Section 112r of the Clean Air Act). [ERPG 1997] None of the concentrations predicted by REEDM for catastrophic launch aborts of the Delta II at CCAS exceeded the ERPG-2 values except in the immediate vicinity of the launch pad.

A Delta II 7925 anomaly occurred on January 17, 1997 at CCAS as a result of a GEM breaking apart during flight. When the launch vehicle exploded, approximately 2,500 pieces of solid propellant, many burning, and 2,100 fragments of the launch vehicle were scattered within a mile (1.6 km) radius on and around LC-17. Numerous ground level secondary explosions resulted due to solid propellant and debris impacting the ground in the local area for nearly 30 minutes after the explosion. All debris impacted within predefined areas. [USAF 1997B] The vast bulk of the plume generated by the explosion was out over the ocean; and

Table 4-7 Health Hazard Quantities of Hazardous Launch Emissions

Compound	EEGL (ppm)	SPEGL (ppm)	PEL (ppm)	STEL (ppm)	TLV (ppm)	IDLH (ppm)
Dimethyl Hydrazine (UDMH)		0.24 for 1 hr 0.12 for 2 hr 0.06 for 4 hr 0.03 for 8 hr 0.015 for 16 hr 0.01 for 24 hr	0.5 (skin)		0.5 (skin)	50
Hydrazine (N_2H_4)		0.12 for 1 hr 0.06 for 2 hr 0.03 for 4 hr 0.015 for 8 hr 0.008 for 16 hr 0.005 for 24 hr	0.1 (skin)		0.1 (skin)	80
Hydro-chloric Acid or Hydrogen Chloride (HCl)	100 for 10 min 20 for 1 hr 20 for 24 hr	1 for 1 hr 1 for 1 day	5 (ceiling)		5 (ceiling)	100
Nitrogen Tetroxide as NO_2		1 for 1 hr 0.5 for 2 hr 0.25 for 4 hr 0.12 for 8 hr 0.06 for 16 hr 0.04 for 24 hr		1	3	50

Source: [USAF 1994]

EEGL Emergency Exposure Guidance Level - Advisory recommendations from the National Research Council (NRC) for the Department of Defense (DoD) for an unpredicted single exposure.

SPEGL Short-term Public Emergency Guidance Level - Advisory recommendations from the NRC for the DoD for an unpredicted single exposure by sensitive population.

PEL Permissible Exposure Limit - Occupational Safety and Health Administration (OSHA) standards averaged over 8-hour period, except for ceiling values which may not be exceeded in the workplace.

STEL Short Term Exposure Limit - OSHA standards averaged over 15-minute period in the workplace.

TLV Threshold Limit value - Recommendations of the America Conference of Governmental Industrial Hygienists.

IDLH Immediately Dangerous to Life or Health - Air concentration at which an unprotected worker can escape without debilitating injury or health effect.

maximum concentrations of HCl and NO2 were both 1 to 2 ppm. A slight wisp at the surface may have blown on-shore at concentrations below detection. A large buoyant and visible plume covered much of southern Brevard County and Indian River County at high altitude. No aspect of this plume was hazardous. The Flight Termination Systems (FTSs) proved able to prevent a hazard to the public. [USAF 1997A, USAF 1997B]

As a result of this launch accident, CCAS has implemented the following new policies: there will be a Brevard County Emergency Management Center (BEMC) representative at the launch console two hours before launch, to provide county officials with immediate access to information about the content of clouds and their direction; and the Air Force has installed direct audio and video communications lines from its control center to BEMC, to ensure open communication lines to the Rockledge emergency bunker, the site from which county officials broadcast emergency alerts. The Air Force has also installed a direct emergency phone line to the Florida State Emergency Response.Center. [USAF 1997-A, USAF 1997-B]

4.3. ENVIRONMENTAL IMPACTS OF ALTERNATIVES

Of the alternate launch vehicle systems available, only the ATLAS II/Centaur is capable of meeting, but not greatly exceeding, the MSP '98 mission requirements. While the ATLAS II/Centaur uses slightly less fuel, the reliability record of the Delta exceeds that of the Atlas, and the Atlas costs significantly more. The environmental impact of using a Delta II launch vehicle would be less than using the ATLAS II/Centaur.

Other launch vehicle alternatives which have more payload capability would contribute potentially greater adverse environmental impacts, at a significantly higher cost to launch.

5. OTHER ENVIRONMENTAL REVIEWS

5.1 AIR QUALITY

The Florida Department of Environmental Protection (FDEP) regulates air pollutant emission sources in Florida and requires permits for the construction, modification, or operation of potential air pollution sources [FDEP 1986]. Emissions from mobile sources, such as aircraft and space launch vehicles, do not require a permit. This exception does not include support facilities, such as propellant loading systems.

Stationary ground-based sources associated with space vehicle launches are subject to FDEP review. Because no new stationary sources would be constructed for the MSP '98 launch, there is no requirement for new air quality permits.

The Delta II oxidizer and fuel vapor air pollution control devices at CCAS are in compliance with NAAQS standards and FDEP regulations. The citric acid scrubber for Delta II propellants is probably one level of control beyond that required by the FDEP.

5.2 WATER QUALITY

5.2.1 STORMWATER DISCHARGE

Florida's stormwater discharge permitting program is designed to prevent adverse effects on surface water quality from runoff. A discharge permit will not be required for MSP '98 because the launch would not increase stormwater runoff rates or reduce the quality of the existing runoff.

5.2.2 SANITARY AND INDUSTRIAL WASTEWATER DISCHARGE

LC-17 and the MSP '98 spacecraft and launch vehicle assembly facilities have potable water and sanitary waste disposal permits. No new permits will be required for the MSP '98 assembly or launch.

Wastewater from LC-17 would include deluge and pad washdown water discharged during MSP '98 launch activities. An application has been filed with the FDEP to permit discharge from LC-17. The permit will be issued based on demonstration that discharge would not significantly degrade surface or ground water.

5.2.3. FLOODPLAINS AND WETLANDS

LC-17 is not located on a floodplain. Impacts to wetlands from the launch of the MSP '98 would not exacerbate impacts from other CCAS activities or launches. Therefore, no new permits would be required for the MSP '98 launch.

5.3. HAZARDOUS WASTES

CCAS was issued a Resource Conservation and Recovery Act (RCRA), Part B Hazardous Waste Operations permit in January 1986 [USAF 1986]. All hazardous wastes generated at CCAS will be managed according to the CCAS Petroleum Products and Hazardous Waste Management Plan (OPlan 19-14). Hazardous wastes produced during processing and launch operations will be collected and stored in hazardous waste accumulation areas before being transferred to a hazardous storage area. These wastes will eventually be transported to an off-station licensed hazardous waste treatment/disposal facility.

5.4. SPILL PREVENTION

To prevent oil or petroleum discharges into U.S. waters, a Spills Prevention, Control, and Countermeasures Plan (SPCCP) is required by the Environmental Protection Agency's oil pollution prevention regulation. A SPCCP has been integrated into the CCAS Oil and Hazardous Substance Pollution Contingency Plan (OPlan 19-1). Spills of oil or petroleum products that are federally listed hazardous materials will be collected and removed for proper disposal by a certified contractor according to CCAS OPlan 19-4, Hazardous Substance Pollution Contingency Plan [USAF 1990]. All spills/releases will be reported to the host installation per OPlan 19-1.

5.5. COASTAL MANAGEMENT PROGRAM

The Federal Coastal Zone Management Act of 1972 establishes a national policy to preserve, protect, develop, restore, and/or enhance the resources of the nation's coastal zone. The Act requires federal agencies that conduct or support activities directly affecting the coastal zone, to perform these activities in a manner that is, to the maximum extent practicable, consistent with approved state coastal zone management programs.

Delta II launches from LC-17 have been demonstrated to be consistent to the maximum extent practicable with the State of Florida's Coastal Management Program, based on compatible land use, absence of significant environmental impacts and compliance with applicable regulations. [USAF 1986] MSP '98 mission processing and launch would add little or no impact beyond those determined to be associated with the Delta II.

CULTURAL RESOURCES

In accordance with 36 CFR Part 800, the Florida Department of State, Division of Historical Resources, reviewed the Mars Pathfinder launch in December 1996 for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. Their review indicated that no significant archaeological or other historical sites are recorded in the Florida Master Site File, nor are any likely to appear there. They considered it unlikely that any such sites would be affected by Pathfinder launch. [FLORIDA 1993] Based on the fact that MSP '98 is planned to be launched on the same type of launch vehicle from the same launch pad, and requires no new facilities, it is assumed that the MSP '98 mission would not affect any significant cultural sites.

NASA has also determined that the proposed action will have no effect on property listed in the National Register of Historic Places.

CORRESPONDENCE WITH FEDERAL AGENCIES

While preparing this Environmental Assessment, NASA solicited comments from a range of Federal and State Agencies. Those responses have been incorporated in this final Environmental Assessment.

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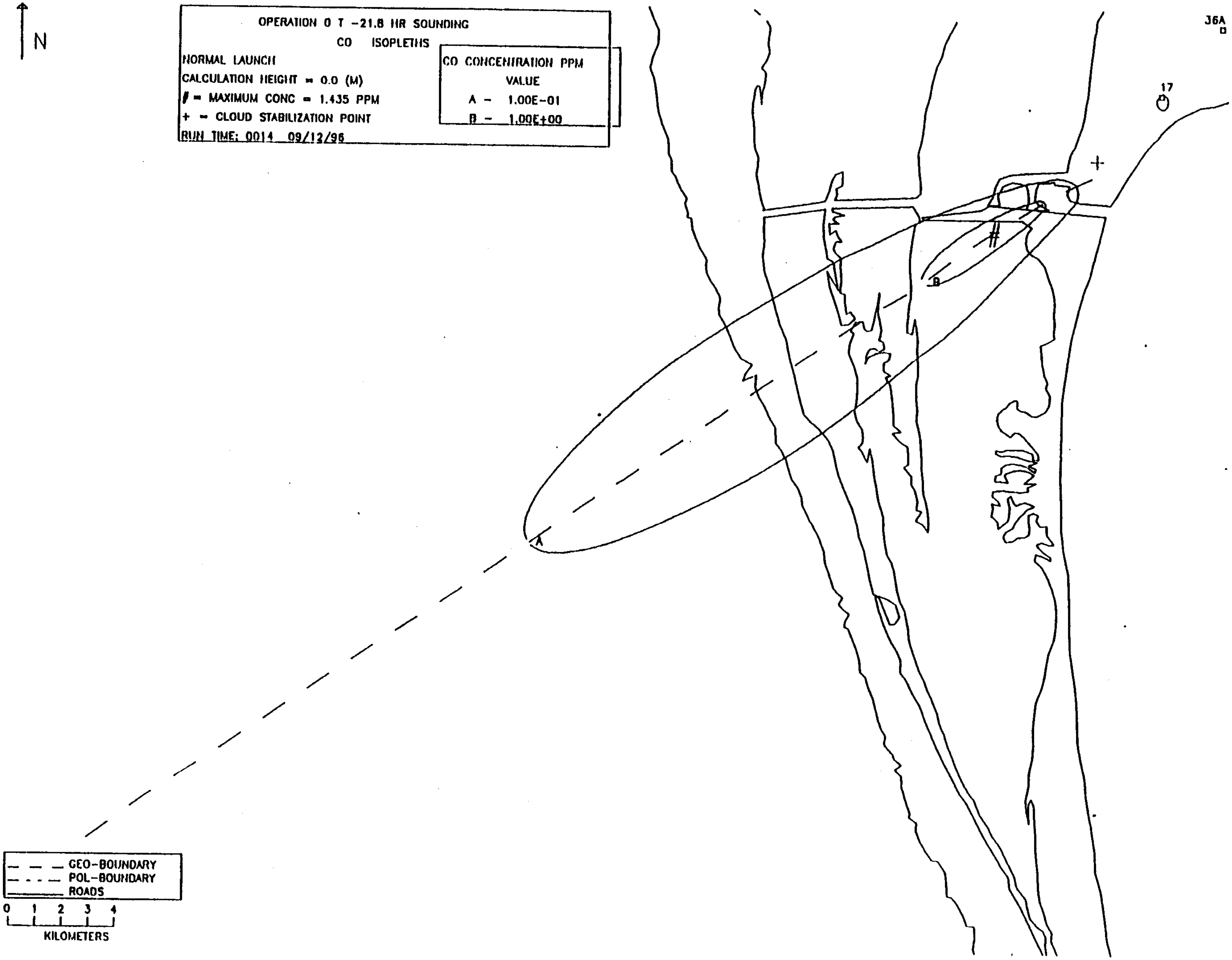
Appendix A
Selected REEDM Output

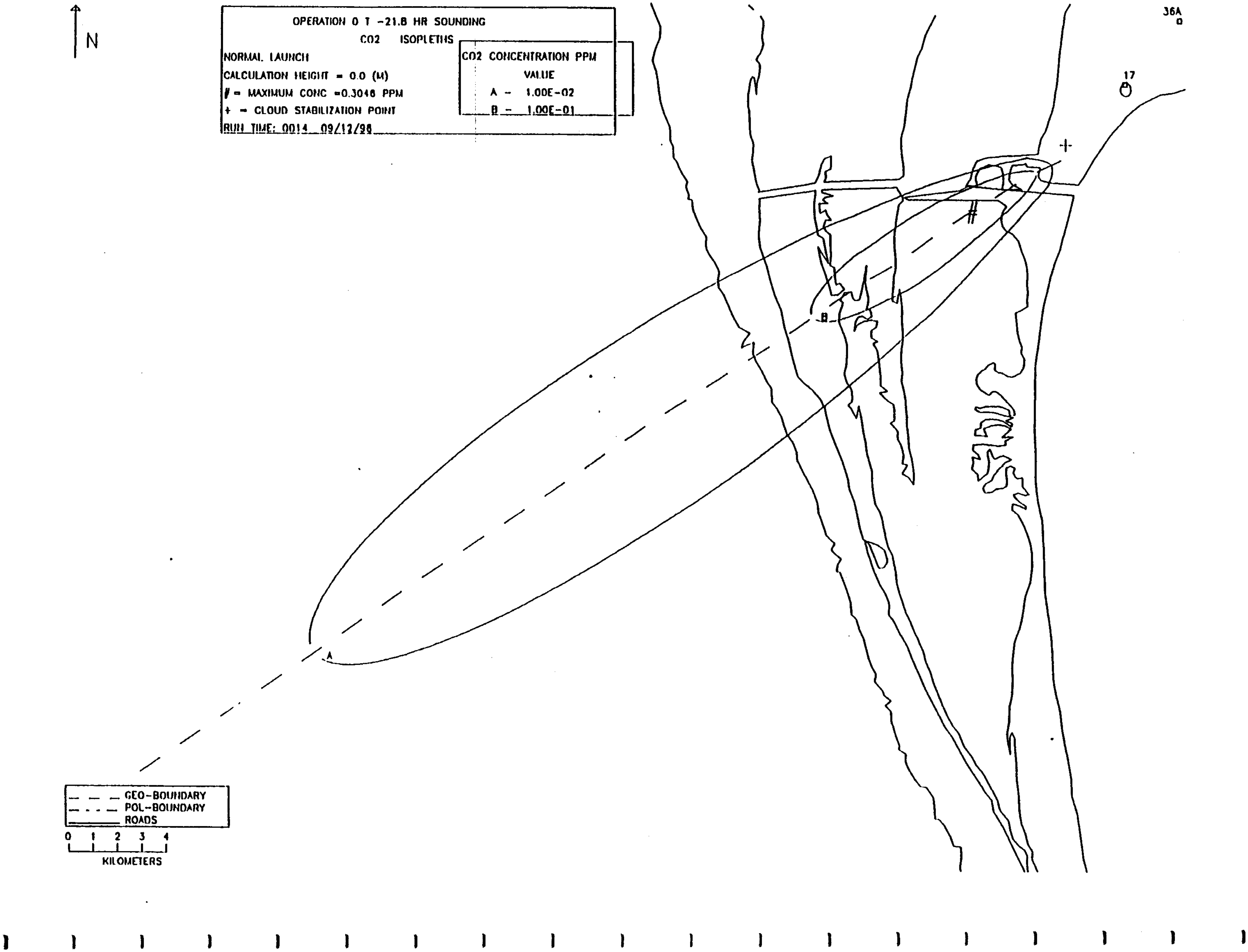
Normal Launch Mode

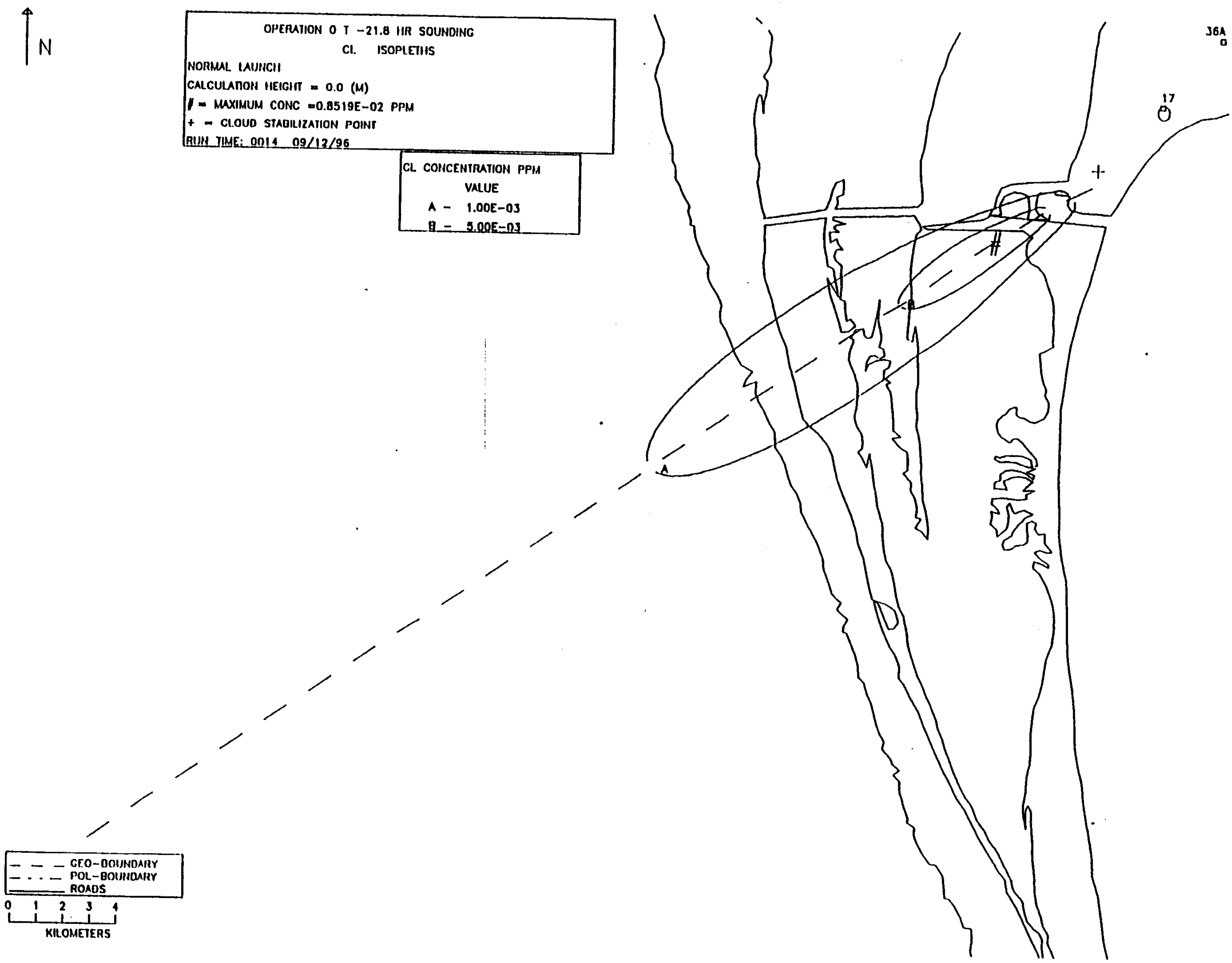
Conflagration Mode Failure

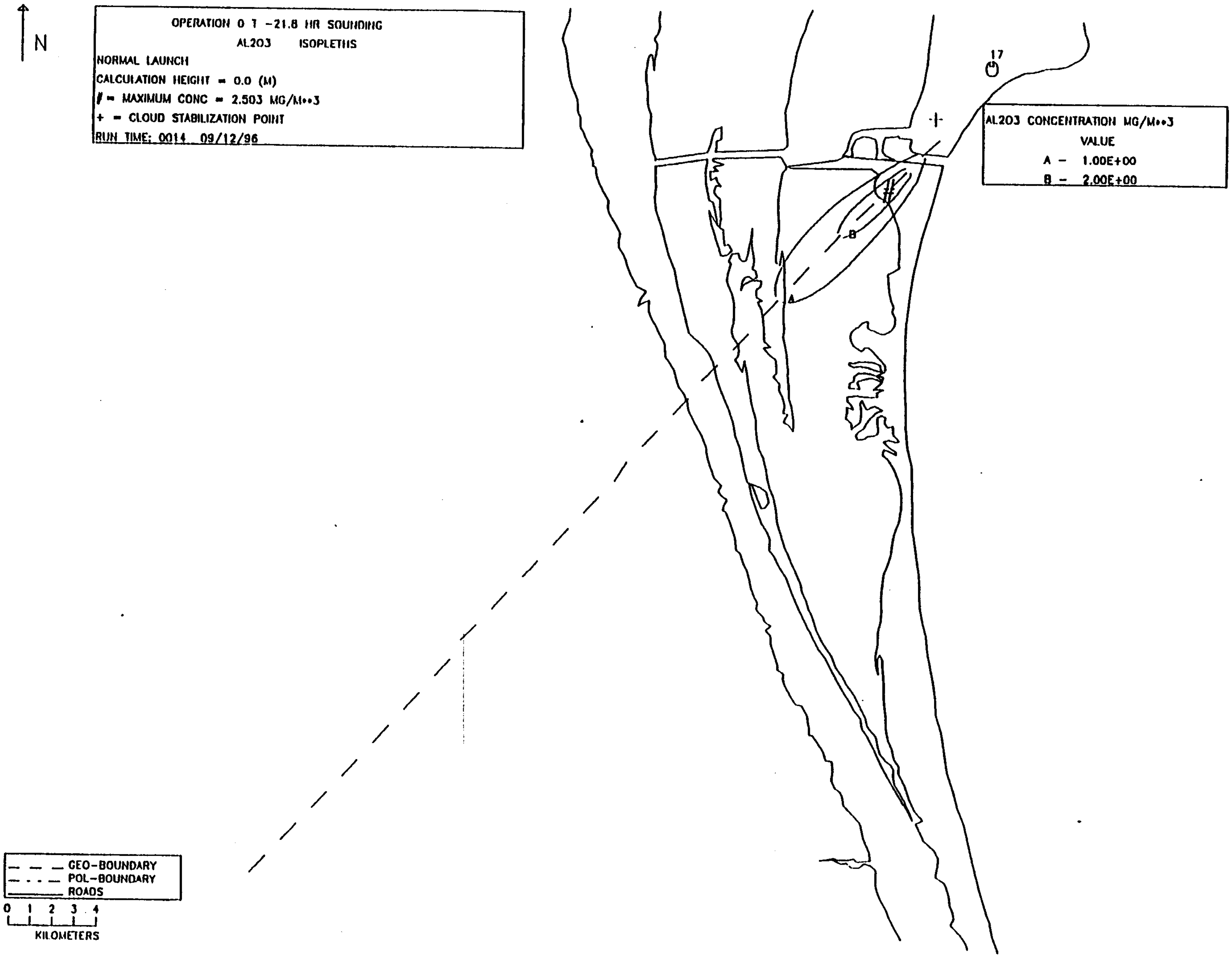
Deflagration Mode Failure



N
OPERATION 0 T -21.8 HR SOUNDING
CO ISOPLETHS
NORMAL LAUNCH
CALCULATION HEIGHT = 0.0 (M)
= MAXIMUM CONC = 1.435 PPM
+ = CLOUD STABILIZATION POINT
RUN TIME: 0014 09/12/96
CO CONCENTRATION PPM
VALUE
A - 1.00E-01
B - 1.00E+00
36A
17
A
B
GEO-BOUNDARY
POL-BOUNDARY
ROADS
0 1 2 3 4
KILOMETERS


N
OPERATION 0 T -21.8 HR SOUNDING
CO2 ISOPLETHS
NORMAL LAUNCH
CALCULATION HEIGHT = 0.0 (M)
= MAXIMUM CONC =0.3046 PPM
+ - CLOUD STABILIZATION POINT
RUN TIME: 0014 09/12/98
CO2 CONCENTRATION PPM
VALUE
A - 1.00E-02
B - 1.00E-01
36A
17
A
B
GEO-BOUNDARY
POL-BOUNDARY
ROADS
0 1 2 3 4
KILOMETERS


N
OPERATION 0 T -21.8 HR SOUNDING
CL ISOPLETHS
NORMAL LAUNCH
CALCULATION HEIGHT = 0.0 (M)
= MAXIMUM CONC =0.8519E-02 PPM
+ = CLOUD STABILIZATION POINT
RUN TIME: 0014 09/12/96
CL CONCENTRATION PPM
VALUE
A - 1.00E-03
B - 5.00E-03
36A
17
A
B
GEO-BOUNDARY
POL-BOUNDARY
ROADS
0 1 2 3 4
KILOMETERS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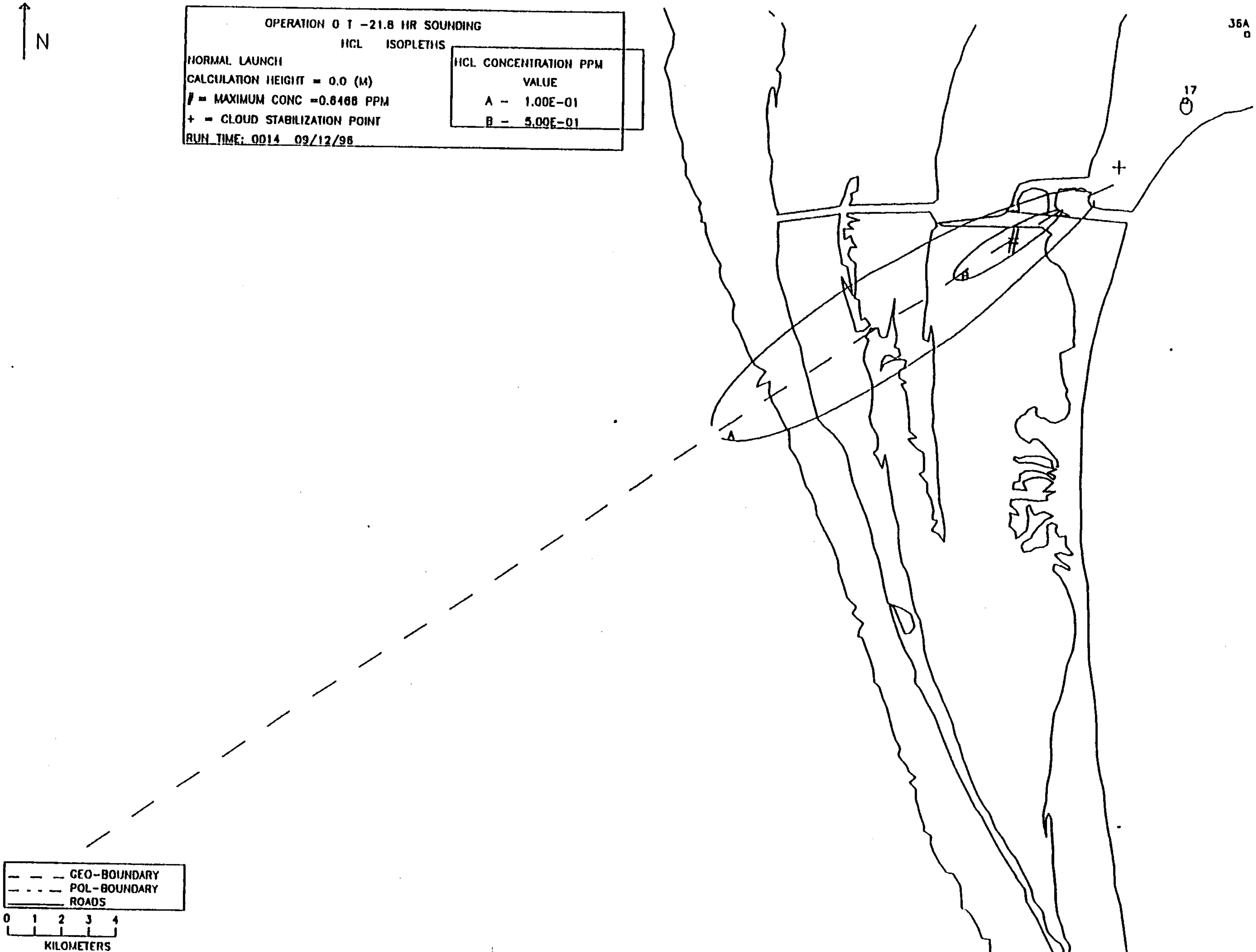
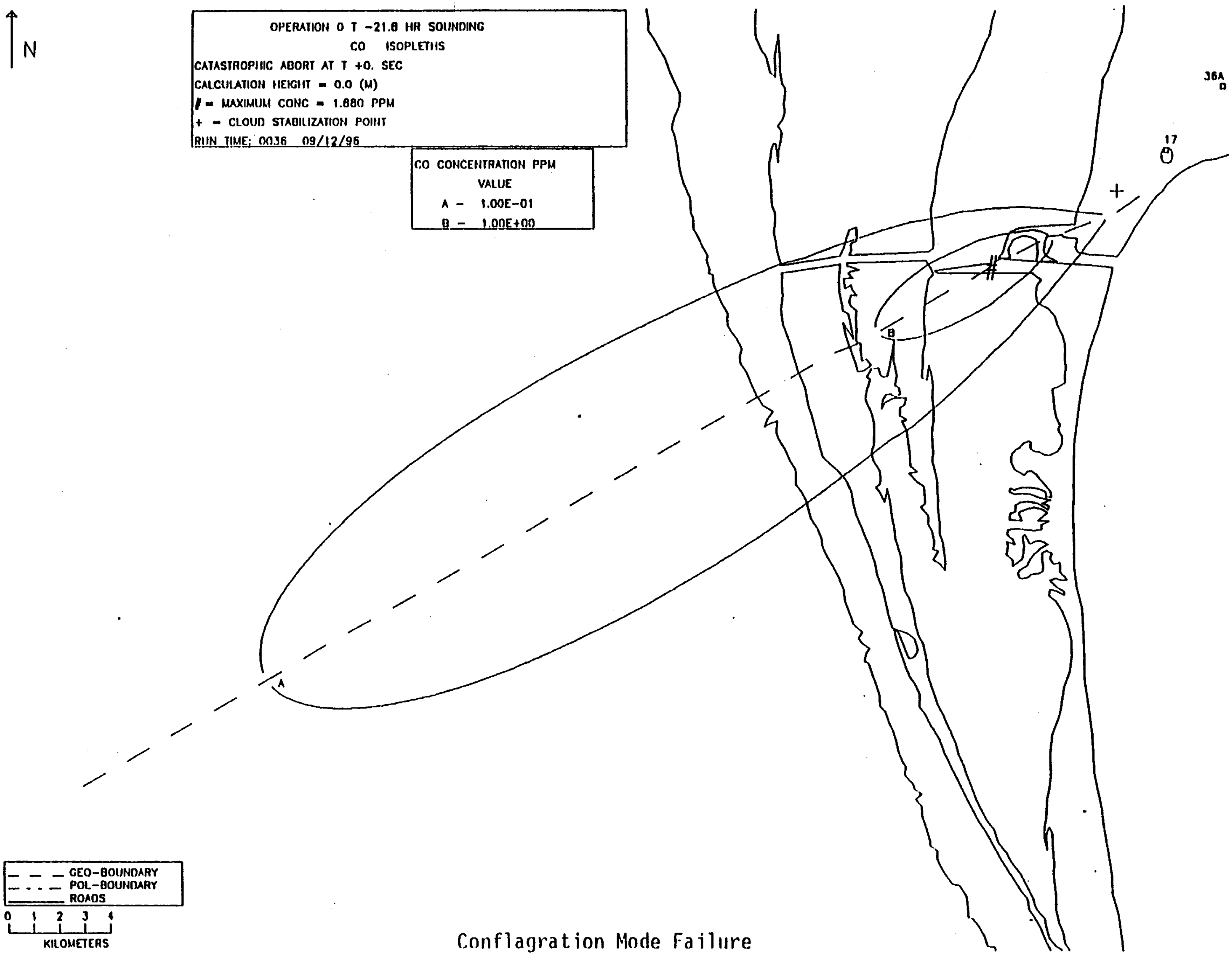
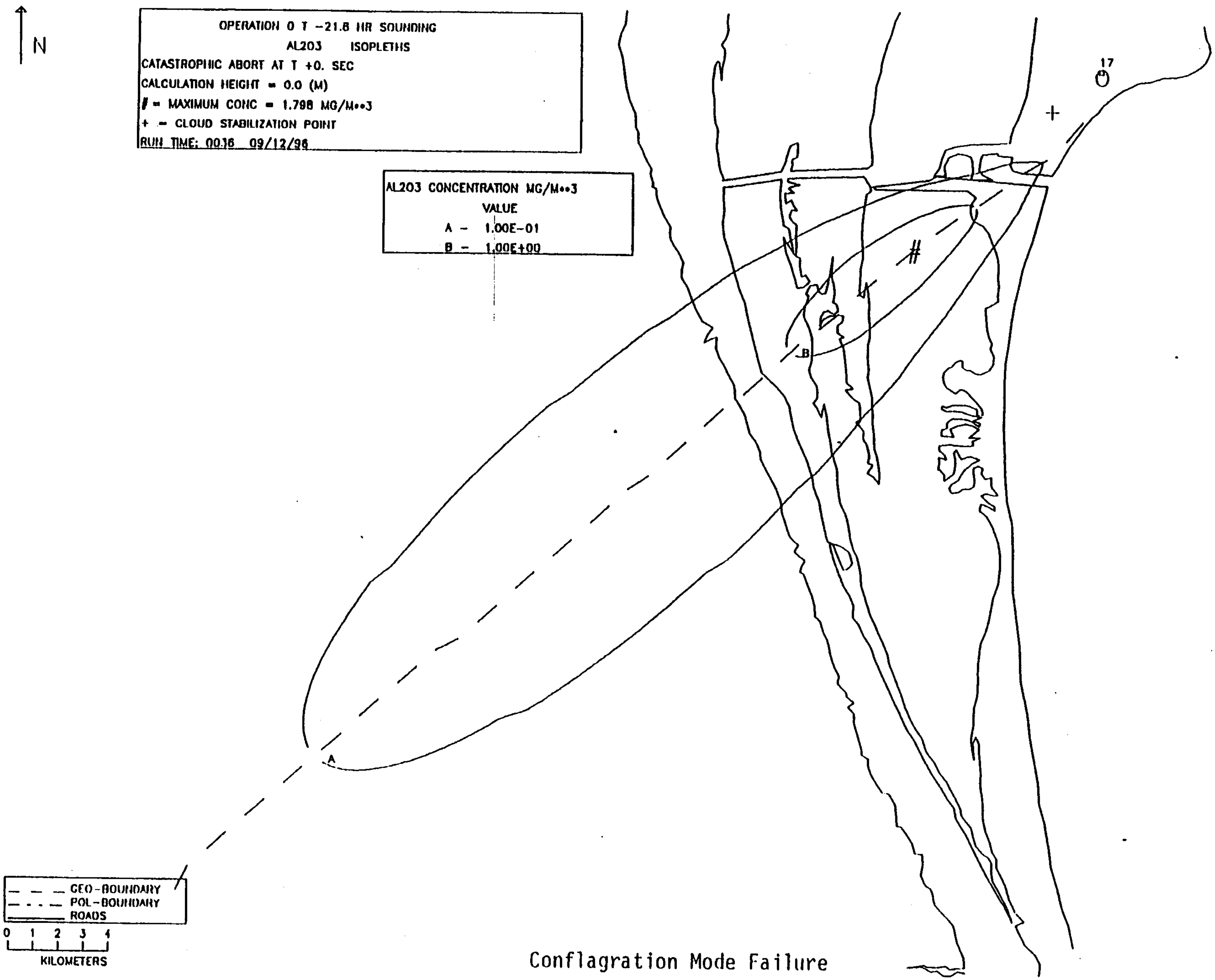
OPERATION 0 T -21.8 HR SOUNDING
AL2O3 ISOPLETHS
NORMAL LAUNCH
CALCULATION HEIGHT = 0.0 (M)
= MAXIMUM CONC = 2.503 MG/M**3
+ = CLOUD STABILIZATION POINT
RUN TIME: 0014 09/12/96
17
AL2O3 CONCENTRATION MG/M**3
VALUE
A - 1.00E+00
B - 2.00E+00
A
B
GEO-BOUNDARY
POL-BOUNDARY
ROADS
0 1 2 3 4
KILOMETERS

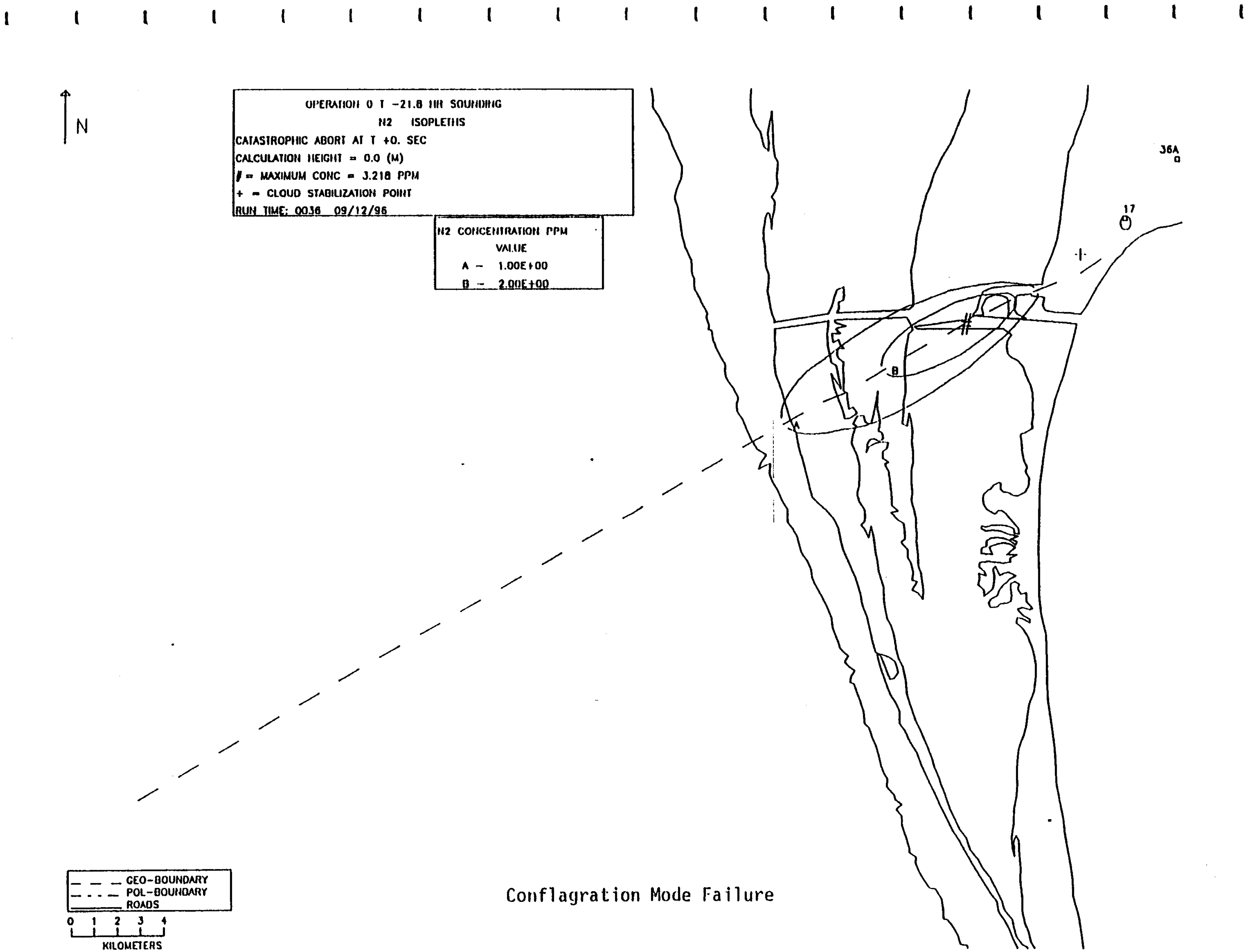

N
OPERATION 0 T -21.8 HR SOUNDING
HCL ISOPLETHS
NORMAL LAUNCH
CALCULATION HEIGHT = 0.0 (M)
= MAXIMUM CONC =0.6468 PPM
+ = CLOUD STABILIZATION POINT
RUN TIME: 0014 09/12/96
HCL CONCENTRATION PPM
VALUE
A - 1.00E-01
B - 5.00E-01
17
A
B
GEO-BOUNDARY
POL-BOUNDARY
ROADS
0 1 2 3 4
KILOMETERS



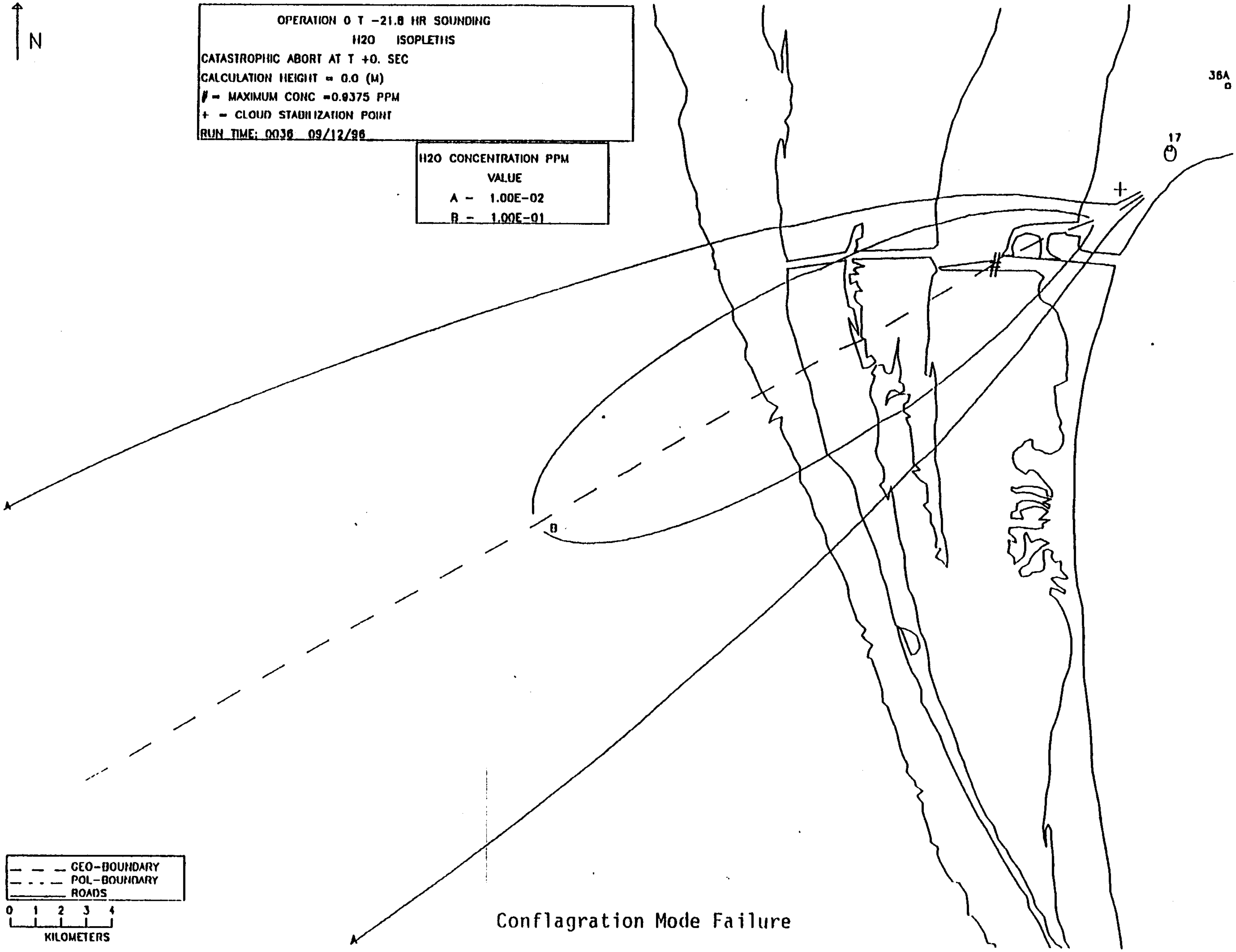
Conflagration Mode Failure



Conflagration Mode Failure



Conflagration Mode Failure



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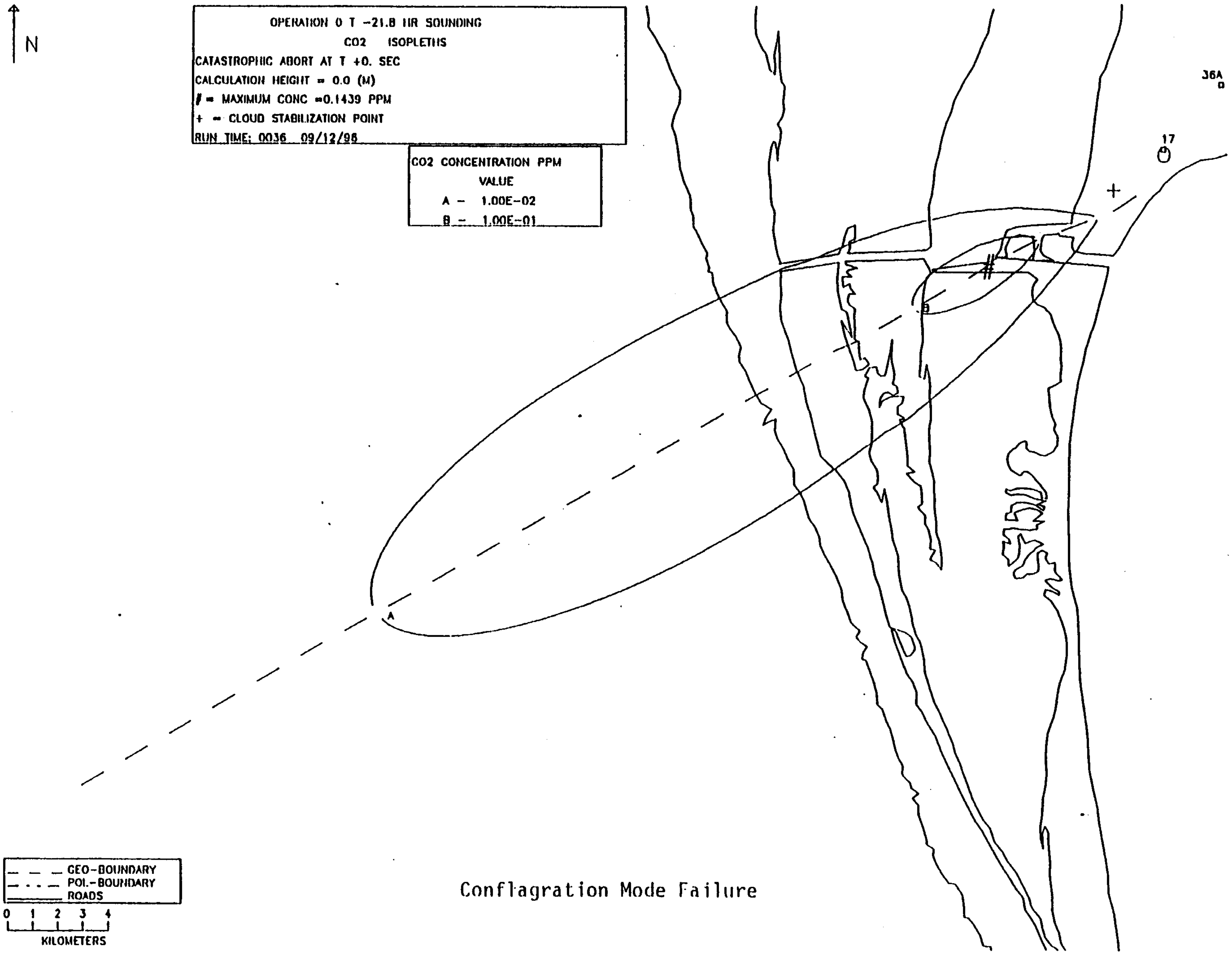

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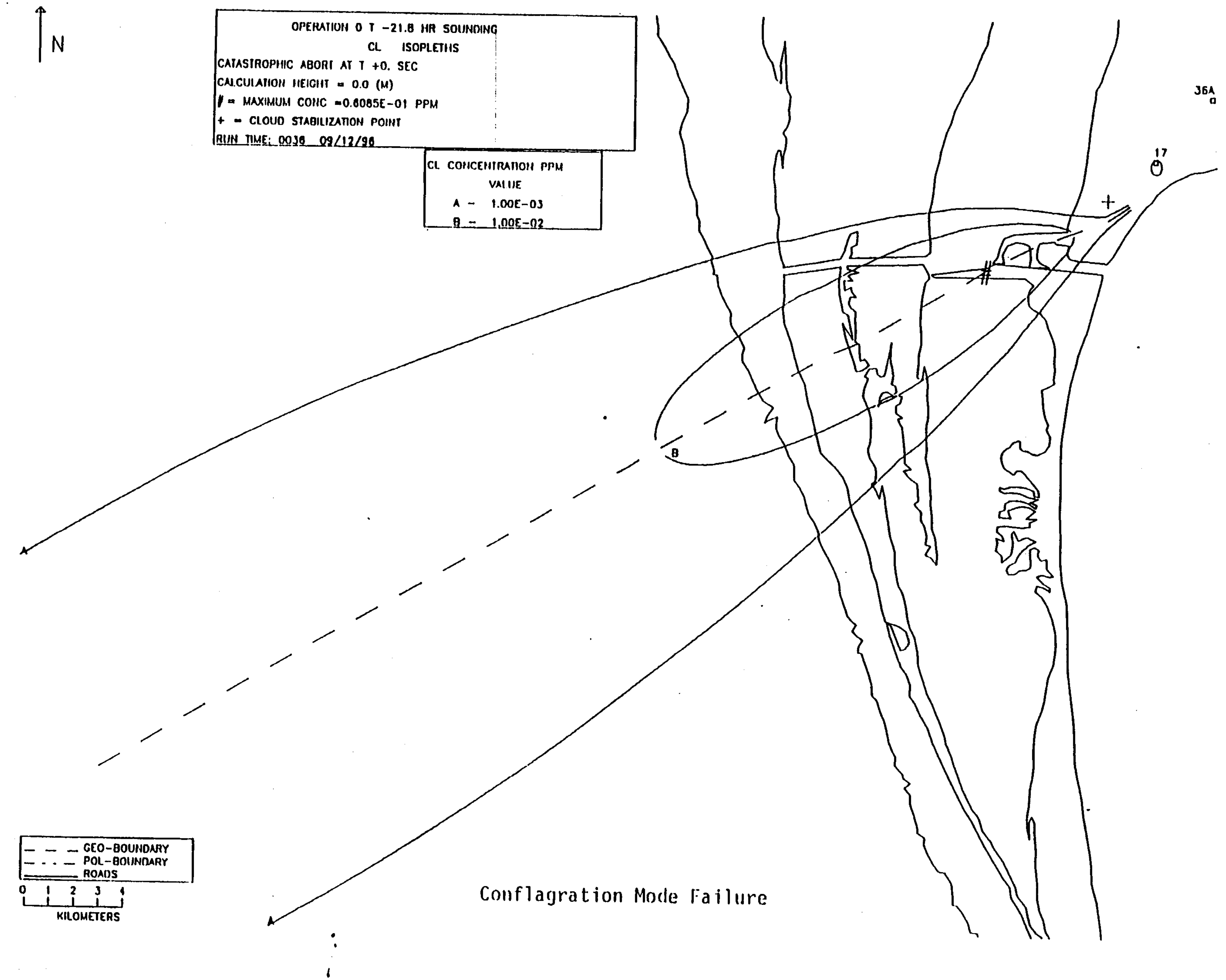

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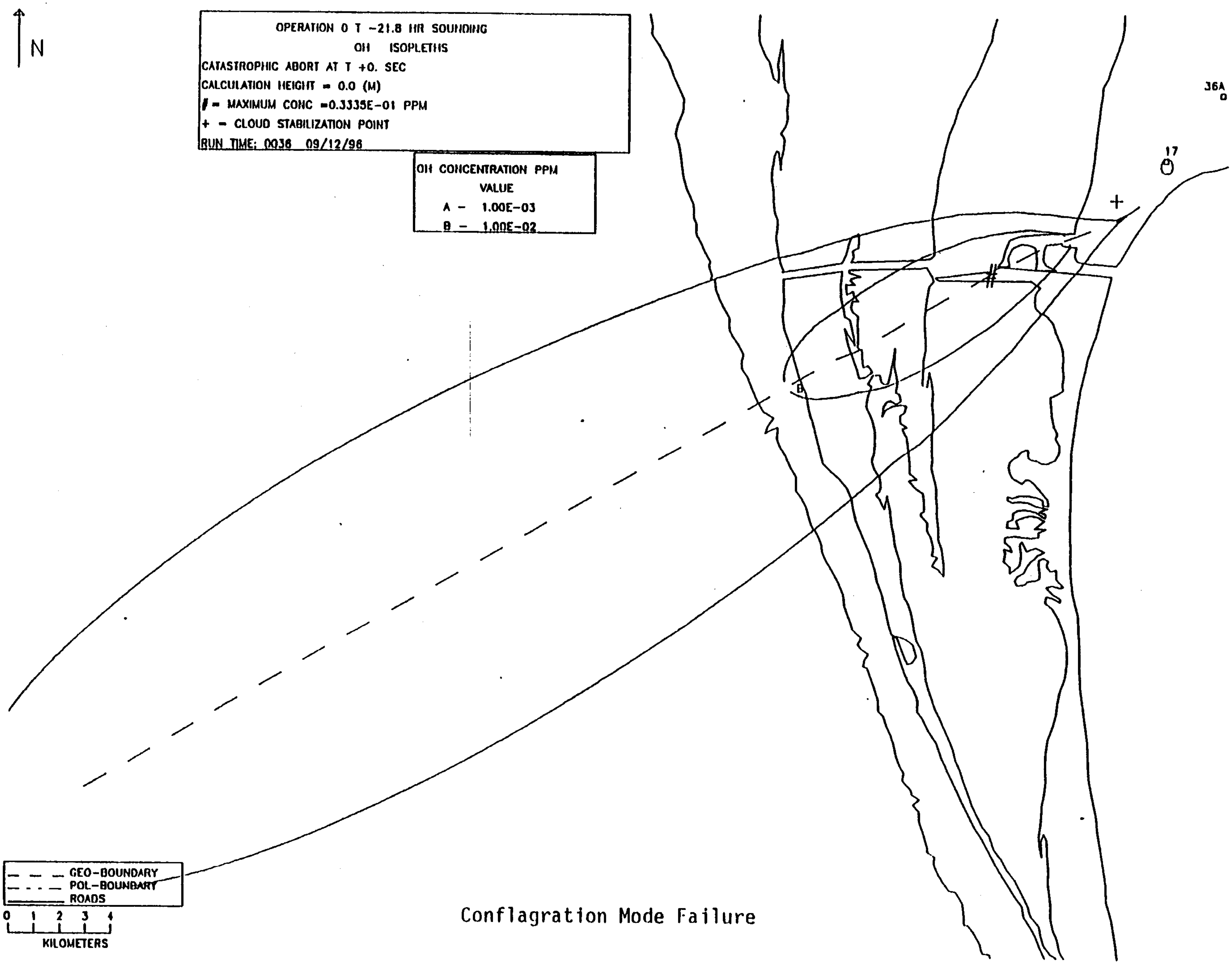

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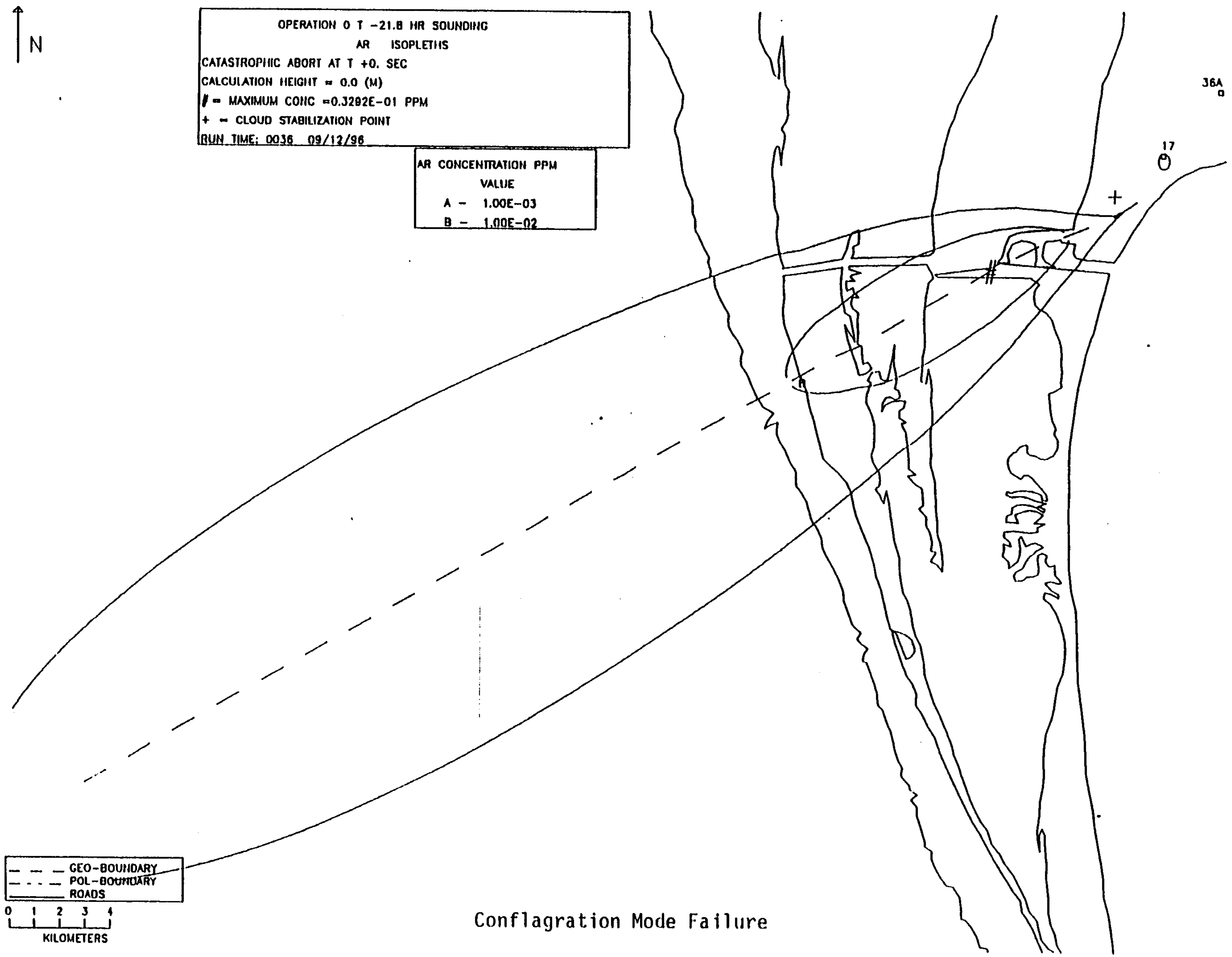

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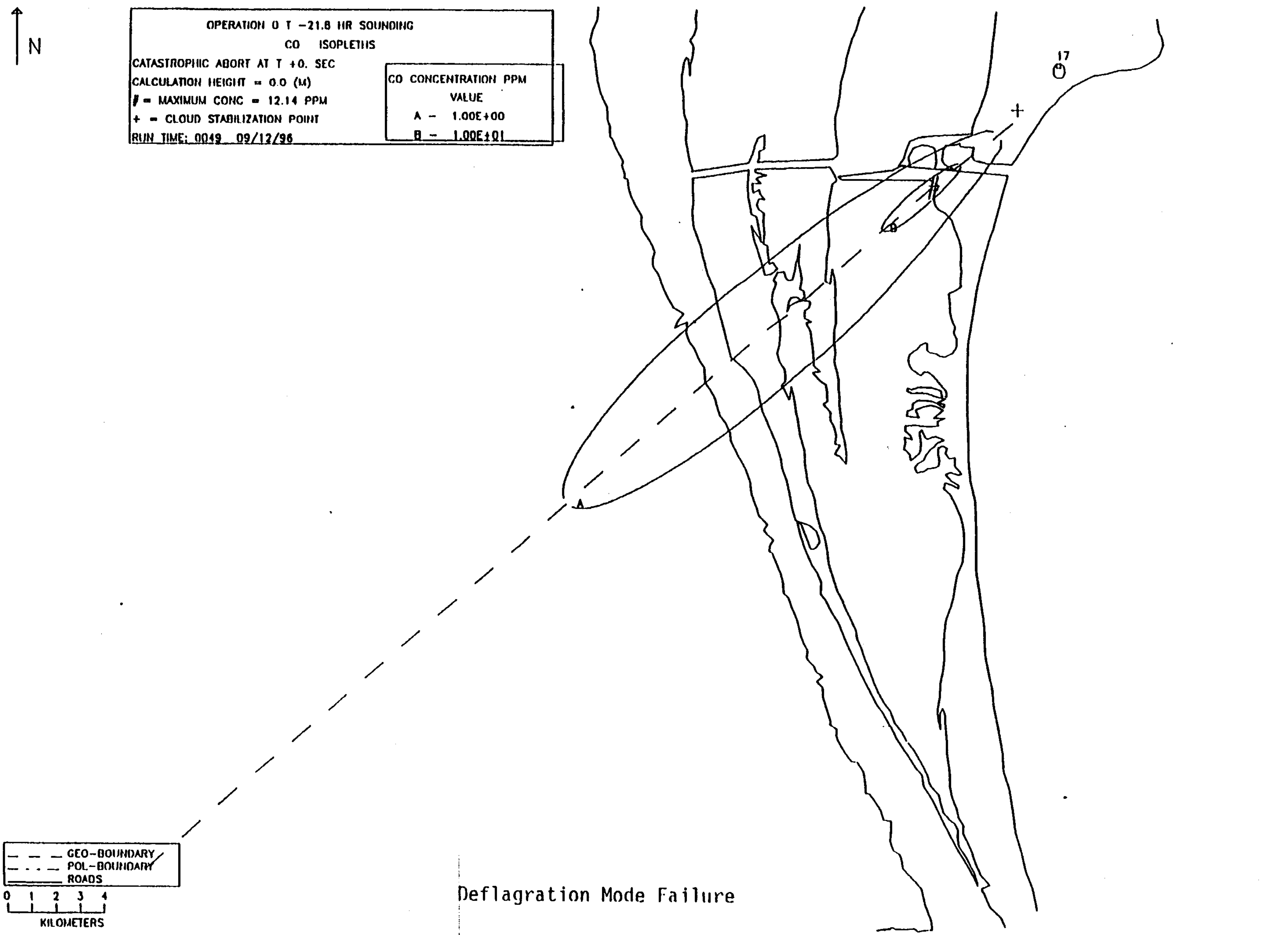

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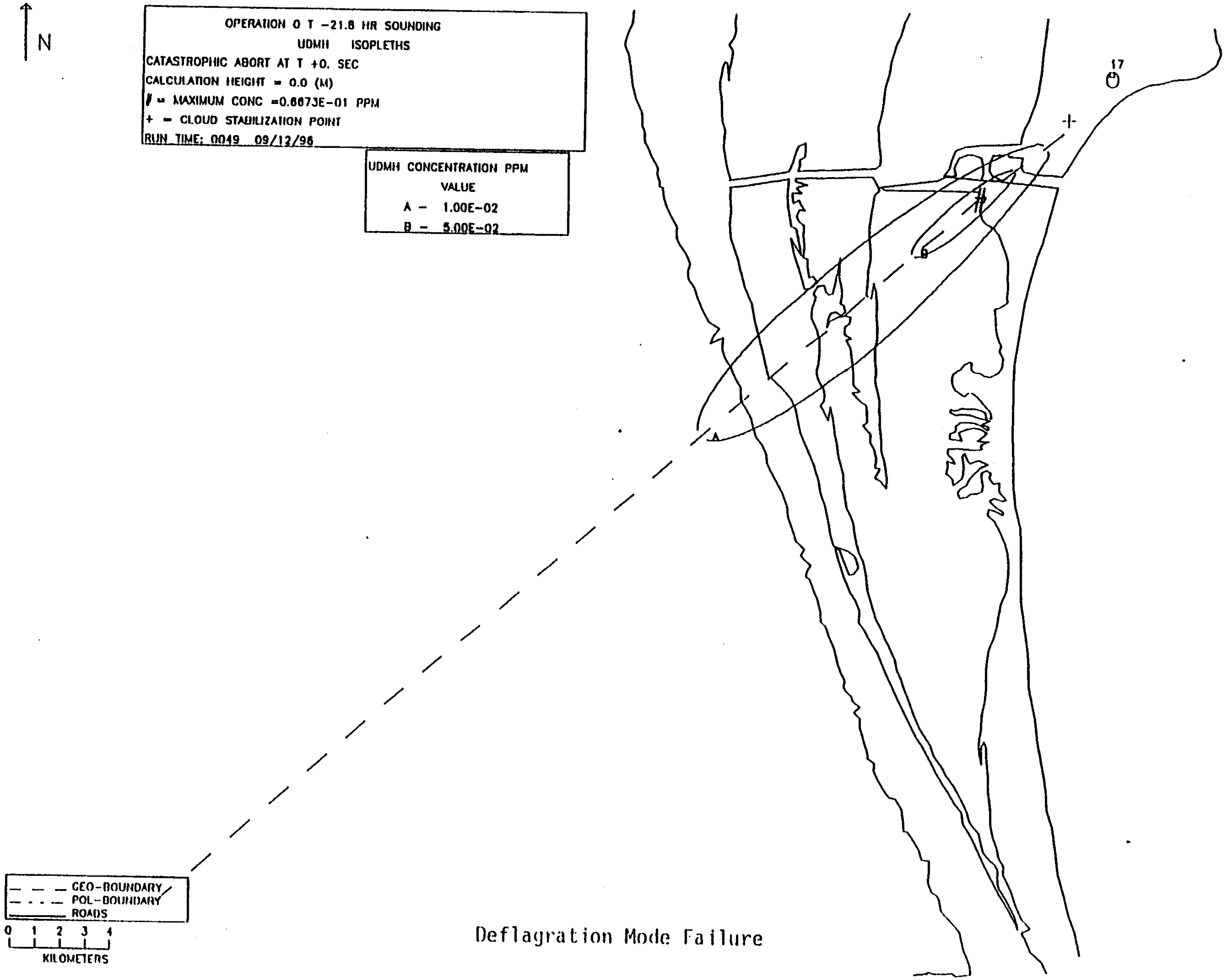

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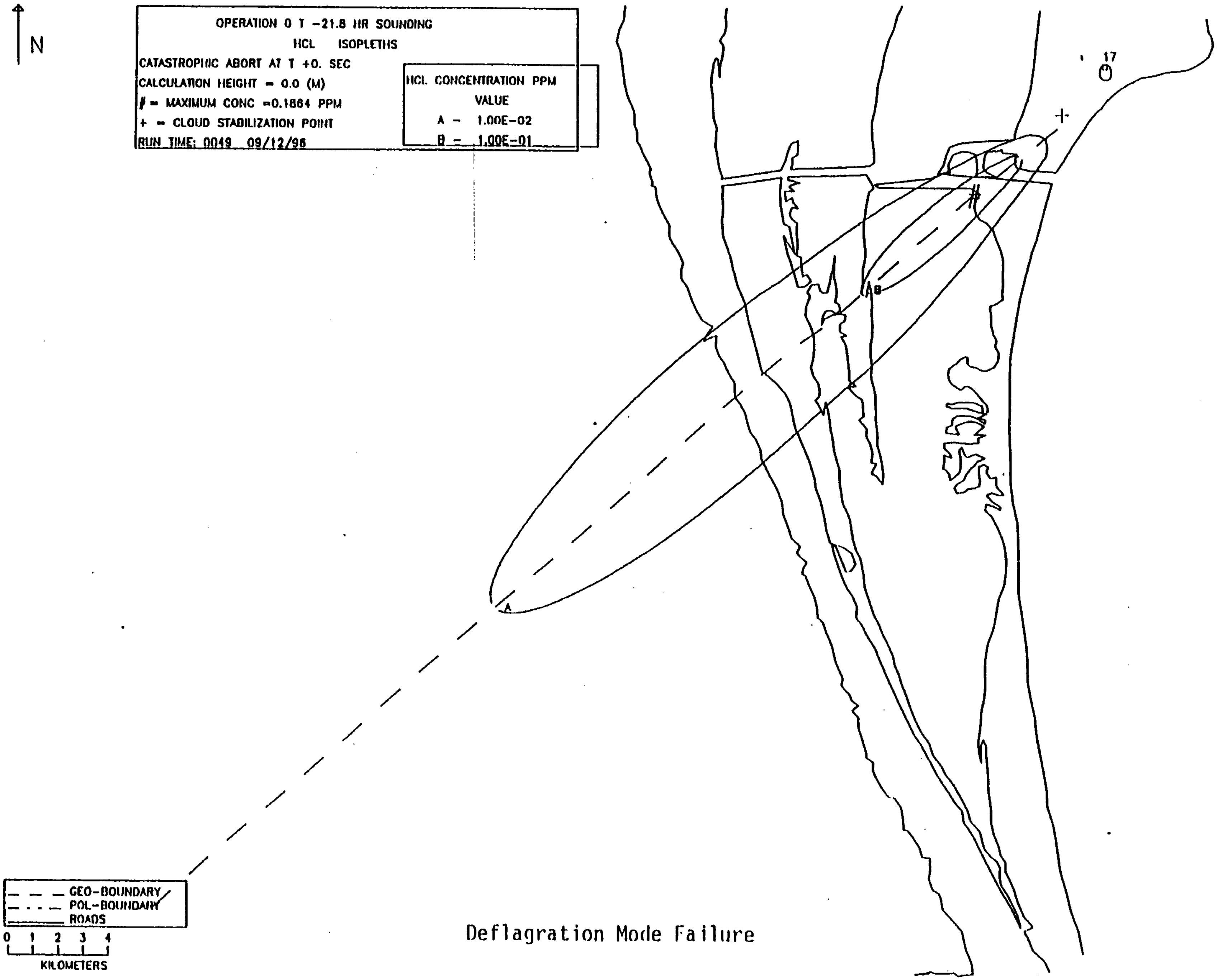

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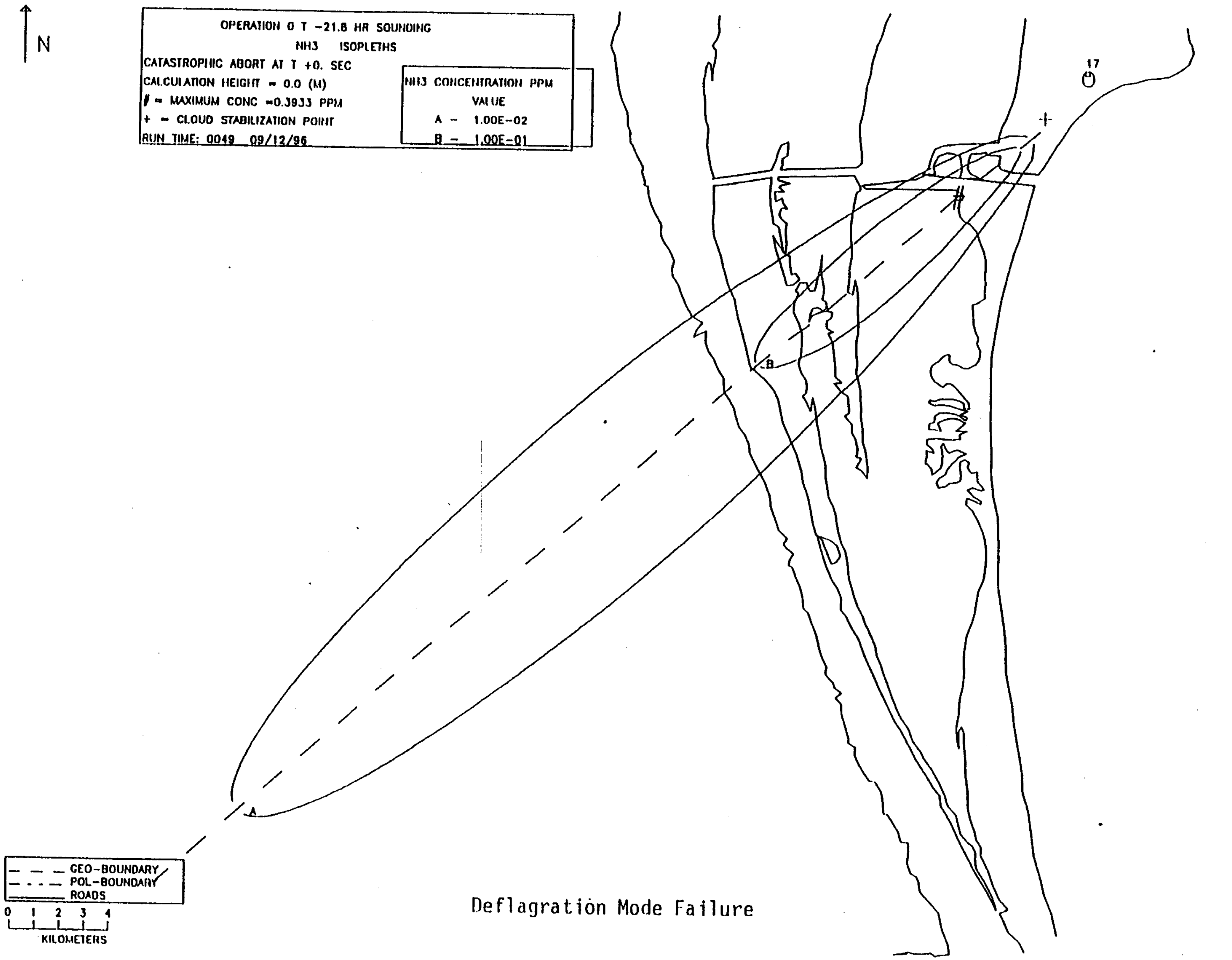

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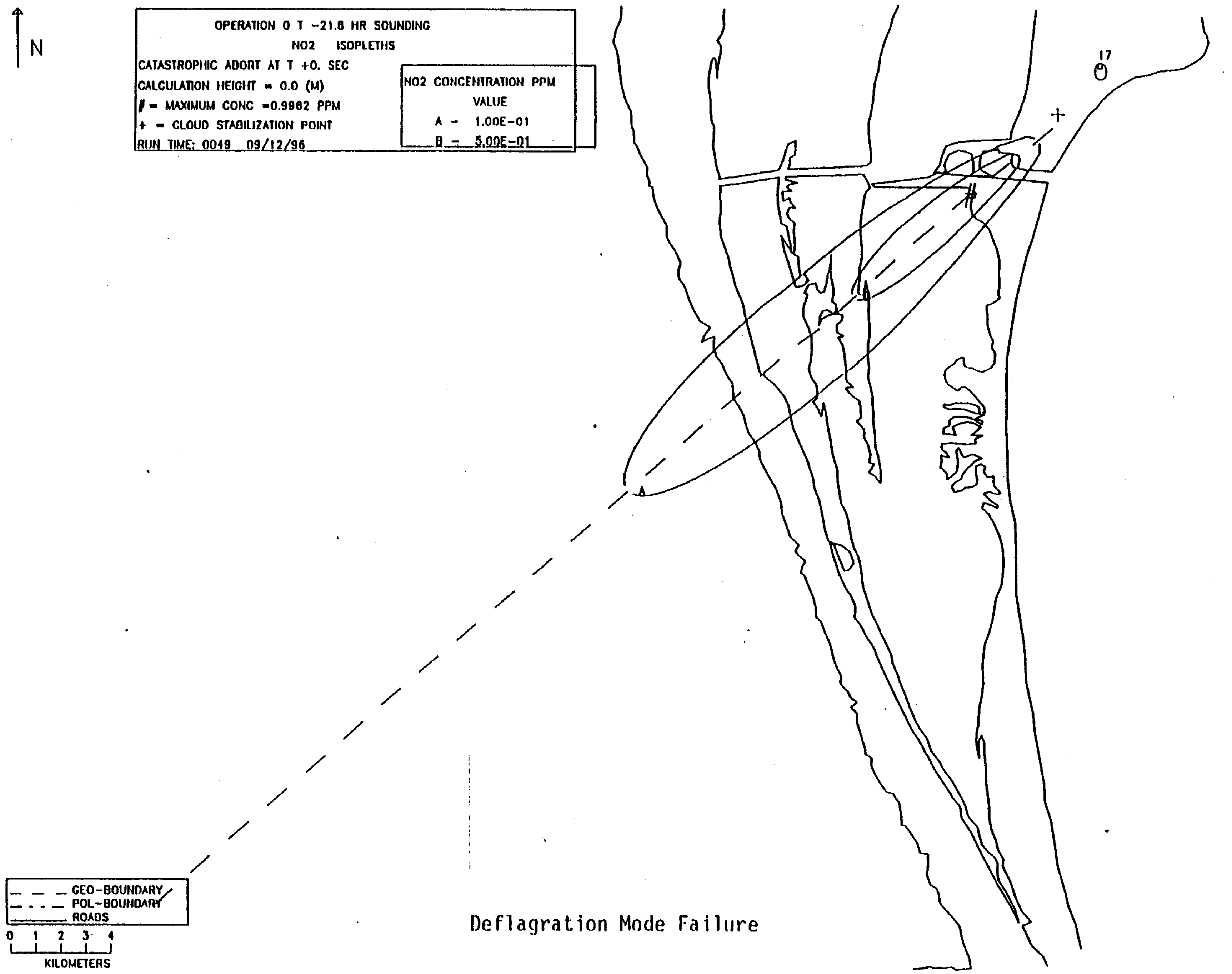

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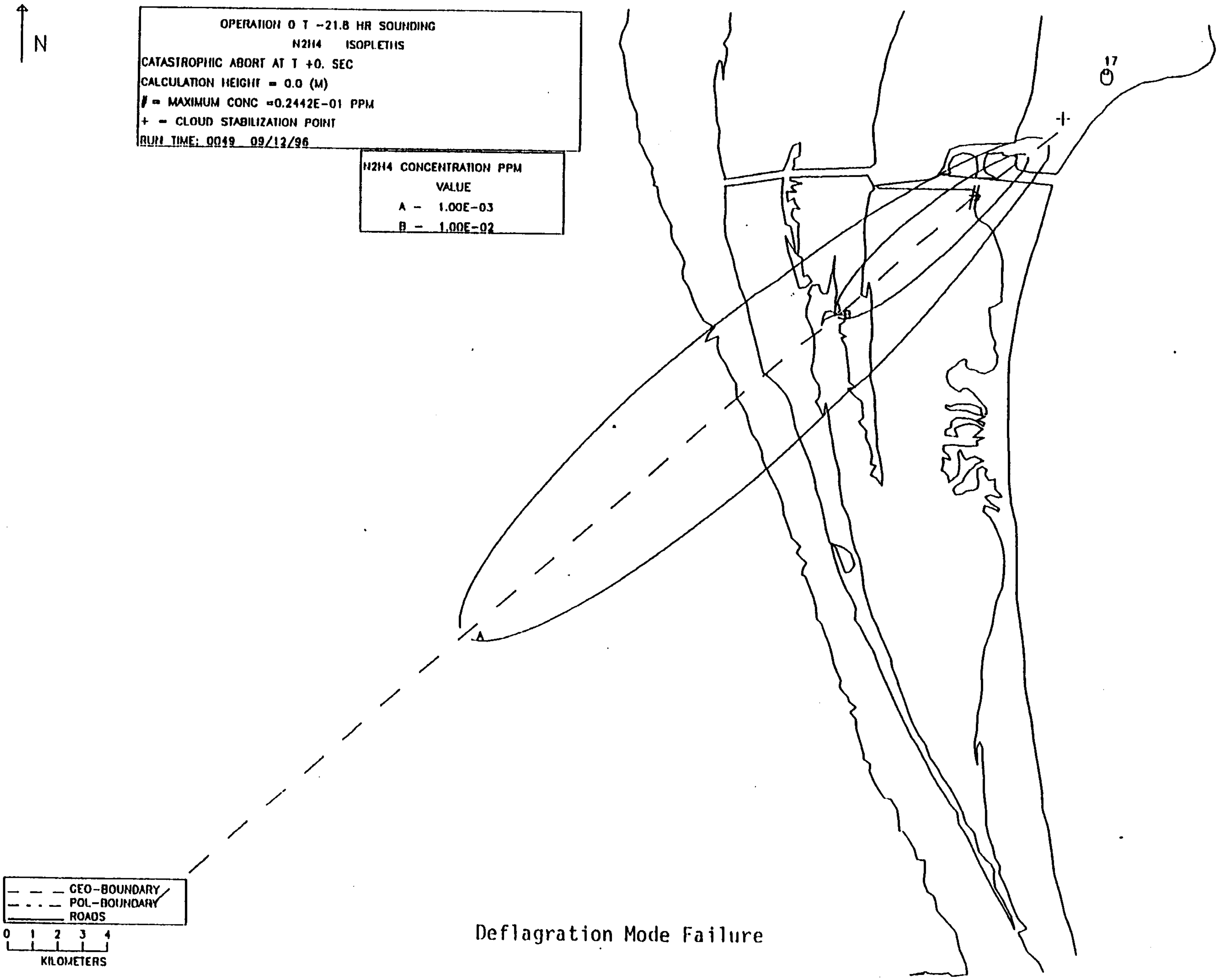

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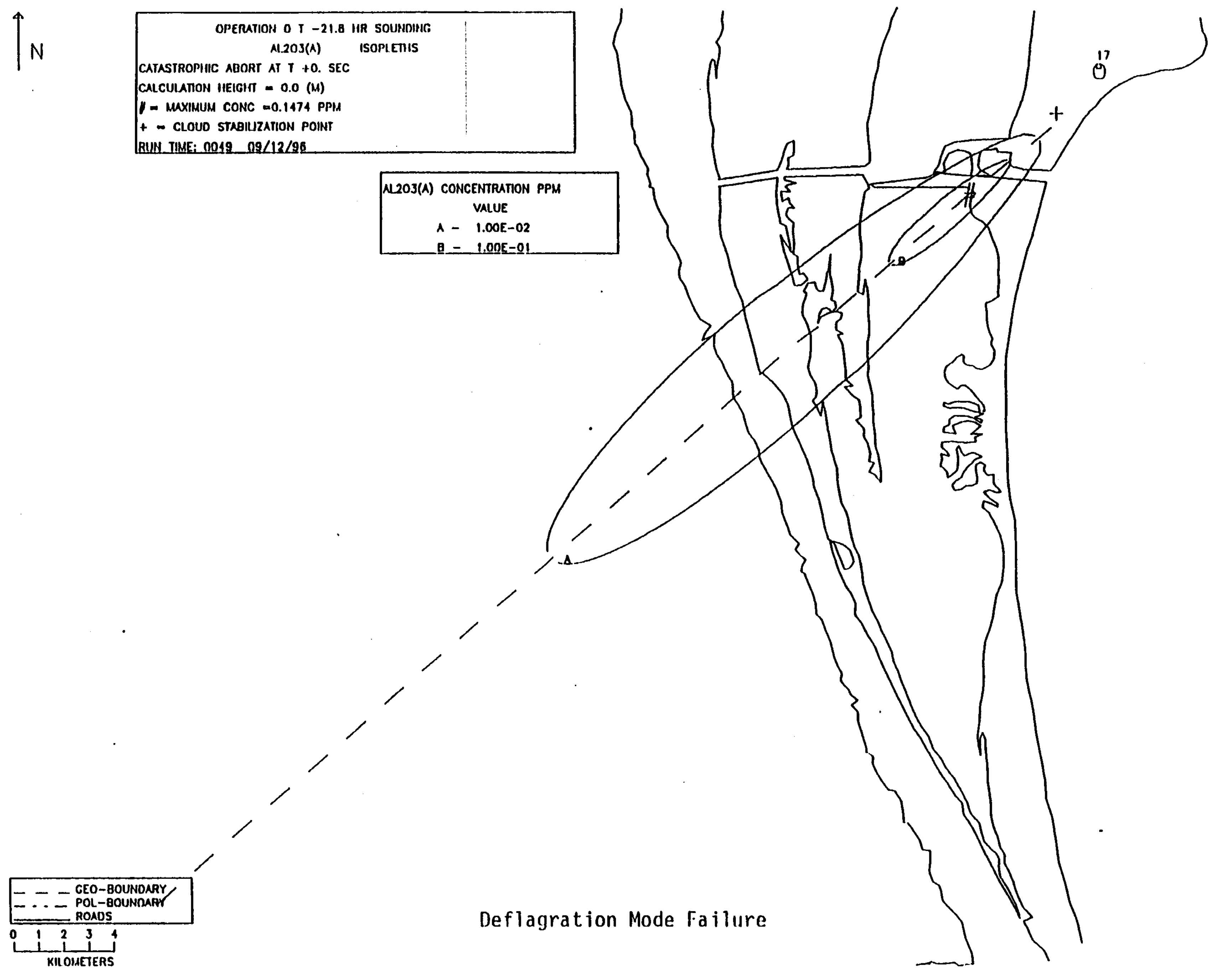

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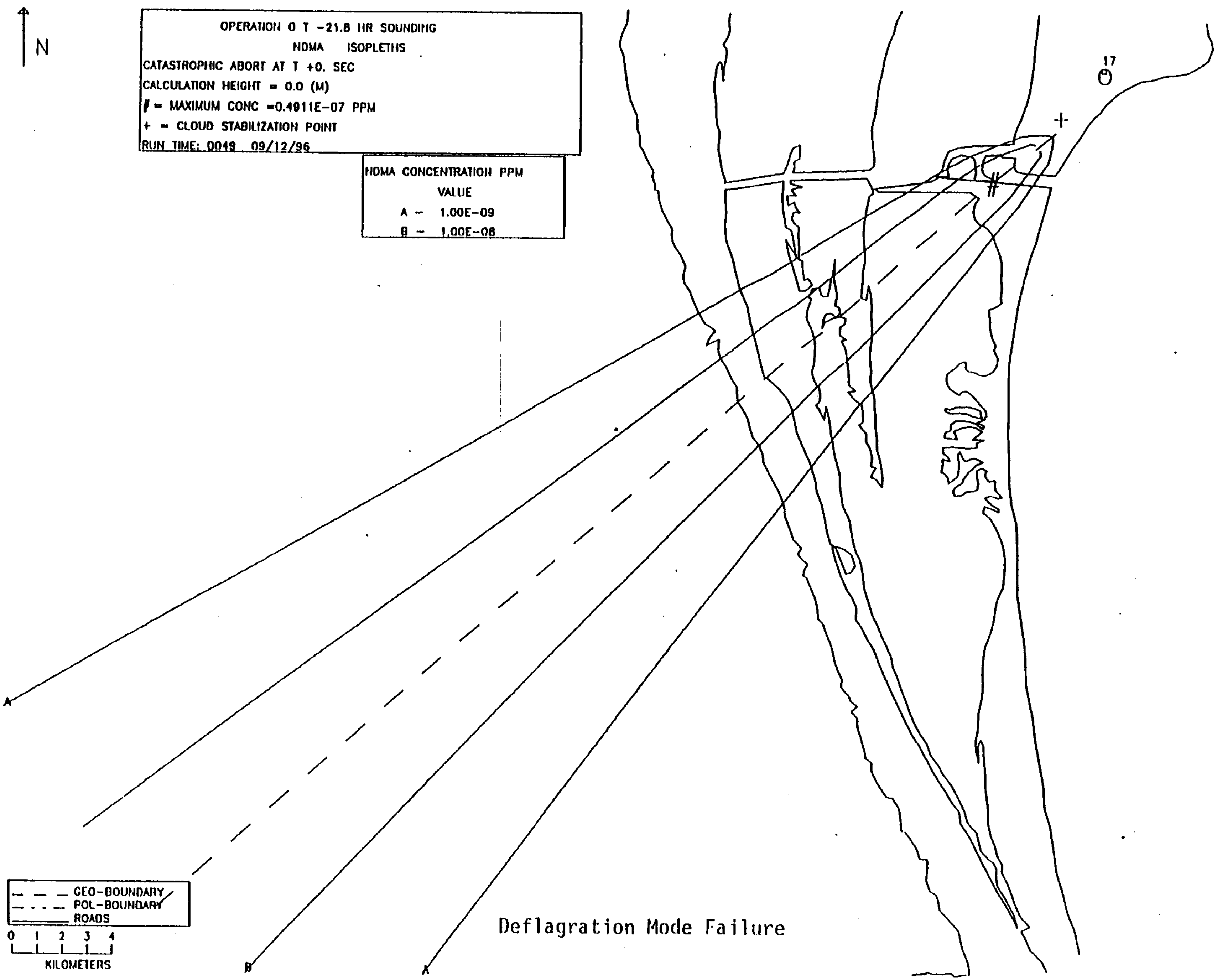

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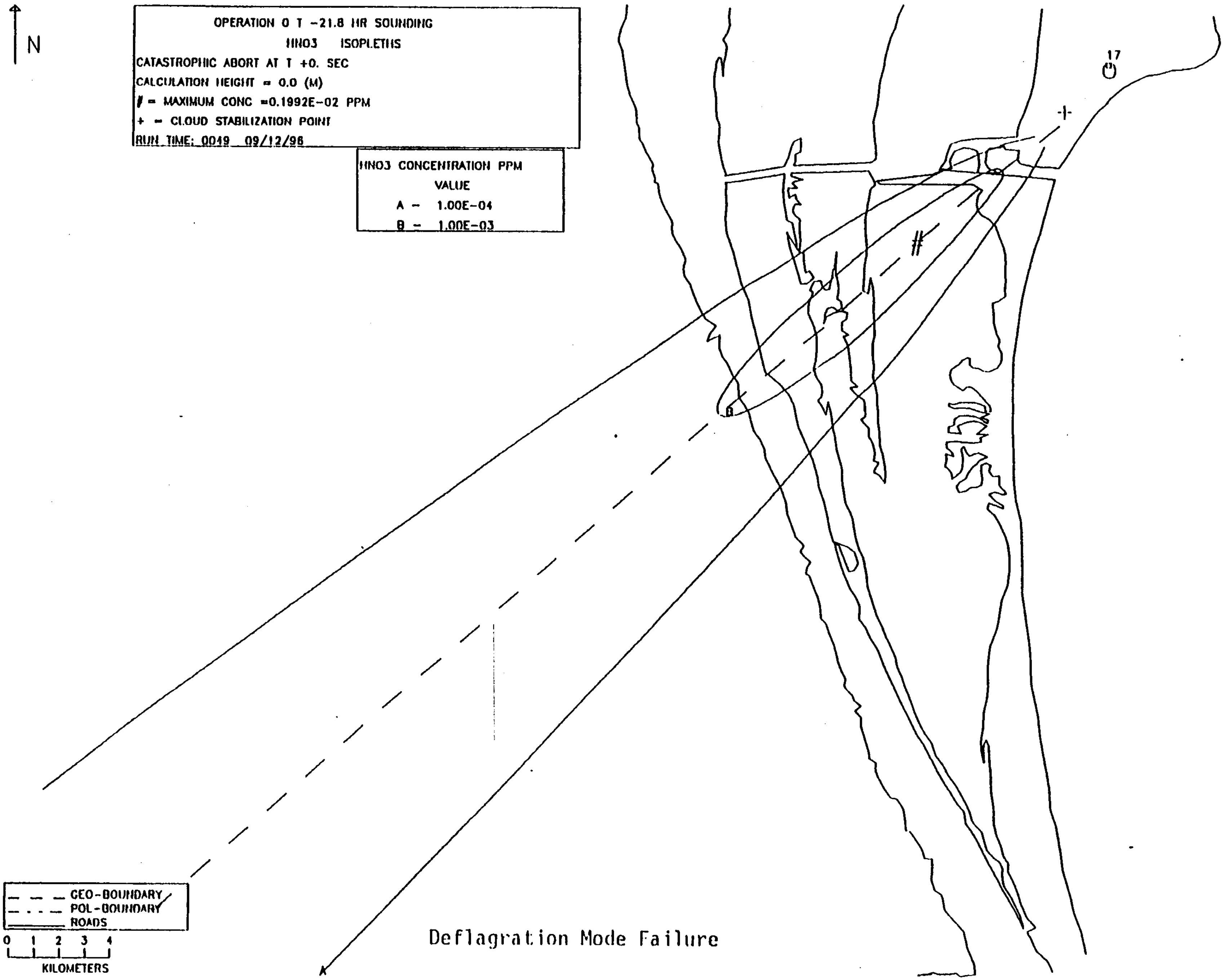

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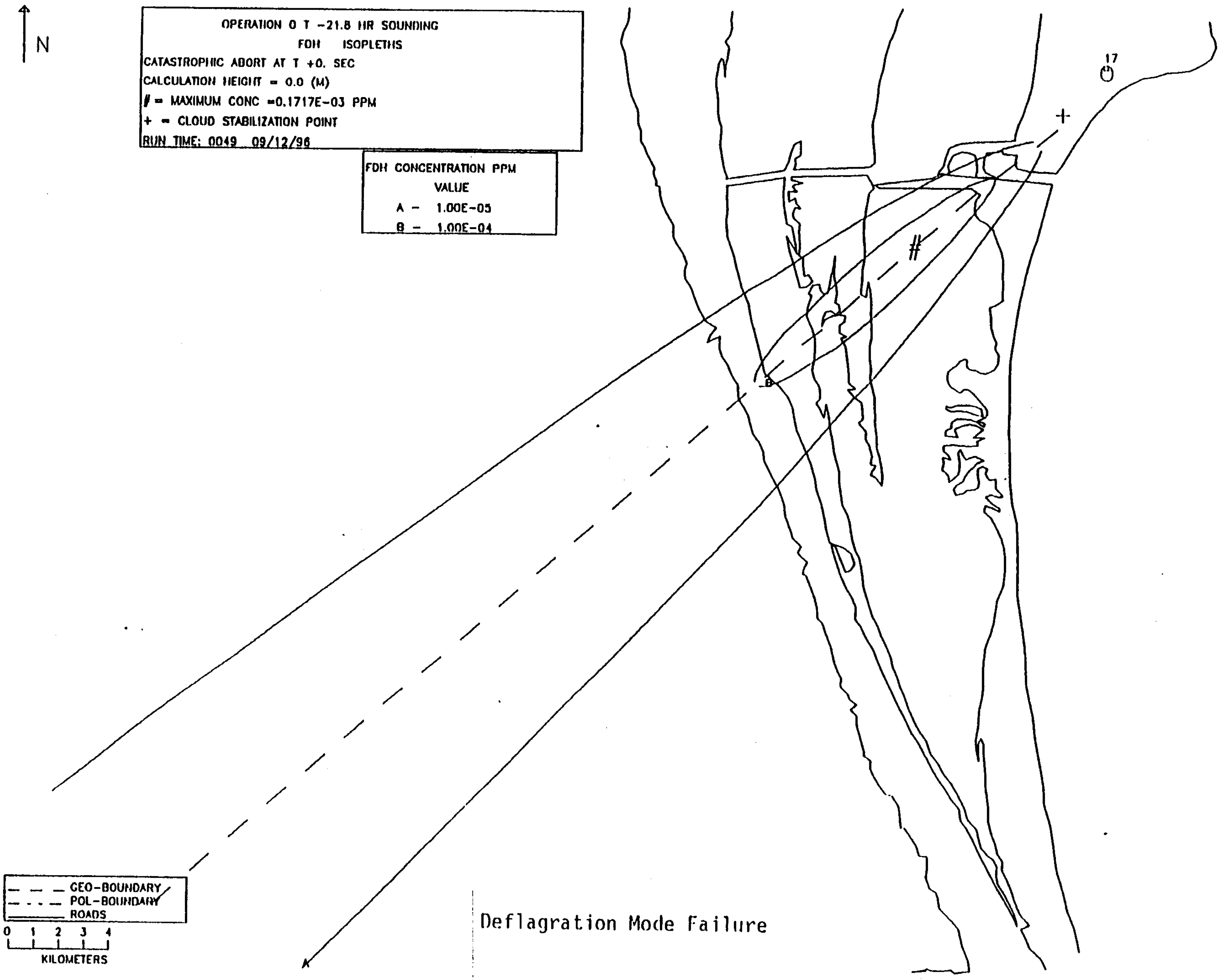

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