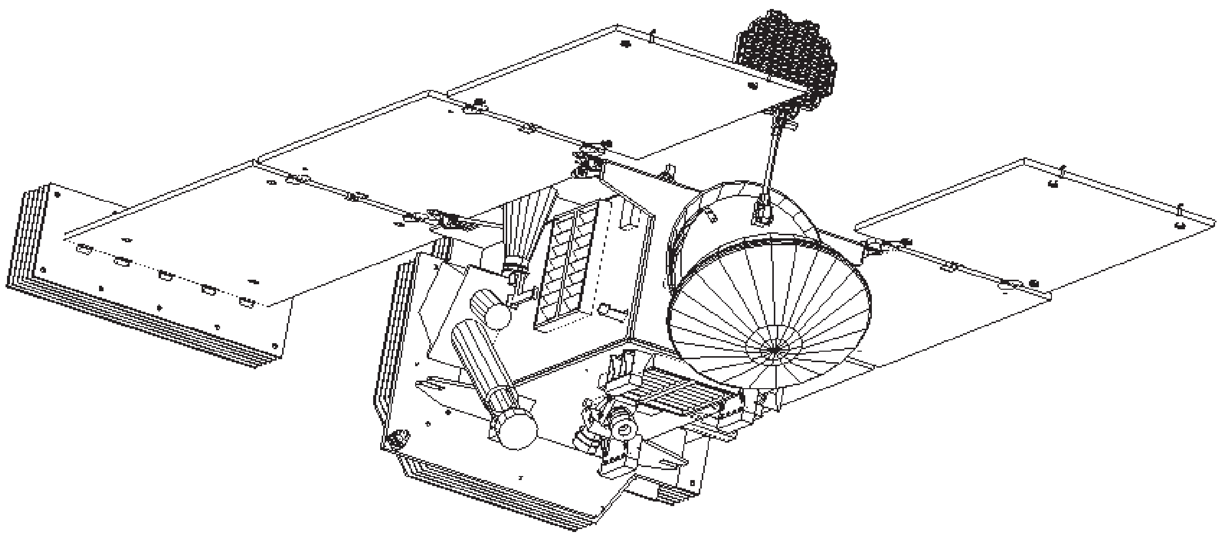
National Aeronautics and
Space Administration

Stardust Mission Environmental Assessment



March 1998

Prepared for and in cooperation with:

National Aeronautics and Space
Administration
Office of Space Science
Solar System Exploration Division
Washington, DC 20546-0001

JPL
Jet Propulsion Laboratory
California Institute of Technology
D-14159

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

May – 7 1998

Reply to Attn. Of SD

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

Re: Stardust Mission Environmental Assessment and
Finding of No Significant Impact

The Stardust Mission Environmental Assessment (EA) and the Finding of No Significant Impact (FONSI) (NASA Notice 98-62) are enclosed and are being distributed to Federal, State, local agencies, 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 June 8, 1998, and directed tot he undersigned at:

Code SD
NASA Headquarters
Washington, DC 20546-0001

NASA will take no final action prior to June 8, 1998.

Sincerely,

Mark R. Dahl
Program Executive, Stardust
Mission and Payload Development Division
Office of Space Science

Enclosures

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

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
ACL	Air Logistic Center, (Ogden, Utah)
AQCR	Air Quality Control Region
AZ	Arizona
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
CIDA	Cometary and Interstellar Dust Analyzer
cm	centimeter(s) = 0.01 m = 0.3937 inch
CN	Cyanide
CNES	French Space Agency
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
DEQ	Department of Environmental Quality (Utah State Agency)
DFMI	Dust Flux Monitor Instrument
DLR	German Space Agency
DMCO	Delta Mission Check-Out
DOD	Department of Defense
DOI	Department of the Interior

DOT	Department of Transportation
DPG	Dugway Proving Grounds, UTTR, Utah
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
ESA	European Space Agency
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
HAFB	Hill Air Force Base
HAFR	Hill Air Force Range
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
IDP	Interstellar Dust Particles
IELV	Intermediate Expendable Launch Vehicle
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
LMA	Lockheed Martin Astronautics
LV	Launch Vehicle
m	meter(s) = 39.37 in
MAA	Michael Army Airfield, Dugway Proving Grounds, UTTR, Utah
MAC	Maximum Allowable Concentration
mg	milligram
mg/m^3	milligram per meter cubed (mass per volume)
mg/l	milligrams/liter
mg/ml	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
MLV	Medium Launch Vehicle
MOAs	Military Operations Areas
mph	miles per hour
MPPF	Multi Payload Processing Facility
m/s	meters per second
MSL	Mean Sea Level

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
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
Nm	Nautical mile
NM	New Mexico
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
NTO	Nitrogen Tetroxide
NUTTR	North UTTR, includes Hill Air Force Range
NV	Nevada
O	Oxygen
O_3	Ozone
OFW	Outstanding Florida Water
OPNAV	Optical Navigation
OSHA	Occupational Health and Safety Administration
PAF	Payload attach fitting
PAFB	Patrick Air Force Base
Pb	Lead
PEL	Permissible Exposure Level
pH	level of acidity or alkalinity relative to water
PHSF	Payload Hazardous Servicing Facility

PIA	Particle Impact Analyzer
PICA	Phenolic Impregnated Ceramic Ablator
PLF	Payload Fairing
PM-10	Particulate Matter less than10 microns in diameter
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
PSP	Project Safety Plan
PVFD	Polyvinylidene Difluoride
RCRA	Resource Conservation and Recovery Act
REEDM	Rocket Exhaust Effluent Diffusion Model
RF	Radio Frequency
ROI	Region of Influence
RP-1	thermally stable kerosene fuel
S&A	Safe & Arm
SC	Sample Canister
SCS	Soil Conservation Service (of the U.S. Department of Agriculture)
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
SRC	Sample Return Capsule
SRM	Solid Rocket Motor
SRP	Safety Review Panel
SSEP	Solar System Exploration Program
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
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
VAST	Vehicle Atmospheric Survival Test
VOC	Volatile Organic Compounds
WAFR	Wendover Air Force Range
WNW	West-North-West
WSA	Wilderness Study Area
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

PROPOSED ACTION

This environmental assessment (EA) addresses the proposed action to complete the integration and launch the Stardust spacecraft from Cape Canaveral Air Station (CCAS), Florida, during the launch window in February 1999, and recover the sample return capsule (SRC) at Utah Test and Training Range (UTTR) approximately forty miles southwest of Salt Lake City, Utah, in January 2006.

LAUNCH

The spacecraft would be assembled and tested at Lockheed-Martin Astronautics (LMA) Denver, and shipped to Kennedy Space Center (KSC) for checkout and propellant loading. The Transfer Orbit stage (Star 37 FM upper stage) would be assembled and integrated with the spacecraft at KSC. The integrated spacecraft and Transfer Orbit stage would then be transferred to Launch Complex 17 (LC-17) on Cape Canaveral Air Station.

The baseline launch vehicle, a Delta II 7426, could be assembled in facilities at CCAS before being transferred to LC-17. The Delta II 7426 consists of a liquid bipropellant main engine, a liquid bipropellant second stage engine, and four graphite epoxy motor (GEM) strap-on solid rocket motors (SRMs). 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.

ENTRY, DESCENT, LANDING, AND RECOVERY OPERATIONS AT UTTR

Separation of the SRC from the spacecraft would occur approximately four hours prior to capsule entry. The SRC would directly enter Earth’s atmosphere with a velocity of 12.8 kilometers/second (km/s) (7.9 miles/second [mi/s]) over the restricted airspace of UTTR. The landing footprint ellipse for the SRC has been determined by Monte Carlo Analysis to be approximately 84 km long by 30 km wide (52 mi x 19 mi) (three standard deviations in each direction) in a west-northwest to east-southeast direction. [NASA 1997-A] Its would decelerate by a parachute system consisting of a mortar-deployed drogue chute to provide stability at supersonic speeds, and a main chute. Velocity of the SRC at touchdown would be approximately 4.5 meters/second (m/s) (14.8 feet/second [ft/s]). Time elapsed from entry to touchdown would be approximately twelve minutes. Following touchdown at approximately three o’clock in the morning, the SRC would be recovered and transported to a staging area at UTTR in preparation for transport by NASA to the planetary materials curatorial facility at Johnson Space Center (JSC).

PURPOSE AND NEED FOR THE ACTION

As a part of the Solar System Exploration Program (SSEP) on planetary science, the Discovery Program goals are to: 1) perform high-quality, focused science investigations that will maintain U.S. leadership in planetary science and that will assure continuity in the U.S. SSEP; 2) pursue innovative ways of doing business with more frequent launches, fast turn-around times, and a requirement that the missions within the Discovery Program’s purview remain within a well-defined cost ceiling; 3) encourage the use and transfer of new technologies in achieving program objectives; and 4) enhance the general public awareness of, and appreciation for, solar system exploration and support the Nation’s educational initiatives. Thus, the Discovery Program solicits proposals for smaller missions, designed by a consortia comprised of industry, small businesses, and universities. [NASA 1991] Stardust has been chosen as the fourth Discovery mission, and is a partnership between the University of Washington, Jet Propulsion Laboratory (JPL), and Lockheed Martin Astronautics.

Stardust is being designed to gather interstellar and cometary material and return it to Earth where the world scientific community can systematically analyze it with powerful research equipment in their laboratories. Stardust supports two of the SSEP's primary objectives: (1) to understand the origin, evolution, and present state of the solar system; and, (2) to establish the scientific and technical database required for undertaking major human endeavors in space, including the survey of near-Earth resources and the characterization of planetary surfaces. The exploration of comets and asteroids has reinforced the opinion held by the scientific community that many planetary processes, including some that operate on Earth, may be universal.

Comets appear to be well-preserved relics of the preplanetary material that gradually accumulated in the outer solar nebula. Comet 81P/Wild-2 is a ‘fresh’ comet which has been recently (1974) deflected by the gravitational action of Jupiter from its previous orbit much further out in the Solar System. Samples from Wild-2 would offer an exciting glimpse of the best preserved fundamental building blocks out of which our Solar System formed. In addition, during its first two orbits about the Sun on its way to Wild-2, the Stardust spacecraft would collect approximately 100 interstellar dust particles. This would provide the international scientific community its first opportunity to collect and analyze these interstellar dust grains.

MISSION DESCRIPTION

The Stardust mission involves placing a single spacecraft within 150 to 1000 km (93 to 620 mi) of the 81P/Wild-2 comet nucleus during a flyby in 2004 to gather 1000 dust particles from the comet's coma. Current plans call for using a Delta II 7426 launch system to inject the Stardust spacecraft into its initial orbit in February 1999. The proposed mission design calls for the Stardust spacecraft to swing by Earth once during its seven-year tour (Figure 2-1a-c); this gravity assist would allow the spacecraft to gain the additional energy required to intercept the comet Wild-2. During its flight, Stardust would transmit pictures of the Earth and Moon taken during the Earth swingby, transmit pictures of the comet nucleus and coma taken during comet encounter, nondestructively capture interstellar and cometary dust particles, and return these samples to Earth for study by the international scientific community.

ALTERNATIVES CONSIDERED

Alternatives to the proposed action that were considered included those relating to launch vehicle and recovery site. Specifically, alternatives considered were those that (1) utilize an alternate launch vehicle/upper stage combination; (2) utilize an alternate landing and recovery site; or 3) eliminate the Stardust mission (the No-Action alternative).

Alternate Launch Vehicles

The most desirable launch vehicle for Stardust would 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 U.S. launch vehicles considered, the Delta II 7426 most closely matches the Stardust mission requirements:

- The mass performance of the Delta II 7426 most closely matches the Stardust performance requirement.
- The Delta II 7426 is the lower cost alternative launch system of those systems meeting the Stardust performance criteria.
- Of the reasonable alternative launch systems examined, all except the Atlas II/Centaur were approximately equal in their potential environmental impacts. The additional cost of the Atlas II launch vehicle would preclude launching the cost-constrained Stardust mission.

Alternative Landing Sites

The Stardust 84 km x 30 km (52 mi x 19 mi) three-sigma landing footprint requires a large, flat, relatively unpopulated, and restricted area to ensure safety of personnel, the public, structures, and the mission science to be returned. Of the landing sites examined, UTTR has been determined to be the best-suited potential landing site for the Stardust mission, for the following reasons:

- Water recovery sites have been rejected due to unacceptable risk to the returned science, higher risk of capsule loss, and higher cost of recovery

- U.S. landing sites were chosen in order to ensure the integrity, safety, and security of the samples.

- Of the possible U. S. landing sites considered, only Nellis Air Force Range, China Lake/Fort Irwin, and UTTR meet the required footprint area. Both Nellis Air Force Range and China Lake/Fort Irwin have large areas of mountainous terrain which represent an unacceptable risk to a successful science return.

- UTTR has the largest overland special use airspace (measured from the surface or near surface, 43,126 sq km [16,651 sq mi]), as well as the largest overland contiguous block of supersonic authorized, restricted airspace in the contiguous United States (See Figure 2-9). [USAF 1997-D]

- UTTR has been identified as the proposed Stardust project recovery operations site because it uniquely satisfies all of the selection criteria discussed in Section 2.2.2.

No-Action Alternative

The No-Action alternative would result in termination of the Stardust mission, which would disrupt the progress of NASA's Inner Solar System Exploration Program. Comets appear to be well-preserved relics of the preplanetary material that gradually accumulated in the outer solar nebula. Samples from Wild-2 would offer an exciting glimpse of the best preserved fundamental building blocks out of which our Solar System formed. The scientific value of having actual bona-fide, relatively pristine comet samples is high. While environmental impacts would be avoided by cancellation of the proposed mission, the loss of the scientific knowledge and database from carrying out the mission could be significant.

SUMMARY OF ENVIRONMENTAL IMPACTS

The only expected environmental effects of the proposed action are associated with normal launch vehicle operation and entry, descent, landing, and recovery of the SRC; these are summarized in the following paragraphs.

Launch

Air Quality

The Air Force uses the Rocket Exhaust Effluent Diffusion Model (REEDM) to determine the concentration and areal extent of launch cloud emission dispersion from launch vehicles. For this assessment, Air Force personnel from 45 Space Wing (45SW) 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.) The Delta II 7425 differs from the 7426 in that it has a Star 48 upper stage, which has 2010 kilograms (kg) (4422 pounds [lb]) of propellant compared to the Star 37 FM motor which has 1077 kg (2368 lb) of the same propellant. [Boeing 1997] The Delta II 7425 is considered to bound the upper limit of propellants for the 7420 series of Delta II launch vehicles.

For the nominal launch scenario the launch cloud was assumed to be 100 meters (m) (328 feet [ft]) in diameter at ground level. The area directly impacted by flame from the rocket exhaust would be approximately 80 m (262 ft) in diameter. [USAF 1994] The cloud height was calculated to be a minimum of 672 m (2200 ft) above the ground, with a minimum time of rise of about 450 seconds. [USAF 1996-B] In a normal launch, exhaust products from a Delta II launch are distributed along the launch vehicle's path. 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.

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. Concentrations for carbon monoxide (CO), carbon dioxide (CO_2), chlorine (Cl), aluminum oxide (Al_2O_3), and hydrochloric acid (HCl) were considered. The exhaust cloud is predicted to stabilize at about 5 km (3 mi) downwind of the launch pad. REEDM predicts that the 60-minute average concentrations would be less than 0.05 parts per million (ppm) for all species considered for a normal launch in either of the two weather scenarios.

The maximum level of HCl expected to reach uncontrolled areas during preparation and launch of the Delta II would be well below the National Academy of Sciences (NAS) recommended short-term exposure limits of 20 ppm for a 60-minute exposure to 100 ppm for a 10-minute exposure. Appropriate safety measures would be taken to ensure that the permissible exposure limits defined by the Occupational Safety and Health Administration (OSHA) (5 ppm) for an 8-hour time-weighted exposure limit) are not exceeded for personnel in the launch area. Hydrogen chloride concentrations in the Delta II exhaust plume should not exceed 5 ppm beyond about 4.3 km (2.7 mi) in a downwind direction. The nearest uncontrolled area (i.e., general public) is approximately 4.8 km (3 mi) from LC-17. Based upon these REEDM runs and the distance to the nearest uncontrolled area, HCl concentrations are not expected to be high enough to be harmful to the general population.

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, concentrates around the launch pad, and disperses quickly, there should be no substantial amount of acidic deposition beyond the near-pad area.

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 ppm for CO, 0.018 ppm for CO_2, and 0.001 ppm for Cl. All maximums are predicted to occur approximately 10 km (6.2 mi) downwind of LC-17. In the presence of the extreme heat generated by the launch, 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 National Ambient Air Quality Standards (NAAQS) for particulate matter smaller than 10 microns (μm) (PM-10). Concentrations for Al_2O_3 range from 0.3 to a maximum of 2.5 micrograms per cubic meter (μg/m^3). The maximum 24-hour Al_2O_3 concentration beyond the distance of the nearest CCAS property boundary predicted by the REEDM for a Delta II 7425 launch, was 3.5 μg/m^3, which is well below the 24-hour average NAAQS for PM-10 of 150 μg/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, 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 according to the 45SW Petroleum Products and Hazardous Waste Management Plan. [OPlan 19-14] The scrubber operation is a Florida Department of Environmental Protection (FDEP) permitted activity. Air emissions monitoring is conducted in accordance with the FDEP permit.

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 ozone (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 of a Delta II 7400 vehicle would contribute an estimated 2.1 x 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 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 nitrogen dioxide (NO_2), which would contribute 6 x 10^{-8} percent consequent global reduction in stratospheric ozone. Launching eight Delta II 7426s in a twelve month period would result in a cumulative net stratospheric ozone depletion on the order of 4.8 x 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 x 10^{-4} percent for eight launches during a twelve-month period.

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 significant 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 U.S. 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.

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 would disperse in the large volume of water and, therefore, would not constitute a danger to the marine environment.

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 insignificant 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 this spacecraft includes no radioactive materials. Thus, there is no radiological risk to the health and safety of human life or the environment from this mission.

Threatened and Endangered Species

Any action that may affect Federally listed species or their critical habitats requires consultation with the U.S. Federal Wildlife Service (FWS) under Section 7 of the Endangered Species Act of 1973 (as amended). The U.S. 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) or endangered species residing on CCAS and in adjoining waters or critical habitats.

Population and Socioeconomics

The Stardust mission 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 Stardust mission would cause no additional adverse impacts on community facilities, services, or existing land uses.

Pollution Prevention

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.

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]

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 Stardust mission, analysis indicates little or no potential of substantial environmental effects on any human populations outside CCAS boundaries.

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 Stardust mission.

Cumulative Impacts

CCAS accommodates various ongoing space programs. The environmental effects associated with these programs have been included in the baseline environmental conditions described in section 3.

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 nitrogen tetroxide 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.

Launch Vehicle Destruction

In the unlikely event of a launch vehicle destruction, either on the pad or in-flight, the liquid propellant tanks and GEM casings would be ruptured. Due to their hypergolic (ignite on contact) nature, a launch failure would result in a spontaneous burning of 10 to 30 percent of the liquid propellants, and a somewhat slower burning of GEM propellant fragments. [USAF 1997-A] 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 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 dispersion of the propellant in the large quantity of ocean water.

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.

SAMPLE RETURN CAPSULE ENTRY, DESCENT, LANDING, AND RECOVERY OPERATIONS

Air Quality

Upper altitude emissions associated with reentry of the SRC would include ablation products of the thermal protection system on the forebody. The SRC would enter the earth's atmosphere directly above UTTR's South Range with a velocity of approximately 13 km/s (8 mi/s). It would decelerate to 600 m/s (1962 ft/s) in two minutes. The material baselined to be used for the forebody heatshield is Phenolic Impregnated Ceramic Ablator (PICA) recently developed at NASA's Ames Research Center by Tran et. al. Due to friction, the peak heating would occur at approximately 54 seconds after reentry begins, which corresponds to an altitude of approximately 60 km (196,860 ft) above the earth. The ablation would continue for about twenty seconds. Models conservatively predict that less than 22 percent of the total PICA material would ablate during reentry, and that ablation would cease at approximately 46.5 km (152,566 ft) above the earth. The total mass of the PICA material would be about 8.5 kg (18.7 lb); of this a maximum of 1.86 kg (4.09 lb) would be ablated during reentry. The chemical species produced during ablation would be dissipated in the shock wave behind the SRC. Two of the chemical species produced in small amounts during ablation, hydrogen cyanide and cyanide (37 grams [g] and 149 g, respectively), are considered to be acutely toxic to humans when inhaled. The ablation process and thus the production of these species would cease more than 46 km (150,000 ft) above the earth. Therefore, these concentrations would disperse in the large volume of air in the upper atmosphere and would not constitute a danger to health or life on earth. The SRC heatshield would be rapidly cooling during the subsonic portion of the descent, and would not be emitting into the lower atmosphere.

The Super Lightweight Ablator (SLA-561V) material comprising the TPS of the backshell portion of the SRC undergoes far less heating during reentry than does the PICA material on the forebody. Of the estimated 2 kg (4.4 lb) of SLA-561V comprising the backshell heatshield, approximately 0.3 kg (0.66 lb) would be lost during reentry. There are no toxic species produced from this heatshield material.

Emissions of criteria pollutants would occur as a result of helicopter and ground vehicle activity during Stardust SRC recovery operations. The SRC itself would not generate any air pollutants in the lower atmosphere (the area subject to NAAQS), nor is it expected that it would contain any chemicals or substances that could emit hazardous air pollutants regulated under National Emission Standard for Hazardous Air Pollutants (NESHAPs). Given that the Stardust mission is a single sample return, the quantities of helicopter emissions would be extremely small. Furthermore, when affected sectors would be scheduled for the Stardust recovery operation, other aircraft would be curtailed, thereby resulting in lower short-term emission levels. It is unlikely that overall emissions in the area would be greater during Stardust recovery operations than under baseline conditions. The proposed action is not expected to result in any violations of the NAAQS or to interfere with Tooele County's ability to reach or maintain attainment.

Land Resources

The proposed action would disturb soils in the location of the SRC touchdown and the immediate vicinity where helicopters or a land vehicle would recover the SRC. Helicopter landings are currently common on UTTR and should have no additional effect. The SRC would have a diameter of 81 centimeters (cm) (32 inches [in]) and would weigh approximately 42.6 kg (93.7 lb). It would have a parachute system which would slow its velocity to approximately 4.5 m/s (14.8 ft/s). The area affected would measure only a few meters. The impact would be similar to a small person parachuting to the surface. Any disturbance to the surface could easily be recovered if desired. Due to the single event nature of this recovery operation, the resulting impact would be negligible. The SRC would contain no propellant, except for the gas that would expel the drogue chute.

Biotic Resources

The SRC landing and recovery operations would affect vegetation in the immediate vicinity of the touchdown. Individual plants within a localized area could be crushed. The impact to plant communities in the area would be insignificant. Ground disturbance could increase the potential for invasive species like halogeton to establish in the area, but the small size of the area disturbed would not increase this effect noticeably above the baseline conditions. The proposed Stardust impact area does not contain any sensitive habitats that could be affected by recovery operations.

Noise

Noise from helicopter operations would not differ from baseline conditions and is therefore not anticipated to have any impact on local wildlife. The sonic boom from the SRC reentry would not have any impact due to its high altitude. The recovery area is overlain by the Gandy Supersonic Operating Area, which experiences sonic booms at lower altitudes and higher overpressures than those that would be created by the Stardust SRC.

Numerous studies have been conducted on the sensitivity of wildlife to noise and sonic boom, including studies of big horn sheep, pronghorn, and elk at UTTR. A literature survey of studies on effects of supersonic and subsonic aircraft noise on animals conducted by the USAF in 1986 revealed few effects from sonic booms. These same studies have shown that there is more potential for effects from subsonic aircraft operations, especially helicopters, and indicated that wildlife acclimated to recurring events. In any case, the proposed project area does not include sensitive wildlife species likely to be adversely affected, and any wildlife in the area is likely already acclimated to the on-going range operations.

Threatened and Endangered Species

No threatened or endangered species are expected to be affected by the proposed action. The probability of a collision between the SRC or a helicopter and a bald eagle or Peregrine falcon in the area is extremely remote -- raptors have a very low incidence of airstrike. It is highly unlikely that any candidate species that could be affected occur in the project area.

Health and Safety

There would be three areas of concern with respect to health and safety during the entry, descent, and landing phase of the mission. The first involves range safety considerations; the second is concerned with SRC recovery safety issues; and the third is the inadvertent reentry of the spacecraft.

UTTR Range Safety Considerations

Scheduling procedures for use of UTTR would preclude any risk of flight hazards involving other aircraft in the area. This is a negligible risk of mishap involving helicopters should they be used in the SRC recovery operations. This risk would be comparable to currently on-going risks at the range. In the event of a helicopter accident, there are no inhabited areas in the proposed recovery area that would be exposed to hazardous conditions. There should be no air activity over this area at the time of SRC entry, descent, and landing, as it is baselined to occur at approximately three o'clock in the morning. Therefore, potential for adverse effect to personnel or the public is considered insignificant.

The Monte Carlo analysis performed by NASA's Langley Research Center for the Stardust project shows that the risk of casualty from the SRC reentry is no greater than one in a million (1×10^{-6}). [NASA 1997-A]

The SRC would have the potential for landing anywhere within the designated safety zone (also known as the 3-sigma landing footprint), which includes targets and areas that may contain unexploded ordnance. In the event that the SRC landed on a target, there is a chance it could initiate an explosion. This could destroy the SRC and result in a release of any materials contained within it. The highest probability is that the experimental materials would be destroyed in the mishap. The risk of this occurrence is substantially less than the risk of a military aircraft crashing on unexploded ordnance on the range. To reduce the possibility of the SRC triggering an explosion upon landing, the AF would search out and explode any undetonated munitions in the proposed recovery site prior to the expected date of reentry.

SRC Recovery Safety Considerations

The SRC would weigh approximately 42.6 kg (93.7 lb), and would be touching down at approximately 4.5 m/s (14.8 ft/s). This is comparable to a human of the same weight parachuting to Earth, or a force of approximately half of a pound under the acceleration of gravity. Therefore, it would pose no risk to personnel or structures.

Four potential hazards in handling the SRC once it has landed have been identified. They include safing of potential unfired parachute ordnance; lithium battery faults such as the production of sulfur dioxide (SO_2), or a lithium fire should the battery be damaged during landing; radio frequency (RF) emissions from the ultra high frequency (UHF) beacon; and handling of the SRC. These will be discussed in detail in the following paragraphs.

Ordnance Safing

The SRC design calls for redundant NASA Standard Initiators (NSIs) to deploy the drogue chute and to cut the cable, thereby enabling the deployment of the main chute. In the nominal landing scenario, the parachute deploys as engineered; this would indicate that at least one NSI fired, but would not provide information that the redundant NSI also fired. Stardust plans to engage a UTTR Explosive Ordnance Demolition (EOD) expert to isolate and remove the drogue initiator outputs in an electrostatic discharge control area. The second NSI on the parachute mortar is designed to be directed toward the center of the parachute canister and parallel to the SRC surface, so that if it discharged upon opening the SRC, it would not pose a safety hazard to personnel. Likewise, the second NSI on the cable cutter releases no hazardous fragments or gases. Unexpended NSIs would be disposed of at UTTR. Off-nominal recovery conditions would be addressed by the recovery team.

Lithium Battery Faults

The SRC would contain 8 lithium battery cells about the size of a commercial "D" cell. These cells would be used only for the SRC return and are diode protected from reverse charging. Potential hazardous characteristics resulting from damaged batteries would be lithium fire, SO_2 production, and explosion or violent venting due to hydrogen gas production. The recovery team would include a safety inspector, who would perform colorimetric tests and pronounce that the SRC is safe for human handling prior to opening. The battery case has been designed to leak before bursting and the cables would be protected at possible abrasion points.

RF Emissions from the UHF Beacon

The batteries would provide power to operate the UHF beacon for a minimum of 40 hours. The UHF antenna is a wire approximately 10 inches long extending from inside the parachute canister and up the parachute bridle. The average transmitting power is 100 milliWatts at 242.000 MegaHertz (MHz), with a duty cycle of 3 seconds on, 5 seconds off. The American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) at 242.000 MHz is 1 mW per square centimeter (mW/cm^2). The safe distance is a minimum of 1.7 cm.

SRC Handling

The SRC would weigh approximately 42.6 kg (93.7 lb). The primary method of handling would be manual, except when it is secured in its handling fixture. Three persons would be required to manually carry the SRC. Gloves would be used for all handling of SRC ablated surfaces, and would also protect the teams from the surface, should it be hot.

The SRC thermal control system design calls for two ablative materials in the heatshields. On the backshell would be the SLA-561V, which is a combination of RTV 663 mixed with silica fibers, treated cork, phenolic microbolloons, and silicon microspheres packed into a phenolic honeycomb. This material is currently used on the Shuttle, and requires no special safety handling procedures. On the forebody would be the PICA material, which is composed of a carbon fiber preform impregnated with phenolic resin, including hexamethylene tetramine, water, and ethylene glycol. It is baked out to minimize volatile materials. During reentry peak heating, which occurs at least 45 km (150,000 ft) above the earth, the PICA material would generate small amounts of cyanide (CN) and hydrogen cyanide (HCN) while ablating. Although the air fluid dynamics models show that the air flow would move the ablation products away from the capsule, these complex organics could enter the SRC through the two vent holes located in the TPS backshell, during repressurization of the SRC. The safety officer accompanying the SRC recovery teams would perform tests for CN and HCN at a vent port before the backshell is removed to verify that levels in the SRC are below 4.5 ppm (the permissible exposure limits for these substances). Recovery team personnel would wear appropriate personal protective equipment to minimize exposure to hot surfaces and any ablation products that may be residues on the surface.

Inadvertent Reentry of the Spacecraft

The Stardust mission has levied a mission requirement that the design shall preclude an impact of the spacecraft with Earth during all mission phases, including Earth return after SRC separation. Extensive analysis and testing support the findings that reentry of the spacecraft is highly unlikely and would require multiple failures, including failure of the primary divert maneuver, which is to be integrated into the onboard software. As part of Stardust’s fault protection, there would be a backup divert maneuver that would utilize different components to avoid reentry. If, however, both divert maneuvers were to fail, the Stardust spacecraft would enter Earth’s atmosphere at approximately 46,000 kilometers per hour (kph) (29,000 mph), which is four to seven times more destructive to this small, lightweight spacecraft than would occur if it re-entered Earth’s atmosphere from low Earth orbit (LEO) (orbital speed in LEO is 27,000 kph or 17,000 mph).

Based on studies of previous spacecraft reentries from LEO (i.e., Vehicle Atmospheric Survival Test [VAST]) and analysis of the potential Stardust reentry speed, the main spacecraft composite structure is conservatively predicted to break apart at altitudes above 100 km. After breakup, aluminum components would burn up above 90 km, followed by more heat resistant steel and titanium components which are predicted to burn up above 80 km. The small quantities of gases produced during burnup are left at these extreme altitudes. There are no chlorofluorocarbons used in the spacecraft. The only materials expected to survive reentry would be lightweight fragments of Nextel fabric from the Whipple shields. This material would survive for two reasons: 1) it is a very high temperature material, sometimes used for thermal blankets intended to protect reentry vehicles, and 2) its low mass allows it to rapidly decelerate such that it undergoes little subsequent heating. Any Nextel fabric heated to its melting point would occur at very high altitude, and by the time pieces reach the ground, they would be at approximately the surrounding air temperature. They would flutter to the ground only a little faster than a piece of paper. These fragments, because of their very low speed descent, would not pose any danger to a person or structure on the ground.

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SECTION 1
PURPOSE AND NEED

The National Aeronautics and Space Administration (NASA) has prepared an Environmental Assessment (EA) for the Proposed Action of preparing for and implementing the Stardust mission, including integration of the Stardust spacecraft, its proposed launch from Cape Canaveral Air Station (CCAS), Launch Complex 17 (LC-17), Florida, in February 1999, and the proposed sample return capsule (SRC) recovery operations at Utah Test and Training Range (UTTR) forty miles from Salt Lake City, Utah, in January 2006. This EA discusses the mission's objectives as well as its potential environmental impacts. Feasible alternatives to the proposed action and their potential environmental impacts 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 (NEPA) of 1969, 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 substantially to the "expansion of human knowledge 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 U.S. Solar System Exploration Program [SSEP]). 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 landers, sample return, and human exploration. [NASA 1983, NASA 1986, NASA 1988] 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.

As a part of the Solar System Exploration Program on planetary science, the Discovery Program goals are to: 1) perform high-quality, focused science investigations that will maintain U.S. leadership in planetary science and that will assure continuity in the SSEP, 2) pursue innovative ways of doing business with more frequent launches, fast turn-around times, and a requirement that the missions within the Discovery Program's purview remain within a well-defined cost ceiling, 3) encourage the use and transfer of new technologies in achieving program objectives, and 4) enhance the general public awareness of, and appreciation for, solar system exploration and support the Nation's educational initiatives. Thus, the Discovery Program solicits proposals for smaller missions, designed by a consortia comprised of industry, small businesses, and universities. Stardust has been chosen as a Discovery mission, and is a partnership between the University of Washington, Jet Propulsion Laboratory (JPL), and Lockheed Martin Astronautics (LMA).

Stardust is being designed to gather interstellar and cometary material and return it to Earth where the world scientific community can systematically analyze it with powerful research equipment in their laboratories. Stardust supports two of the Solar System Exploration Program's primary objectives: (1) to understand the origin, evolution, and present state of the solar system; and, (2) to establish the scientific and technical database required for undertaking major human endeavors in space, including the survey of near-Earth resources and the characterization of planetary surfaces.

Although little is known about comets, it seems clear that they are small ancient bodies that have resided at great distances from the Sun for most of the lifetime of the solar system. This distant region is the best place to preserve solar system materials for long periods. Solar heating is negligible; illumination levels are only a few microwatts per square meter. Furthermore, individual objects are widely dispersed, which decreases the likelihood of collisions. These conditions produce a unique isolation ward where primordial materials, cryogenically stored, can remain unchanged for eons. Planetary scientists suspect that comet-like objects were among the basic building blocks of the planets and that they may have played a role in the later stages of planetary evolution by providing volatile and organic constituents for planetary atmospheres. Some of the cometary constituents may have been essential to the origin of life.

Comets are unique cosmic laboratories, which can be used to study the chemical kinetic phenomena and the collective plasma phenomena that may be important throughout the universe, wherever there is interaction between gas, radiation, plasma, and dust. Comets are expected to contain intact and unaltered samples of interstellar dust, thus allowing a much deeper understanding of the physical and chemical processes involved in the creation and evolution of dust grains in the interstellar medium and in interstellar clouds.

All comets have one characteristic in common -- the coma, which appears as a round, diffuse, nebulous glow. Far from the sun, where a comet typically spends most of its time, it is very cold and the material is frozen in the nucleus. As a comet approaches within a few astronomical units of the sun, the surface of the nucleus is warmed and begins to evaporate. The evaporated molecules, carrying many small dust particles with them, begin to produce a coma of gas and dust. These gas atoms and molecules have speeds sufficient to easily escape the weak gravitational field of the nucleus. For this reason the coma usually expands to an enormous size as the atoms and molecules disperse in space; as the comet reaches the point in its orbit closest to the sun, it becomes quite bright. Comet coma samples consist of two components: coma dust particles and volatile molecules. These comet samples would comprise the ancient pre-solar interstellar grains and nebular condensates that are believed to have been incorporated into comets at the birth of the solar system.

The purpose of the Stardust mission is to fly within 150 to 1000 kilometers (km) (93 and 620 miles [mi]) of the comet Wild-2 in early 2004, at a sufficiently low velocity (less than 6.5 kilometers/second [(km/s) 4.5 mi/s]) to non-destructively collect cometary dust and volatiles and acquire images of the comet nucleus and coma.

During the cruise phase, Stardust would also collect contemporary particles that recently came into our solar system from the center of the galaxy. This interstellar dust was first detected by Ulysses in 1993, and later confirmed by observations made via the Galileo spacecraft. Stardust would return the samples to Earth in January 2006 using a streamlined, low-cost reentry capsule (hereafter referred to as the sample return capsule or SRC). The instruments and objectives of the Stardust mission are described in detail in Section 2 of this EA.

1.2 NEED FOR THE PROPOSED ACTION

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 origin, composition, distribution and succession of layers (stratigraphic sequences), structural relationships, and the external structure (morphology) of land forms. (An isotope is an atomic species of a chemical element with different atomic mass and physical properties, e.g., carbon-12 versus carbon-14.) The exploration of comets and asteroids has reinforced the opinion held by the scientific community that many planetary processes, including some that operate on Earth, may be universal.

Comets are among the most dynamic and spectacular bodies in our Solar System. They appear to be well-preserved relics of the preplanetary material that gradually accumulated in the outer solar nebula. Comet 81P/Wild-2 is a 'fresh' comet which has been recently (1974) deflected by the gravitational action of Jupiter from its previous orbit much further out in the Solar System. Samples from Wild-2 would offer an exciting glimpse of the best preserved fundamental building blocks out of which our Solar System formed. In addition, during its first two orbits about the sun on its way to Wild-2, the Stardust spacecraft would collect approximately 100 interstellar dust particles in diameters ranging from 0.1 to 1 micron (µm) (3.9×10^{-6} to 3.9×10^{-5} inches [in]). This would provide the international scientific community its first opportunity to collect and analyze these interstellar dust grains.

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SECTION 2

PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

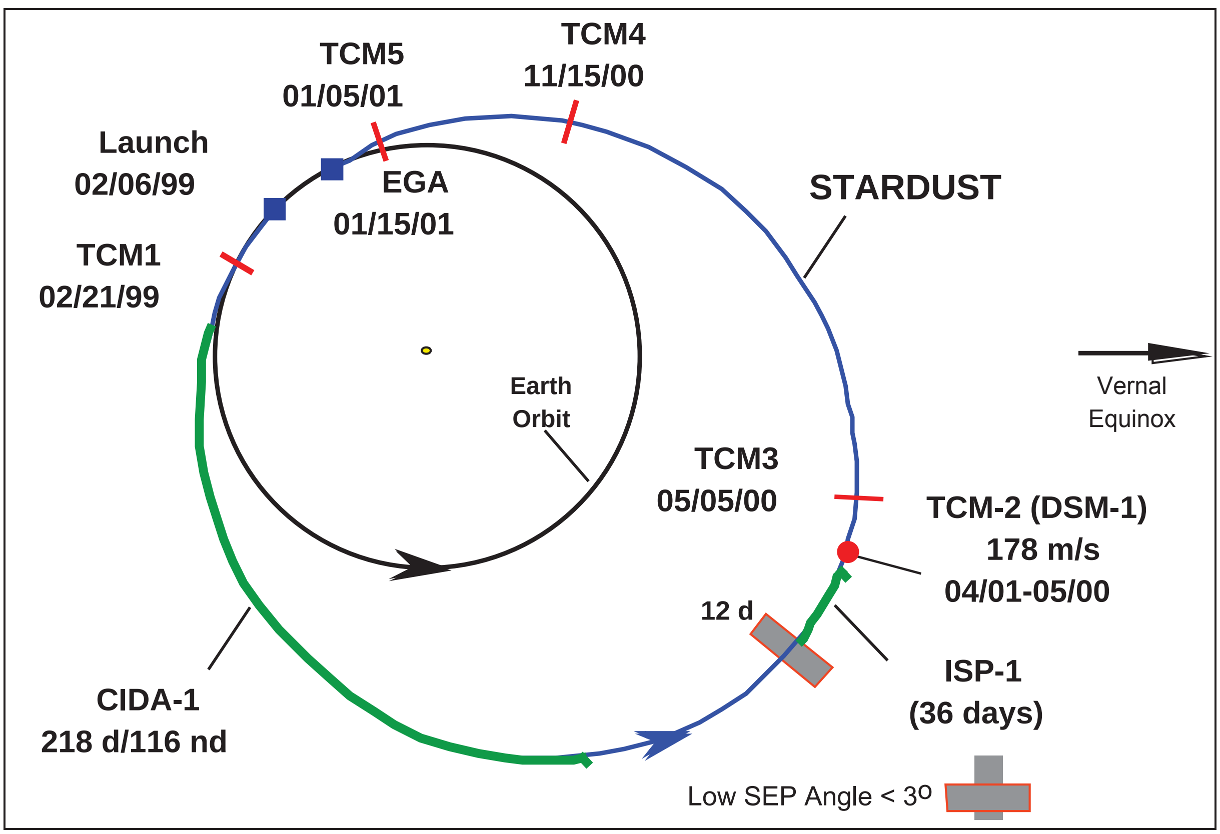
This section describes the Proposed Action of preparing for and implementing the Stardust mission, which includes integration of the Stardust spacecraft with a Delta II 7426 launch vehicle, launch from Launch Complex-17 (LC-17) at Cape Canaveral Air Station (CCAS), and sample return capsule (SRC) recovery operations at the Utah Test and Training Range (UTTR) seven years later. Alternatives to this Proposed Action, including the No-Action alternative, are discussed in Section 2.2.

2.1.1 MISSION DESCRIPTION [JPL 1996-A]

The Stardust mission involves placing a single spacecraft within 150 to 1000 kilometers (km) (93 and 620 miles [mi]) of the 81P/Wild-2 comet nucleus during a flyby in 2004 to gather 1000 dust particles from the comet's coma. The proposed mission design calls for the Stardust spacecraft to swing by Earth once during its seven-year tour (Figures 2-1a-c); this gravity assist would allow the spacecraft to gain the additional energy required to intercept the comet Wild-2. Current plans call for using a Delta II 7426 launch system to inject the Stardust spacecraft into its initial orbit in February 1999. During its seven year flight, Stardust would transmit pictures of the Earth and Moon taken during the Earth swingby, transmit pictures of the comet nucleus and coma taken during comet encounter, nondestructively capture interstellar and coma dust particles, and return these samples to Earth for study by the international scientific community.

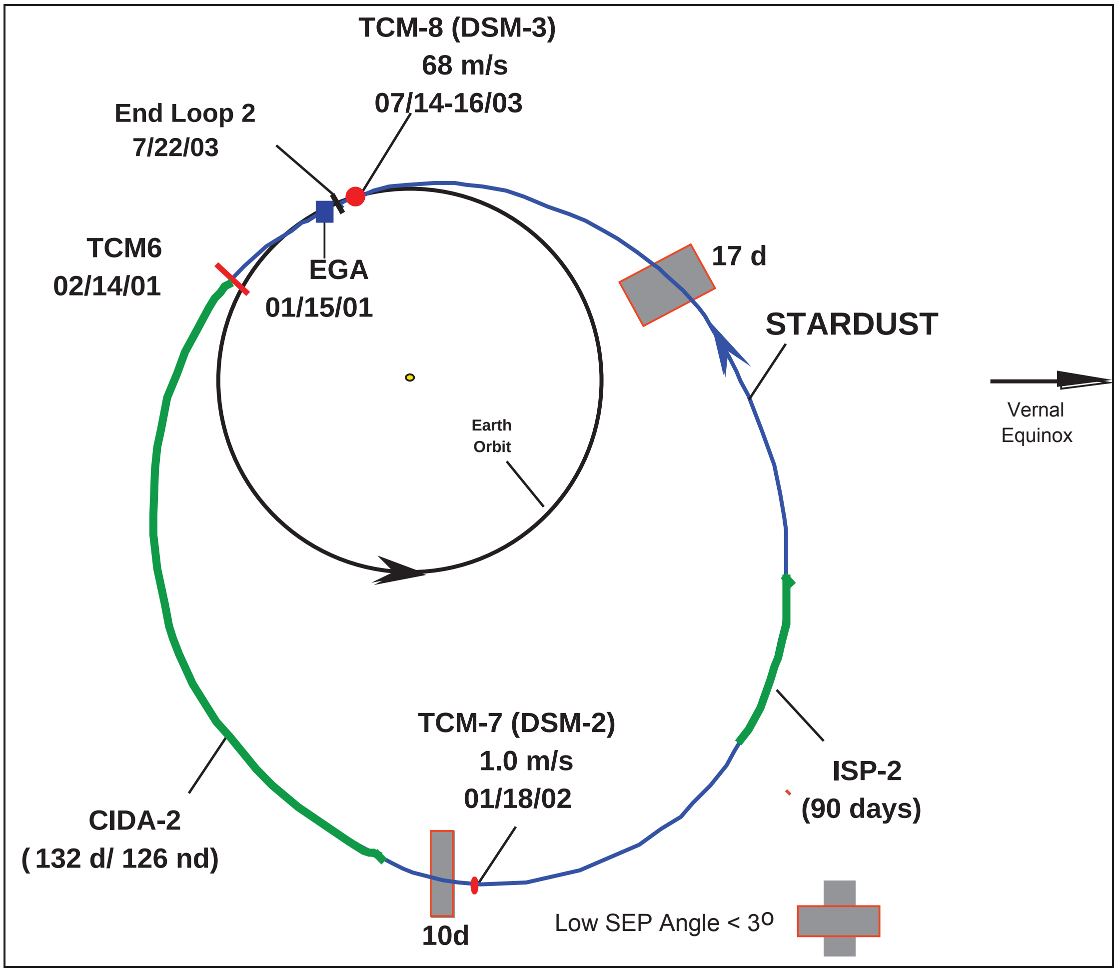
As the spacecraft travels along its elliptical orbit, the SRC would open in a clamshell-like fashion to deploy an aerogel collector from the sample canister to capture interstellar dust particles (IDP) entering the solar system (Figure 2-2). Following the first sample collection period, the spacecraft would retract the collector into the sample canister and the SRC would close. At the completion of the first orbital loop (approximately two years), a swingby of the earth would be targeted to obtain a gravity assist. The spacecraft would continue on this trajectory for another solar orbit, and again collect interstellar dust particles. During the third orbit loop, the spacecraft would encounter the Wild-2 comet along its orbital path within the solar system, and collect the images and cometary particles. Up to a distance of at least 263,000 km (163,456 mi) from the comet, images of the nucleus and tail would be taken by the optical navigation camera and sent back to Earth for spacecraft navigation past Wild-2 and for dust flux model development to select the flyby distance. About nine days prior to Wild-2 closest flyby, the aerogel collector would be redeployed. The coma dust particles would be captured by the collector during its approximately ten-hour fly through of the coma. The spacecraft would continue along its trajectory toward the vicinity of Earth. At a prescribed distance (about four hours from Earth entry) a command would be sent to the spacecraft to orient itself for separation from the SRC. Upon release of the SRC, the spacecraft would fire its thrusters, thus placing it on a trajectory away from Earth so that it would not re-enter Earth's atmosphere nor contribute to the debris in Earth orbit. The SRC would directly enter the atmosphere to land with the aid of a parachute on UTTR. Following touchdown, the SRC would be recovered and removed to a staging area at UTTR established for preparing the SRC for transport to the planetary materials curatorial facility at Johnson Space Center (JSC), as specified in the NASA Discovery Program Announcement of Opportunity. [NASA 1996-A]

Like the lunar samples returned by the Apollo mission, the Stardust samples would be stored under dry nitrogen in stainless steel glove boxes; they would be handled in much the same manner as on-going programs of curation and distribution of lunar samples, Antarctic meteorites, cosmic dust samples collected in the stratosphere, and returned spacecraft parts that have experienced exposure to micrometeoroid bombardment and other space exposure effects.



Source: [JPL 1996-C]

Figure 2-1a. Proposed Stardust First Orbital Loop, Launch Through First Trajectory Correction Maneuver



Source: [JPL 1996-C]

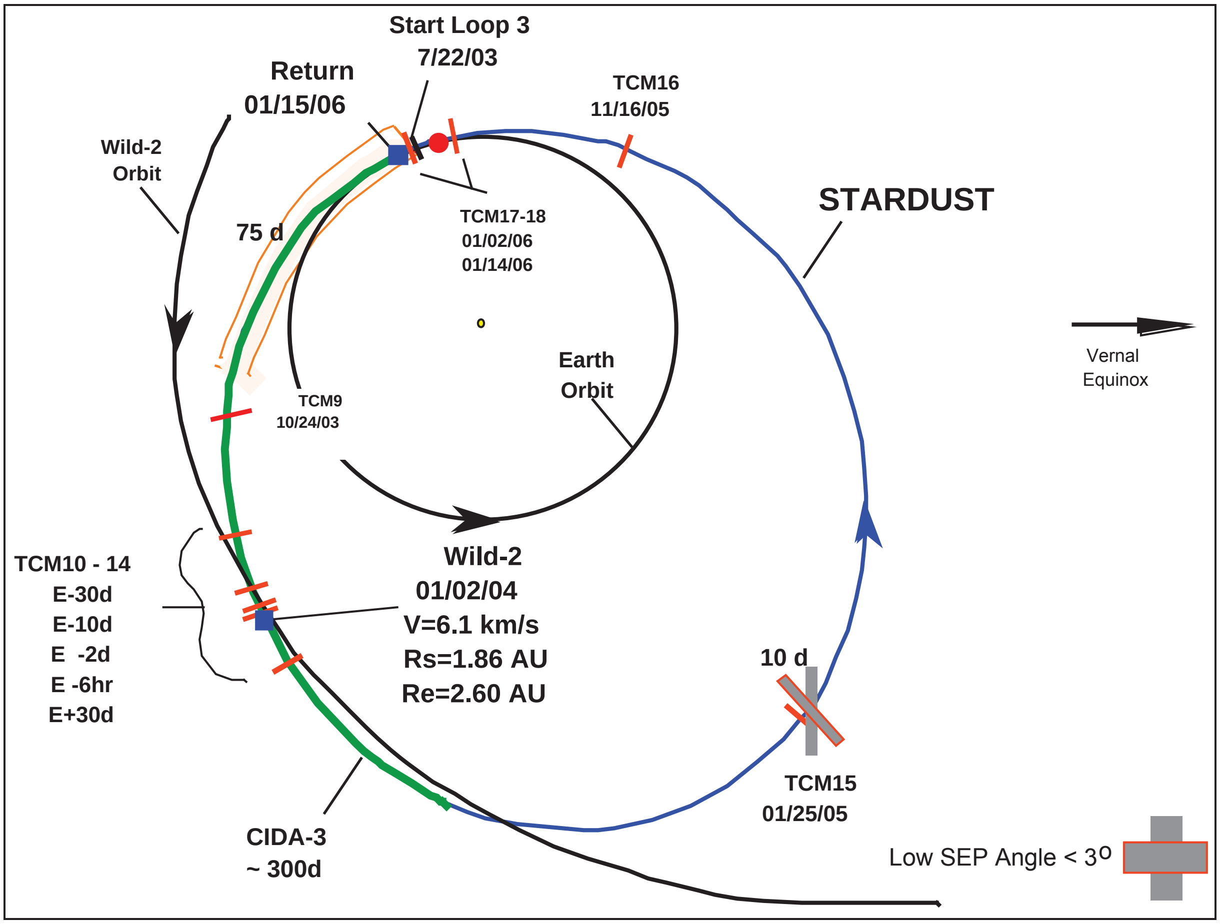
Figure 2-1b. Proposed Stardust Second Orbit Loop - After Earth Gravity Assist

2.1.2 MISSION SCIENCE OBJECTIVES [JPL 1996-A]

The Stardust science objectives are derived from the recommendations of the Solar System Exploration Committee in their report, "Planetary Exploration Through Year 2000: A Core Program." [NASA 1983] The areas of scientific investigation for the Stardust mission are summarized in the following paragraphs.

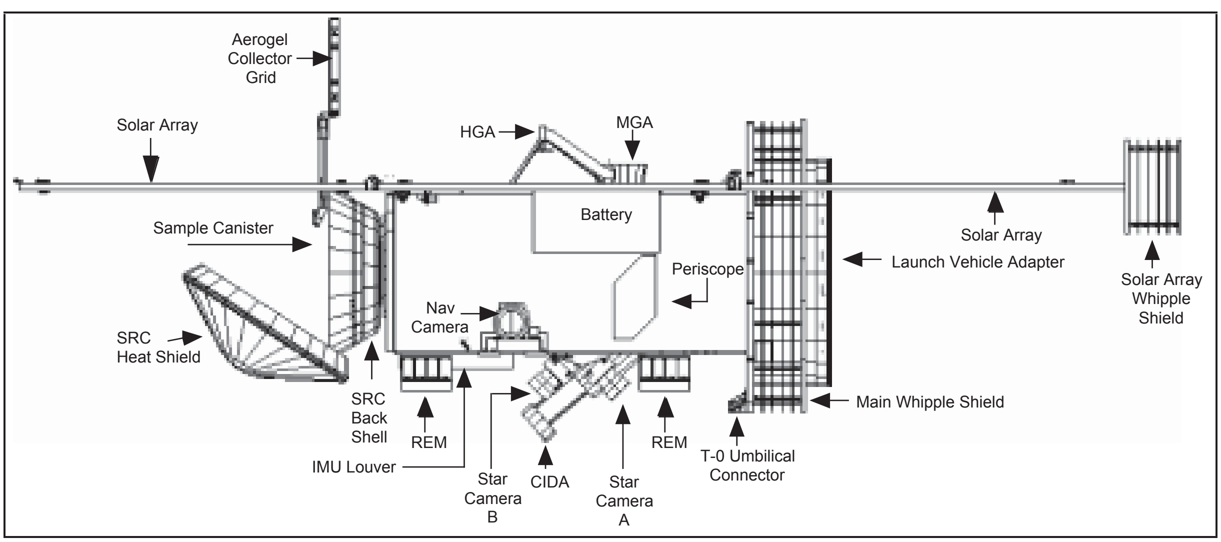
2.1.2.1 Collect intact cometary dust particles from the coma of Wild-2.

The primary objective of the Stardust mission is to non-destructively collect comet dust particles greater than 15 microns (μm) in size, at an encounter velocity less than 6.5 km/s (4 mi/s), and return them to Earth for scientific study.



Source: [JPL 1996-C]

Figure 2-1c. Proposed Stardust Third Orbit Loop, Including Encounter with Wild-2



Source: [JPL 1997-E]

Figure 2-2. Proposed Stardust Spacecraft Configuration with Aerogel Collector Deployed

Based on particle-size distribution model predictions, which have been derived from observations of comet Halley by European Space Agency's (ESA's) Giotto spacecraft in 1986, Stardust would focus on the collection and return of a statistically significant number of relatively large coma dust grains and coma volatiles, such as complex organic molecules that remain stable in vacuum above a temperature of 300 degrees Kelvin (K) (27 degrees Celsius [ºC], 81º Fahrenheit [F]). Assuming that the comet is similar to Halley, the gas is expected to be largely water, with smaller amounts of carbon monoxide (CO), methanol (CH_3OH), glucose (CH_2O), and others. The most volatile of these would not be retained on the Stardust collector. Hydrogen cyanide (HCN) and other compounds of interest could be present, but only in exceedingly small amounts (less than 2 parts per million (ppm)). If Wild-2 is similar to Halley, most of the carbon (C) and nitrogen (N) will be contained in dust particles. The composition of this dust is unknown and it is called CHON just because it predominantly contains the light elements carbon, hydrogen, oxygen, and nitrogen. Another possibility is that the comet is similar to carbonaceous chondrites, which are meteoric stones characterized by embedded rounded carbon granules of cosmic origin. If Wild-2 is similar to carbonaceous chondrites, the bulk of the organic materials will be like coal.

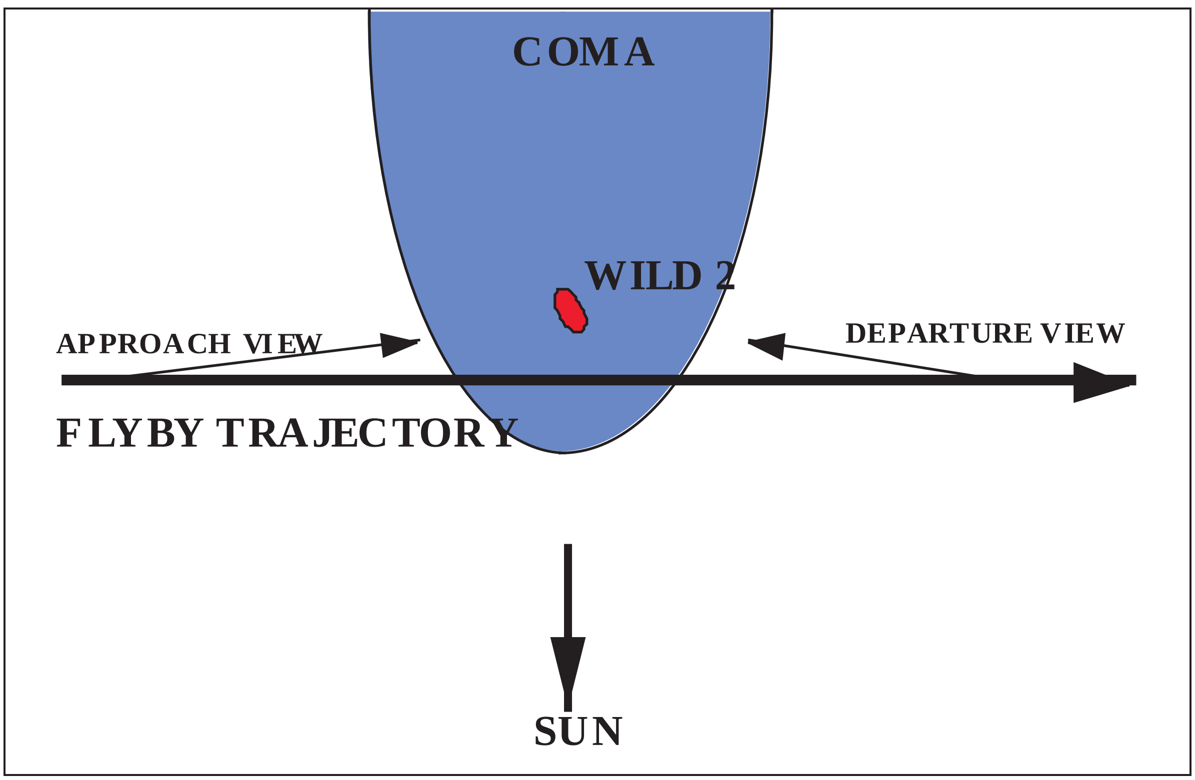
The dust particle and volatiles capture modules would be made of silica aerogel, an ultra-low density pure glass that is 99 percent air. After impacting the collector, the particle would be slowed down from its relative velocity of 6.5 km/s. The particle would shed its kinetic energy into the collector during a span of about a microsecond (1×10^{-6} seconds), causing the 3 centimeters (cm) (1.2 in) thick aerogel to melt around it and trap it intact. The SRC would be designed to thermally protect the sample canister, such that the temperature of the aerogel collector would not exceed 348 degrees K (75 ºC, 167 ºF), thus providing thermal protection for the dust particles collected during the flythrough.

2.1.2.2 Collect intact particles from the Interstellar Dust Stream impinging into our solar system from the center of the galaxy.

A secondary objective of the Stardust Mission would be to non-destructively capture interstellar dust particles greater than 0.1 μm (3.9×10^{-6} in) in size and return them to Earth for scientific study. The aerogel collector is the mechanism for intact capture of the interstellar dust particles. Because the interstellar dust particles are estimated to be 100 times smaller than the cometary dust particles, the aerogel collector would be a two-sided aluminum grid with 1-cm (0.4-in) thick aerogel on the back side and 3-cm (1.2-in) thick aerogel on the front side. Some modules would be graded in density (low to high) to provide the most gentle collection for smaller particles, yet have the ability to stop larger particles (up to 100 μm [3.9×10^{-3} in] in diameter). The back side of the grid would be exposed to the interstellar dust stream allowing the IDP to be passively trapped by the 1-cm thick aerogel as the Stardust spacecraft moves through the stream on its orbit about the Sun.

2.1.2.3 Provide multiple images of Wild-2, having a factor of ten times the resolution of any comet image to date, taken within 2000 km (1240 mi) of the comet nucleus.

The Stardust Optical Navigation (OPNAV) camera is necessary to achieve a flyby accurate enough to assure adequate coma dust particle collection. This camera is able to offer high-resolution images of the comet coma and nucleus during the comet encounter. The plan for the comet encounter is to utilize the OPNAV camera system to return as much high quality image data as possible. As the spacecraft approaches Wild-2, the camera would take images through each of eight filters, two wideband and six which cover the visual electromagnetic spectrum in the range of 0.4 μm to 0.9 μm. The high activity period for scientific imaging is five minutes on either side of closest approach. During the comet encounter, the camera would use a mirror with the ability to rotate through 180 degrees to change its viewing direction in order to capture images throughout the flyby (Figure 2-3). These images would be used to construct the best possible three-dimensional model of the entire illuminated hemisphere of the nucleus, and to create a color map of the nucleus during flyby.



Source: [JPL 1996-B]

Figure 2-3. Stardust-Wild-2 Flyby Geometry

2.1.2.4 Provide in-situ particle analysis capable of resolving abundant elements in cometary fields for dust particles during coma fly-through.

The Cometary and Interstellar Dust Analyzer (CIDA) would be a mass spectrometer instrument modified from the Particle Impact Analyzer (PIA) and PUMA instruments flown on the ESA's Giotto and VEGA missions, respectively, to comet Halley. It would provide information on comet compositions during the coma flythrough. The CIDA could return data on particles smaller than could be effectively collected, as well as provide information on incorporated volatiles that might not survive the capture process.

2.1.2.5 Provide in-situ particle analysis for interstellar dust particles and planetary dust.

Interstellar dust grains are theorized to be the main repository of condensable elements in the Galaxy. Dust influences nearly all types of astronomical observations and plays an important role in interstellar processes. From the Ulysses and Galileo measurements of the interstellar dust flux, scientists anticipate collection of particles in the 0.5 to 10 µm size range. However, most of our knowledge of interstellar dust is necessarily indirect. Analysis of even a few captured interstellar dust particles would profoundly influence our understanding of the interstellar medium and would be the key to a better interpretation of the existing indirect data from the Ulysses and Galileo missions.

2.1.2.6 Collect comet coma molecules and return them to Earth

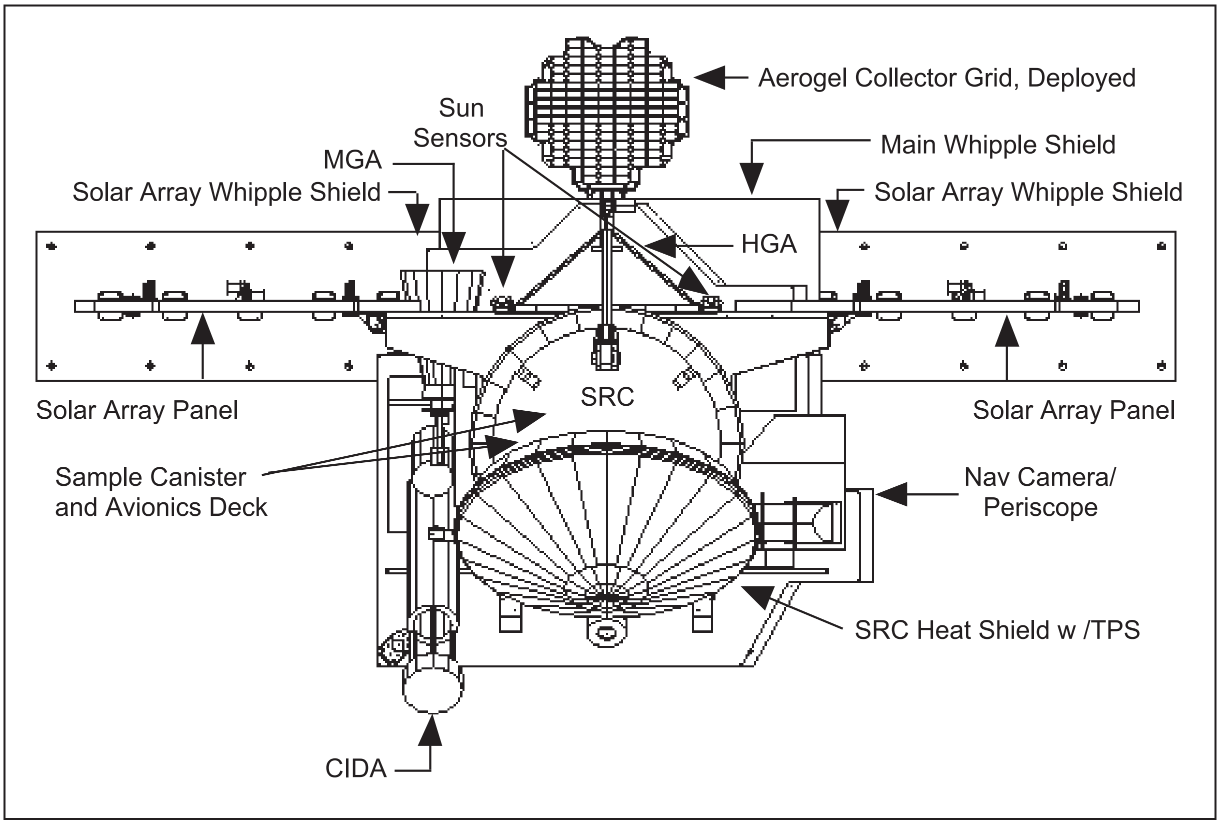
Some cometary gas molecules, such as carbon, hydrogen, oxygen, and nitrogen groupings, will be absorbed on the surfaces of the exposed aerogel and its aluminum grid. Gas absorbed into the aerogel will be at the outer surfaces of aerogel blocks containing particle tracks. The total amount of all volatiles collected is anticipated to be less than 1 milligram (mg). The complex organic molecules could be analyzed after sample return in the laboratory by non-destructive techniques, such as infrared and ultraviolet absorption spectroscopy and luminescence spectroscopy.

2.1.2.7 Provide dust flux measurement of 10^{-9} gram to 1 gram particles

The Dust Flux Monitor Instrument (DFMI) would monitor the dust flux during comet encounter for purposes of monitoring spacecraft environment and health. The electronic detection sensitivity would provide valuable scientific data on the temporal, spatial and size distributions of dust in the coma. From these dust distributions, scientists could ascertain the particle size distribution of the Wild-2 coma, which is not measurable on Earth, the particle size distribution of Wild-2 over time, the spatial distribution of Wild-2 dust, and the spatial distribution of Wild-2 dust over time.

2.1.2.8 Measure the dust mass flux, number of large particles, and comet mass upper limit

Scientists could determine the rate of dust moving in the stream and identify large specific dust impacts from analysis of the two-way spacecraft telecommunications signal and the spacecraft attitude control system. It would be possible to set an upper bound on the mass of the nucleus by determining how much the gravitational field of the comet nucleus deflects the spacecraft from its trajectory, as well as how much momentum is transferred to the spacecraft by collisions with dust, as the spacecraft approaches and departs from the comet nucleus.



Source: [JPL 1997-E]

Figure 2-4 Proposed Stardust Flight System During Sample Collection - Rear View

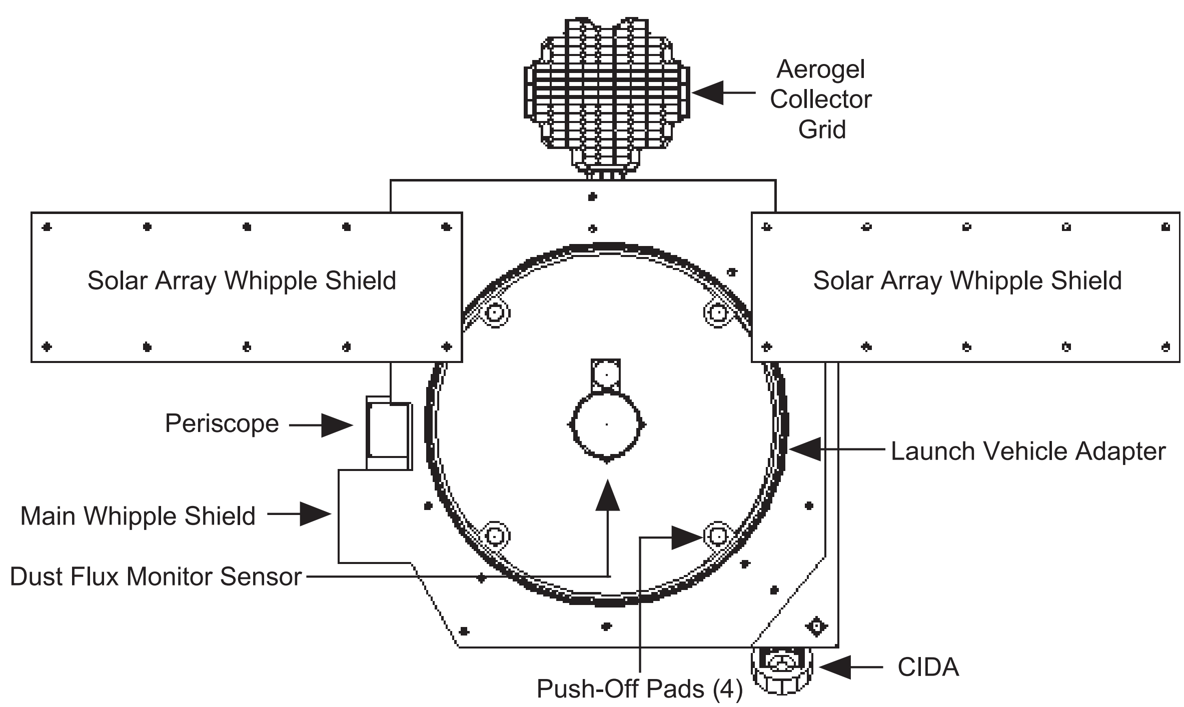
2.1.3 SPACECRAFT DESCRIPTION [JPL 1996-A], [JPL 1996-C], [JPL 1996-D]

2.1.3.1 General

The Stardust spacecraft would provide a three-axis stabilized platform for observations of Wild-2 comet by the science payload. The baseline design is derived in large part from the Mars 98 Surveyor Orbiter spacecraft, with necessary modifications made to incorporate the instruments required to collect the dust particles and image the comet for navigation purposes (Figure 2-4).

2.1.3.2 Spacecraft Pyrotechnic Devices

The Stardust spacecraft would use a total of seven (four primary, three backup) pyrotechnic devices, all classified as self-contained in case of inadvertent firing. All would be NASA Standard Initiators (NSIs) or equivalent, to be used in the deployment and release of the SRC parachute. The design includes 11 non-pyrotechnic burnwire separation devices, which would be used for releasing the SRC and solar arrays. The SRC would contain a small mortar and redundant NSIs for parachute deployment. Ordnance installation would be performed at LMA in Denver prior to shipping the spacecraft to Kennedy Space Center (KSC) for spacecraft processing.



Source: [JPL 1997-E]

Figure 2-5. Proposed Stardust Spacecraft During Sample Collection - Front View

2.1.3.3 Science and Engineering Instrumentation

The scientific and engineering instruments onboard Stardust would be used to gather data required to meet the science objectives. (Refer to Figure 2-5.)

2.1.3.3.1 Aerogel Collector

Intact capture of comet dust is the highest priority of the mission. The technology in this field that has been developed over the past decade allows hypervelocity particles to be captured upon impact into an underdense, microporous media, such as silica aerogel glass. The density of the aerogel is expected to be in the range from one milligram per milliliter (mg/ml) to twenty mg/ml. The collector would have two distinct sides; the front side of the collector would be about 3 cm (1.2 in) thick, and would be used to collect the coma dust particles during flythrough. The back side that would collect the IDP would be about 1 cm (0.4 in) thick. The aerogel media would be a refinement of a series of Shuttle sample return experiments, which show that when particles with speeds greater than 3.048 km/s (10,000 ft/s, known as hypervelocity) are captured in this ultra-low density glass, they produce narrow 'carrot'-shaped tracks that are hollow and can easily be seen in the transparent aerogel. The carrot is largest at the point of entry and the particle is collected intact at the end of the carrot. Extensive experience has been gained from both laboratory and space flights of aerogel for collecting hypervelocity particles at speeds of 6 km/s (4 mi/s).

With proper illumination, the track of a 10 μm (3.9×10^{-4} in) particle can be seen with the naked eye. The captured particle is seen optically just beyond the tip of the carrot, and it can be recovered by a variety of techniques. Recovered samples would then be treated by sequential analysis techniques that have been developed for analysis of small meteoritic samples and IDPs.

2.1.3.3.2 Cometary and Interplanetary Dust Analyzer (CIDA)

The CIDA would be provided to Stardust by the German Space Agency (DLR) and the Max-Planck-Institut fur Extraterrestrische Physik, with the cooperation of the Finnish Meteorological Institute and the French Space Agency (CNES). The scientific functions of the CIDA instrument are to:

- determine the overall elemental composition
- characterize the organic component
- characterize the mineralogy of the dust particles
- measure the mass and density of the dust particles
- measure the range of elemental ratios
- measure the light element abundance relative to carbonaceous chondrites

- measure the light carbon and other gross isotopic peculiarities
- measure the light element distributions within the coma
- determine the mass loss from CHON particles
- determine the existence and nature of very small particles, known as 'attodust'

Stardust's flyby of Wild-2 would be closer than any previous comet mission. As such it is anticipated that data gathered by the CIDA could be used to increase scientific knowledge about the light element spatial distribution and the amount of mass loss from the CHON particles. Confirmation of the CHON component, in addition to characterization of the organic component, could provide better definition of chemical state and could identify more molecules. Mineralogy of individual dust particles could be gained from the additional negative ions and from more spectra. High quality spectra from the CIDA could confirm the presence of light isotopes of carbon in Halley's dust. The data would consist of more than 5000 mass spectra of individual micron- and submicron-sized particles. Ions generated by hypervelocity impact of dust onto the instrument would be separated in a drift tube and produce time-delineated mass spectra at the detector. Each spectrum would consist of a 72 microsecond (µs) record digitized for transmission. Due to improved instrument design, the CIDA could be able to detect the existence of very small particles.

2.1.3.3.3 Dust Flux Monitor Instrument (DFMI)

The Dust Flux Monitor Instrument would be provided by the University of Chicago. The DFMI would measure the spatial and temporal variations of particle flux and mass distribution during the Stardust flyby of the comet. It would consist of a sensor unit (SU) and electronics box (EB) mounted to the Stardust spacecraft. The SU would be mounted to the Whipple shield (see Figure 2-2), and the EB would be mounted internally to the spacecraft. The SU would consist of two independent polyvinylidene difluoride (PVDF) sensors (sensor 1 and sensor 2) mounted in a frame, and an acoustic sensor mounted one layer in from the main Whipple Shield bumper (Figure 2-5). The combined mass thresholds of sensor 1 and sensor 2 would provide cumulative and differential particle fluxes over the particle mass range of 10^{-11} to 10^{-4} gram (g) (particle diameter range 2 to 418 µm), as well as cumulative flux for particles with mass greater than 1×10^{-4} g. The acoustic sensor would provide the capability of identifying impacts made by particles large enough to penetrate the Whipple Shield bumper. The EB would contain the analog and digital electronics, the instrument low voltage power supply and the SU and spacecraft interface connectors.

The maximum diameter of any particle encountered during flyby is anticipated to be no larger than 1 cm (0.4 in) in diameter. For each particle impact, the DFMI would categorize the particle by size and the cumulative impact data would be transferred to the flight computer once a second. This monitoring data stream would be valuable scientific data on the concentration, size distribution and spatial distribution of dust in the coma.

The accumulated dust flux would be correlated with the two-way Doppler tracking to calibrate data consistency. Specific large particle impacts would be correlated with spacecraft attitude control signals. The combined information would determine both the temporal and spatial distribution of dust sorted by the mass of the particles.

2.1.3.3.4 Spacecraft Elements Which Can Be Used to Provide Scientific Data

High quality data are also produced by two Stardust engineering subsystems which provide science value: the optical navigation camera and the radio frequency lock link.

2.1.3.3.4.1 Optical Navigation (OPNAV)

Both radiometric and optical navigation would be employed to navigate the Stardust spacecraft to Wild-2. Doppler tracking of the spacecraft would be implemented throughout all phases of the mission with this activity intensified during deep space maneuvers (DSMs), trajectory correction maneuvers, (TCMs), and the Wild-2 encounter. Optical navigation pictures of Wild-2 and adjacent stars would be taken by the spacecraft-mounted camera and would begin approximately 90 days prior to Wild-2 encounter; the rate of optical data would increase as the spacecraft approaches the comet. All navigation data would be sent to the ground for processing and maneuver command generation. The navigation facilities to be used are located at JPL. They are largely inherited from Voyager and other deep space missions carried out at JPL, and therefore no new facilities would be required.

The optical navigation of the spacecraft would use the on-board star cameras as backup to acquire images of the comet and adjacent stars should the navigation camera become unavailable for this purpose. The baseline star camera would be an instrument with a 25-degree field-of-view and a 512 x 512 pixel array. The spacecraft could be navigated successfully with this instrument for the primary mission objective of cometary dust collection.

2.1.3.3.4.2 Radio Frequency Lock Link

From the analysis of the spacecraft telecommunications downlink signal, it is expected to be possible to obtain Doppler shifts as the spacecraft moves through the coma. This would provide a measurement of momentum transfer due to collisions with dust, and hence the spatial mass density of dust on approaching and departing from the comet nucleus. For a close flyby, it may be possible to place an upper bound on the mass of the comet nucleus from trajectory deflection. This dynamics science would utilize only that hardware needed for spacecraft telecommunications. It would not be necessary to fly any special hardware, such as an ultra-stable oscillator, to accomplish these measurement objectives. In addition, the inertial measurements unit (IMU) and star cameras could provide data on attitude changes which result from particle impacts. Analysis of this information could be useful in diagnosing large particle impact events.

2.1.4 SAMPLE RETURN CAPSULE (SRC)

Separation of the SRC from the spacecraft would occur approximately four hours prior to capsule entry. The SRC would not enter into Earth orbit, but would directly enter Earth's atmosphere, with an entry velocity of 12.8 km/s (7.9 mi/s). Taking into account SRC separation and entry corridor uncertainties, vehicle aerodynamics uncertainties and atmospheric dispersions, the landing footprint ellipse for the SRC has been determined to be approximately 84 km long by 30 km wide (52 mi x 19 mi) (three standard deviations in each direction) . [NASA 1997-A] The flight path of the SRC as it approaches UTTR would be approximately a west-northwest to east-southeast trajectory. The parachute system would consist of a mortar-deployed drogue chute to provide stability at supersonic speeds, and a main chute (8.2-m, 27-ft diameter), which would be released at about 3 km (10,000 ft). Velocity of the SRC at touchdown would be approximately 4.5 m/s (14.8 ft/s). Weight-wise, this can be compared to a 110-pound parachuter landing. At no time during the entry and descent would the SRC release its heatshield or back shell. Time elapsed from entry to touchdown would be approximately twelve minutes. Following touchdown in the early morning hours, the SRC would be recovered and transported to a staging area at UTTR in preparation for transport by NASA to the planetary materials curatorial facility at Johnson Space Center.

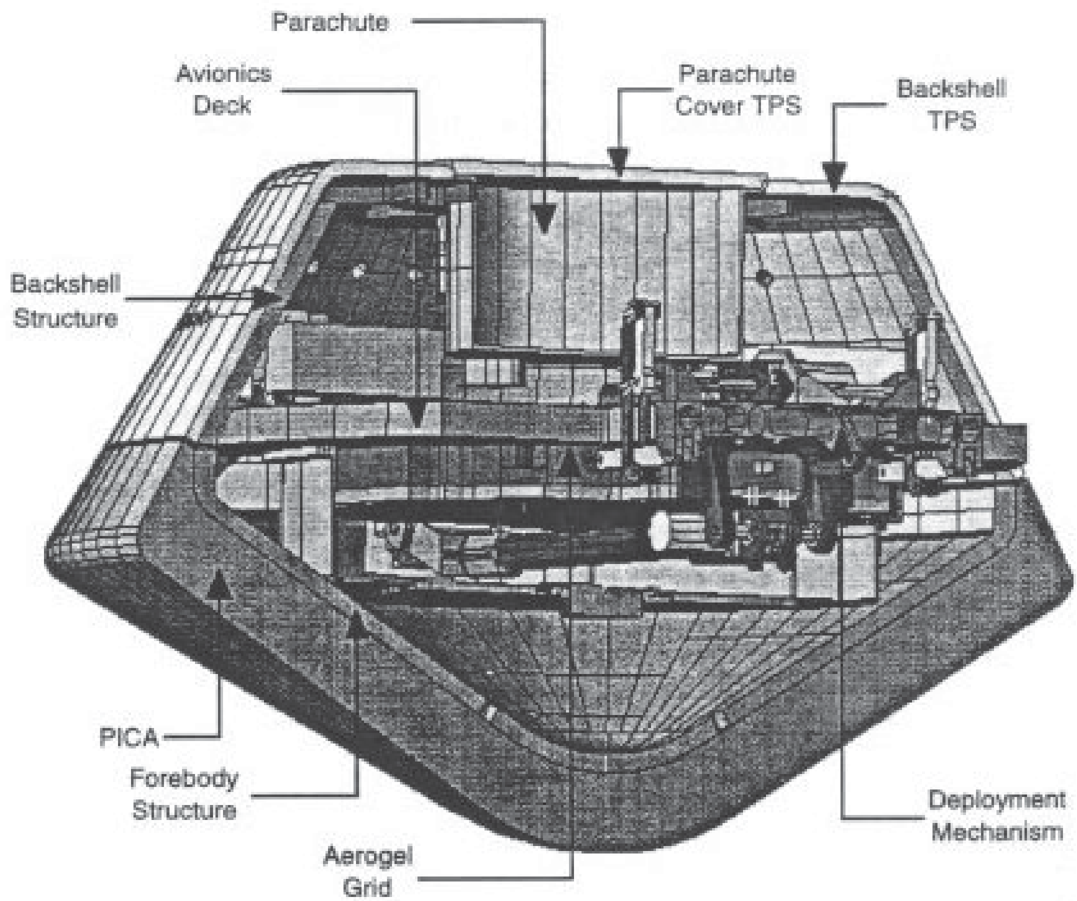
Given the small size and mass of the SRC (see section 2.1.4.1), it is not expected that recovery and transportation of the capsule would require extraordinary handling measures or hardware other than a specialized handling fixture to be provided by LMA to cradle the capsule during transport. Other than the parachute deployment/separation system, the SRC would not contain any explosive ordnance, pyros, rocket motors, etc. The SRC will be discussed in detail in section 2.1.6.2 and the potential environmental effects associated with the recovery operation will be discussed in section 5.3 of this document.

2.1.4.1 Recovery Vehicle Description [JPL 1997-C]

The SRC would be composed of five major components: heat shield, back shell, sample canister, parachute system, and avionics. The total mass of the SRC, including parachute system would be 42.6 kg (93.7 lb). The SRC would have a diameter of 81 cm (32 in), as shown in Figure 2-6.

2.1.4.1.1 Heat Shield

The heat shield would be made of a graphite/epoxy composite covered with a thermal protection system (TPS). The TPS to be used for Stardust would be a phenolic impregnated carbon ablator (PICA) developed by NASA's Ames Research Center for use on high-speed reentry vehicles. The SRC heat shield would remain attached to the capsule throughout descent and serve as a protective cover for the sample canister at touchdown.



Source: [JPL 1997-C]

Figure 2-6. The Proposed Stardust Sample Return Capsule

2.1.4.1.2 Back Shell

The back shell structure would also be made of a graphite/epoxy composite covered with a TPS. The TPS that is planned for use on the backshell is a cork based material called SLA-561V that was developed by Lockheed Martin for use on the Viking missions to Mars and is currently used on the Space Shuttle External Tank. The back shell would provide the attach points for the parachute system.

2.1.4.1.3 Sample Canister

The sample canister would be an aluminum enclosure that holds the cometary particle capture medium (aerogel) and the deployment mechanism used to deploy and stow the aerogel trays during the mission. The canister would be mounted to an equipment deck suspended between the backshell and heat shield.

2.1.4.1.4 Parachute System

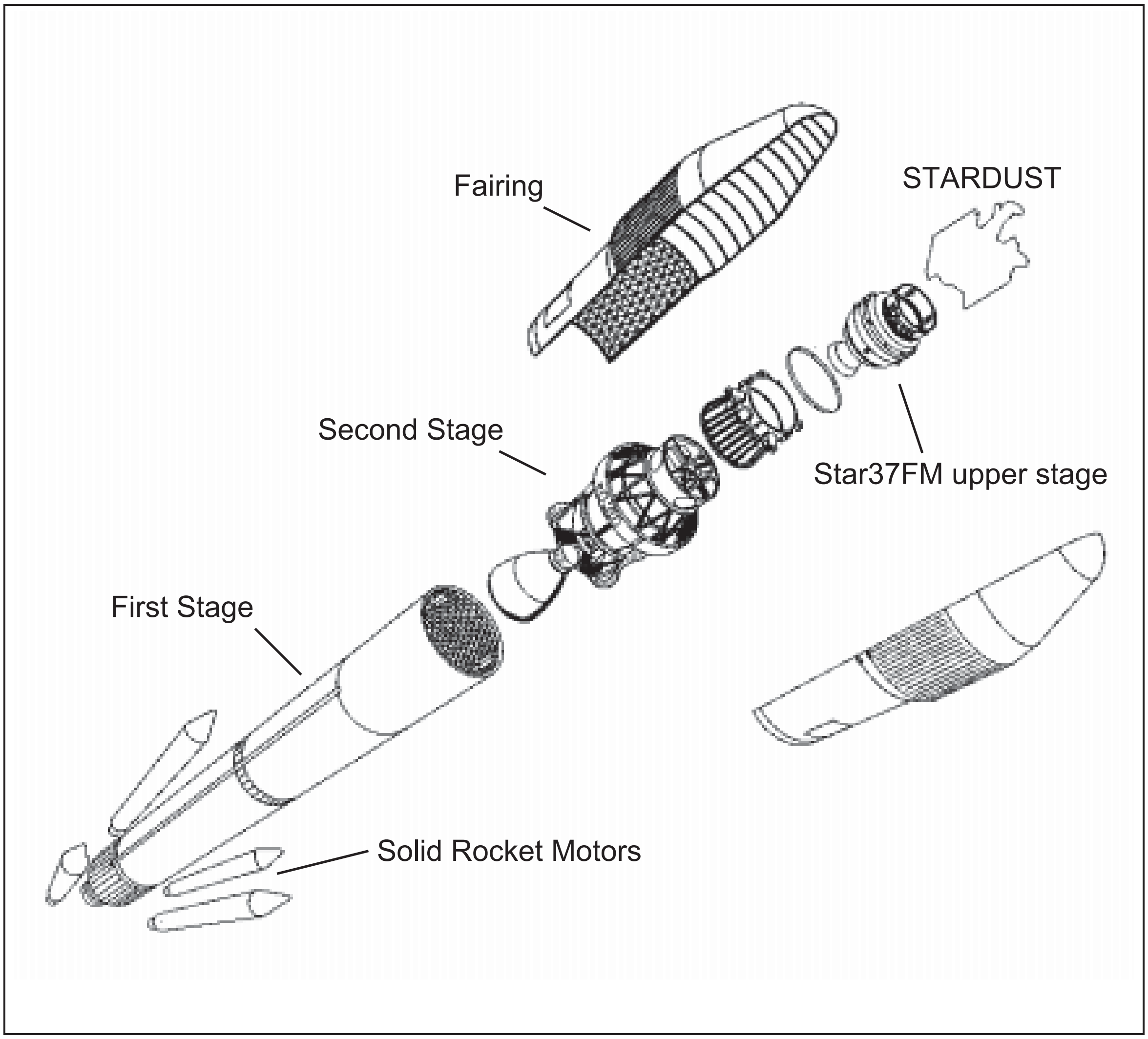
The parachute system would incorporate a drogue and main parachute into a single parachute canister which would contain the NSIs and the drogue deployment mortar. Inside the canister would be a gas cartridge that would be used to pressurize the mortar tube and expel the drogue chute. The drogue chute would be deployed at an altitude of approximately 30 km (100,000 ft) mean sea level (MSL) at a speed of about Mach 1.4 to provide SRC stability until the main chute is released. A gravity-switch/timer would initiate release of the drogue chute. Based on timer and backup pressure transducers, a NSI-fired cutter would release the drogue chute from the SRC at approximately 3 km (10,000 ft) MSL. As the drogue chute moves away from the SRC, it would extract the main chute from the parachute canister. Upon touchdown, cutters would fire to cut the main chute cables so that winds would not drag the SRC across the terrain.

2.1.4.1.5 SRC Avionics

The current Stardust SRC baseline design includes a ultra high frequency (UHF) Locator Beacon to be used in conjunction with UHF-DF equipment on the recovery helicopters. The beacon would be turned on at main parachute deployment and would remain on until turned off by recovery personnel. The beacon would be powered by redundant sets of primary cell lithium sulfur dioxide batteries, which have long shelf life, tolerance to wide temperature extremes, and handling safety. The SRC would carry sufficient battery capacity on-board to operate the UHF beacon for at least 40 hours.

2.1.4.2 Landing Footprint Determination Accuracy [NASA 1997-A]

The driving requirement to meet the proposed footprint onto UTTR is the entry flight path angle. An accuracy of 0.08 degrees (3 standard deviations or 3 sigma) is necessary to maintain the downrange footprint within UTTR. In order to support the trajectory accuracy needed, navigation tracking requirements have been established by JPL. Sixty-seven days prior to entry, navigation cutoff would occur and JPL would then begin to incorporate available data into a navigation solution with a highly accurate set of entry conditions. The resulting maneuver solution would be translated by LMA into a spacecraft command to be uplinked



Source: [JPL 1996-C]

Figure 2-7. Delta II 7426 Launch Configuration

through the NASA's Deep Space Network (DSN). At entry minus sixty days the spacecraft would perform the TCM to implement preliminary entry targeting. Another TCM to refine entry targeting would be performed thirteen days prior to entry. The final entry targeting TCM would be performed 24-hours prior to entry. The landing footprint location for the Stardust capsule would be predicted by tracking the spacecraft with DSN prior to SRC release from the spacecraft. Roughly six hours prior to entry, an updated footprint would be provided to the SRC recovery management team for review of the predetermined safe entry decision criteria, which would include a one-in-a-million probability of impacting a person or damaging a range asset. Since the SRC would not have a propulsion system, there would be no way to abort the entry sequence following SRC release. Since the Stardust spacecraft would be following a direct entry path to Earth from deep space, there is only one chance for sample recovery. A no-go decision for Stardust SRC separation represents mission failure and would be considered if personnel are in danger or serious property damage is probable. Assuming the criteria for safe entry are satisfied, the SRC would be released from the spacecraft four hours before entry. The spacecraft would perform a divert maneuver at three hours prior to entry. In the event that the criteria are not met, a command would be sent to prevent SRC release, so that when the divert maneuver is performed, the entire flight system, with the SRC still attached, would be diverted from entry.

Following SRC release, entry into Earth's atmosphere is defined to occur when the SRC is 125 km (77.5 mi) above a 6378 km (3,954 mi) spherical radius reference. Earth's atmosphere would quickly decelerate the SRC. The SRC trajectory would remain above 30 km (100,000 ft) until the SRC is over UTTR. Atmospheric data from high altitude weather balloons would be used for final updates to the predicted landing location.

2.1.5 LAUNCH VEHICLE [USAF 1988, USAF 1994, JPL 1996-C]

The Delta II 7426 has been selected as the baseline launch vehicle for the Stardust mission. The Delta II launch vehicle (Figure 2-7) consists of a payload fairing, the first and second stage propulsion systems with four graphite epoxy motors (GEMs) used as strap-on boosters to the first stage, and a Star 37FM upper stage.

2.1.5.1 Payload Fairing (PLF)

During ascent, the Stardust spacecraft/Star 37FM 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 130 km (80 mi).

2.1.5.2 Delta II First and Second Stage and GEMs

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 kilograms (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 (UDMH)) 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).

2.1.5.3 Star 37 FM Upper Stage [Boeing 1997]

The third stage of the launch vehicle provides the final velocity required to insert the Stardust spacecraft onto its trajectory. The upper stage consists of: (1) a spin table to support, rotate, and stabilize the Stardust spacecraft/upper stage combination before separation from the second stage, (2) a Star 37FM solid rocket motor for propulsion, and (3) a payload attach fitting (PAF) to mount the Star 37FM motor to the spacecraft. The Star 37FM is fueled with 1,077 kg (2,370 lb) of solid propellant (HTPB). The PAF, spacecraft separation system, and cabling between the upper stage and the spacecraft do not remain with the spacecraft after its separation from the upper stage.

2.1.5.4 Flight Termination System [EWR 127-1]

The Eastern Range (ER), Range Safety Office has the responsibility for establishing flight safety limits for the trajectory of a launch vehicle. These limits are defined to ensure that errant launch vehicles (or debris resulting from a launch failure) would not pose a danger to human life or property. These flight safety limits are determined before launch, using predicted values for winds, explosively produced fragment sizes and velocities, human reaction time, transmission delay time, and other pertinent data. During a launch, if the vehicle trajectory indicates that these limits would be exceeded, the ER Mission Flight Control Officer would take appropriate action, including destruction of the vehicle. [EWR 127-1]

As specified by Range Safety requirements, the Stardust 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 Mission Flight Control 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. [MDSSC 1991]

2.1.5.5 Launch Vehicle Debris

Delta launch vehicles use containment devices to mitigate the spread of debris generated during normal staging operations. Once separated, the Delta II payload fairing, first stage, and GEMs do not achieve Earth orbit. After burnout, the GEMs fall into the Coast Guard-controlled area of the Atlantic Ocean. The first stage burns to depletion to avoid potential tank rupture and breakup from over-pressurization caused by solar heating, then falls into the Atlantic Ocean. After third stage separation, the second stage propellants also burn to depletion. The second stage achieves and remains in low Earth orbit (LEO) until its orbit decays (in approximately sixty days). Its orbital decay time falls below the limit NASA has set for orbital debris consideration. The second stage is designed to burn up upon reentry, however, in the event that it does not completely incinerate, its footprint is less than NASA's requirement for uncontrolled reentry, i.e., $8m^2$ total footprint. [NASA 1995-A] The Stardust Project will follow the NASA guidelines regarding orbital debris and limiting the risk of human casualty for uncontrolled reentry into the Earth's atmosphere. [NASA 1997-C, NASA 1995-A]

The Stardust spacecraft/upper stage would be "parked" in LEO for less than one hour before the third stage engine fires, putting the spacecraft on its initial trajectory.

2.1.6 CAPE CANAVERAL AIR STATION (CCAS) OPERATIONS

Delta launches have occurred from CCAS Launch Complex 17 since May of 1960, with a reliability of greater than 94 percent. During this long period of federally sponsored activities, launch preparation procedures have been well documented, standardized, and continuously reviewed. Stardust launch 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. The Stardust Project would prepare a Project Safety Plan (PSP) and a Missile System Pre-Launch Safety Package (MSPSP) in accordance with JPL, KSC, and Air Force Eastern and Western Range Safety Requirements (EWR 127-1). A Safety Review Panel (SRP) high-performance work team, as specified by EWR 127-1, would be convened and meet as required to review and guide the resolution of safety issues.

2.1.6.1 Launch Vehicle Processing [USAF 1988, USAF 1994, MDA 1993]

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 for hardware integration and systems testing. The first stage would then be transferred to the Horizontal Processing Facility (HPF) 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 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 in Solid Motor Buildup Area 57 before being transported to the LC-17 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 1976, NASA 1995-E]

The objective of planetary protection is to minimize the uncontrolled exchange of organic or biological material between Earth and solar system bodies on which abiotic chemical evolution could have taken place or life could exist. 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 (COSPAR) of the International Council of Scientific Unions. NASA implements this policy by establishing planetary protection requirements for each applicable mission.

For the proposed Stardust mission of a comet flyby and sample return, the planetary protection policy applies to evolved chemical material returned to Earth. The outbound mission phase covers the mission up to and through the encounter with Wild-2 and flythrough of its coma, during which time samples of the ambient dust and molecules would be obtained. For this part of the mission the spacecraft has been classified as a Planetary Protection Category II mission, with a Planet Priority of “B.” A Planet Priority of “B” defines the planetary body as being “of significant interest relative to the process of chemical evolution but only a remote chance that contamination by spacecraft could jeopardize future exploration.” [NASA 1995-E] The solar system body to be protected on the out-bound phase of the mission is the comet Wild-2. There are no specific requirements for clean room assembly other than those required by the necessity to control contamination of the aerogel collector prior to comet encounter. The likelihood of an accidental impact with the comet would result in mission failure and as such would be avoided.

The inbound mission phase covers the mission subsequent to sample acquisition and continues through entry, descent, and landing (EDL) at Earth. The comet and interstellar dust particles would be traveling at very high speed relative to the collector and would be stopped in 1 to 3 cm of glass (aerogel) within microseconds. The particles would undergo extreme heating during impact and capture; this is a much more severe environment than any known sterilization techniques they might be subjected to on Earth. Because there is little possibility of biological contamination during sample collection, and thus an insignificant chance of returning any living organism to Earth (known as back-contamination), the Stardust project has requested and received certification from NASA’s Planetary Protection Officer, Dr. Mike Meyers, as a Planetary Protection Category V mission, “Unrestricted Earth Return,” for this mission phase. No further planetary requirements beyond those levied on the outbound phase of the mission would be levied. [NASA 1976, NASA 1995-E, JPL 1995-B]

2.1.6.2.2 Spacecraft Component Assembly and Test Operations

The Stardust main spacecraft bus with SRC installed, would be transported via escorted surface carrier from Lockheed Martin, Denver to KSC incased in the reusable Topex shipping container. The main spacecraft batteries would be transferred separately. All spacecraft parts would arrive at KSC for final assembly in mid-November 1998. At KSC’s Payload Hazardous Servicing Facility (PHSF), 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 the upper stage. This work is performed at KSC because the requisite facilities to perform these tasks are not available at CCAS. The following major component assembly activities would occur in the PHSF:

- 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 mating with the third stage

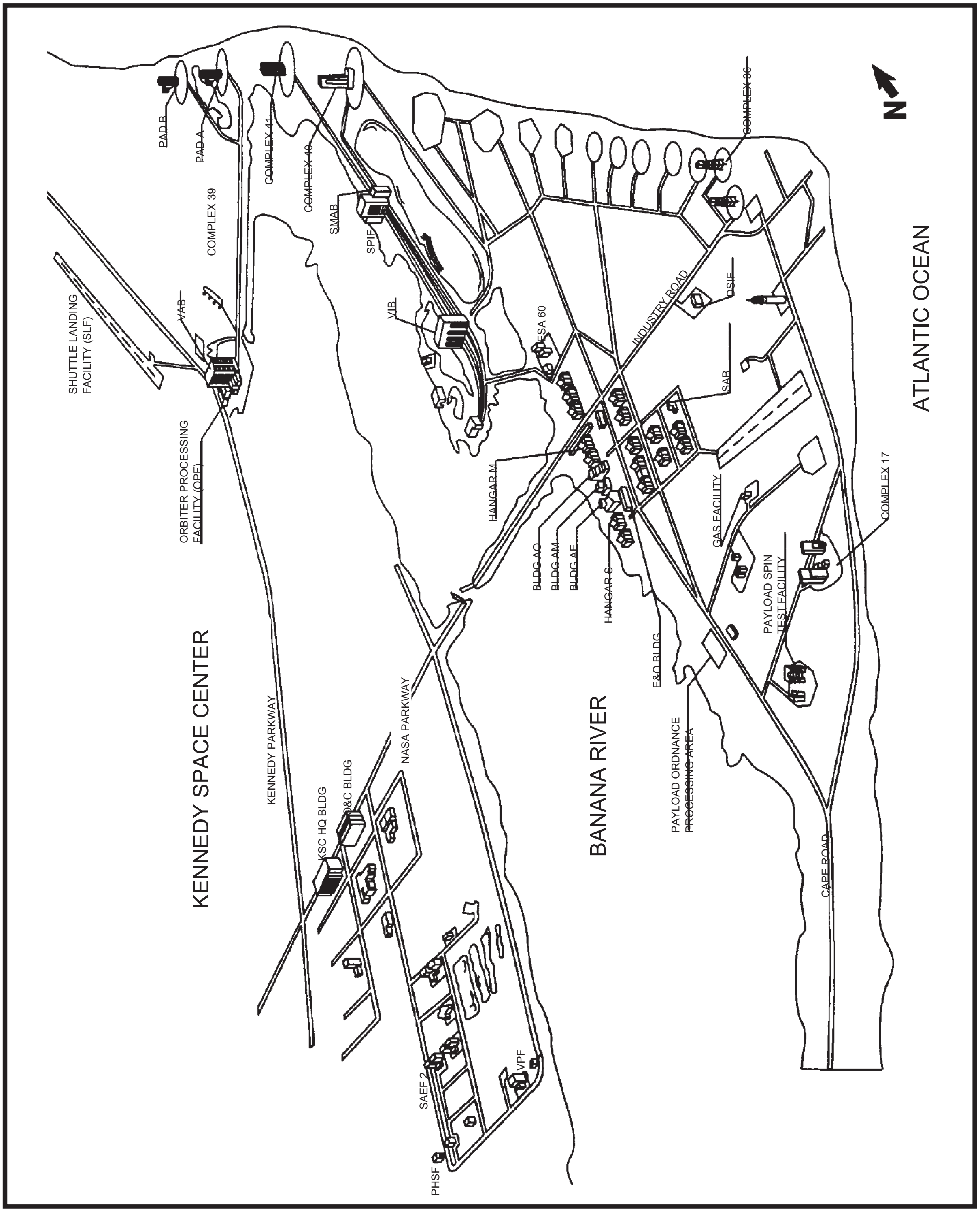
In mid-January 1999, the spacecraft and upper stage would be transferred to CCAS LC-17 via the Boeing Payload Transport Trailer, mated to the Delta launch vehicle, and final integrated tests with the launch vehicle would be conducted in preparation for the February 1999 launch.

2.1.6.2.3 Pad Activities

The spacecraft, joined to the upper stage, 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:

- The upper stage/spacecraft structure would be electrically mated to the Delta II 7426 launch vehicle.
- Final spacecraft functional tests would be performed.



Source: [USAF 1990]

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

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, (2) utilize an alternate landing site, and (3) cancel the Stardust mission (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. Normally, the most desirable launch system would meet, but would not greatly exceed, the mission's minimum launch performance requirements.

For the Stardust mission, constraints on launch system performance are the Stardust launch mass of approximately 396 kg (871 lb) and an injection energy (C_3) of 26 km^2/s^2 (10 mi^2/s^2). [JPL 1996-C] 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 Stardust launch systems include the Space Transportation System (STS) and various Taurus, Atlas, Delta, and Titan configurations. [JPL 1996-C]

2.2.1.2 U.S. Launch Systems

2.2.1.2.1 Space Transportation System

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

2.2.1.2.2 U.S. Expendable Launch Systems

Potential alternative U.S. expendable launch systems include the Taurus, Titan IIG/Star 48, Delta II 7325/Star 48, Titan IIS/Star 48, Delta II 7425/Star 48B, Delta II 7925/Star 48B, and the Atlas II Centaur.

- The payload fairings available for the Taurus are not large enough to accommodate the Stardust spacecraft.

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

- The Titan IIS/Star 48 would potentially meet the mass and C_3 performance criteria, but further development of the Titan IIS would be contingent upon the selection of Lockheed Martin as the contractor for NASA's Intermediate Expendable Launch Vehicle (IELV). The schedule and level of performance associated with this launch system at this time make it an undesirable alternative.

- A Delta II 7925 has 9 GEMs and a Star 48B upper stage whereas the 7426 has four GEMs and a Star 37FM upper stage. The Delta II 7925 launch system greatly exceeds the minimum mass performance criteria, and is not considered a reasonable alternative.

- The primary difference between the Delta II 7425 and 7426 is the upper stage. The Delta II 7425 has a Star 48B upper stage, which contains more propellant than the Delta II 7426's Star 37FM upper stage.

- The Atlas II launch vehicle has a booster section consisting of two liquid oxygen/kerosene booster engines, which feed the sustainer section propellant tanks. The sustainer section fuel tank contains approximately 48,988 kg (108,000 lb) of kerosene (RP-1) as compared to the 30,229 kg (66,504 lb) [USAF 1994] contained by the Delta II first stage. [AIAA 1991] The launch vehicle exhaust effluents are distributed along the trajectory for both launch vehicles. Due to it's larger mass, the Atlas II launch vehicle accelerates off the launch pad more slowly than the Delta II 7426, and thus, more of its exhaust products are ejected into the lower atmosphere. The Atlas II would contribute less potential environmental impacts than the Delta II 7426 because it does not have the solid rocket boosters, but it exceeds the launch capability of the Delta II 7426 by approximately 1000 kg, and would cost significantly more than the Delta II 7426.

2.2.1.3 Summary

Of the launch systems examined, the Delta II 7426 is the best-suited for the Stardust mission, for the reasons listed below:

- The mass performance of the Delta II 7426 most closely matches, without exceeding, the Stardust performance requirement. [JPL 1993]

- The Delta II 7426 is the lower cost alternative launch system of those systems meeting the performance criteria. [JPL 1993, AIAA 1991]

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

2.2.2 ALTERNATE LANDING SITES

Selecting a recovery operations site for a sample return mission largely depends on matching the safety and mission critical criteria to the facilities and capabilities of the prospective landing site. Issues of concern include minimal risk to public safety and to the returned samples. Because a water landing would most probably compromise the mission science objectives by increasing the risk of contamination of the aerogel-collected samples, a recovery site on land is mandated. Sites that can effectively be closed to the public minimize any chance of the reentering SRC harming individuals or their possessions within the controlled site boundary. The selection criteria for prospective landing sites is listed below:

2.2.2.1 Recovery Site Selection Criteria

Potential recovery sites investigated included Yuma Marine Corp Air Station (AZ), Luke Air Force Base (AZ), Edwards Air Force Base (CA), Chocolate Mountain Gunnery Range (CA), Twenty-Nine Palms Marine Corps Base (CA), Camp Pendleton Marine Corps Base (CA), Fort Bliss Military Reserve (NM), White Sands Missile Range (NM), Tonopah Test Range (NV), Nellis Air Force Range (NV), China Lake/Fort Irwin (CA), and UTTR (Utah). These sites were evaluated against the following criteria:

- Safety
  - ⇒ site must accommodate 84 km (52 mi) downrange x 30 km (19 mi) cross range recovery footprint, (the major axis of footprint from WNW to ESE) (Figure 2-9.)
  - ⇒ site must have reserved air space to provide separation from commercial air traffic

- Science Return
  - ⇒ site must have a flat recovery area, free from hills or terrain features that impose side loads on the sample return capsule
  - ⇒ the locale must allow prompt delivery of the samples to the JSC curatorial facility
  - ⇒ the samples must experience minimum exposure to a high-G environment
  - ⇒ the samples must experience minimum exposure to high temperature or high humidity

- Land Recovery versus Water Recovery
  - ⇒ salt water is highly corrosive
  - ⇒ the SRC is at risk of sinking in a water landing
  - ⇒ there exists a risk of the SRC being carried by ocean currents if not promptly recovered

- Range Recovery Assets
  - ⇒ descent tracking capability
  - ⇒ ground recovery operations capability

- Cost
  - ⇒ STARDUST is a low cost / cost-capped Discovery mission

- United States Range versus a Foreign Landing Site
  - ⇒ time and uncertainty associated with obtaining the necessary agreements with foreign governments
  - ⇒ cost associated with forging complex agreements
    time to transport samples to the JSC curatorial facility, ensuring integrity, safety, and security of samples

2.2.2.2 Summary

The Stardust 84 km x 30 km (52 x 19 mi) three-sigma landing footprint requires a large, flat, relatively unpopulated, and restricted area to ensure safety of personnel, the public, structures, and the mission science to be returned. Of the landing sites examined, UTTR has been determined to be the best-suited potential landing site for the Stardust mission, for the reasons listed below:

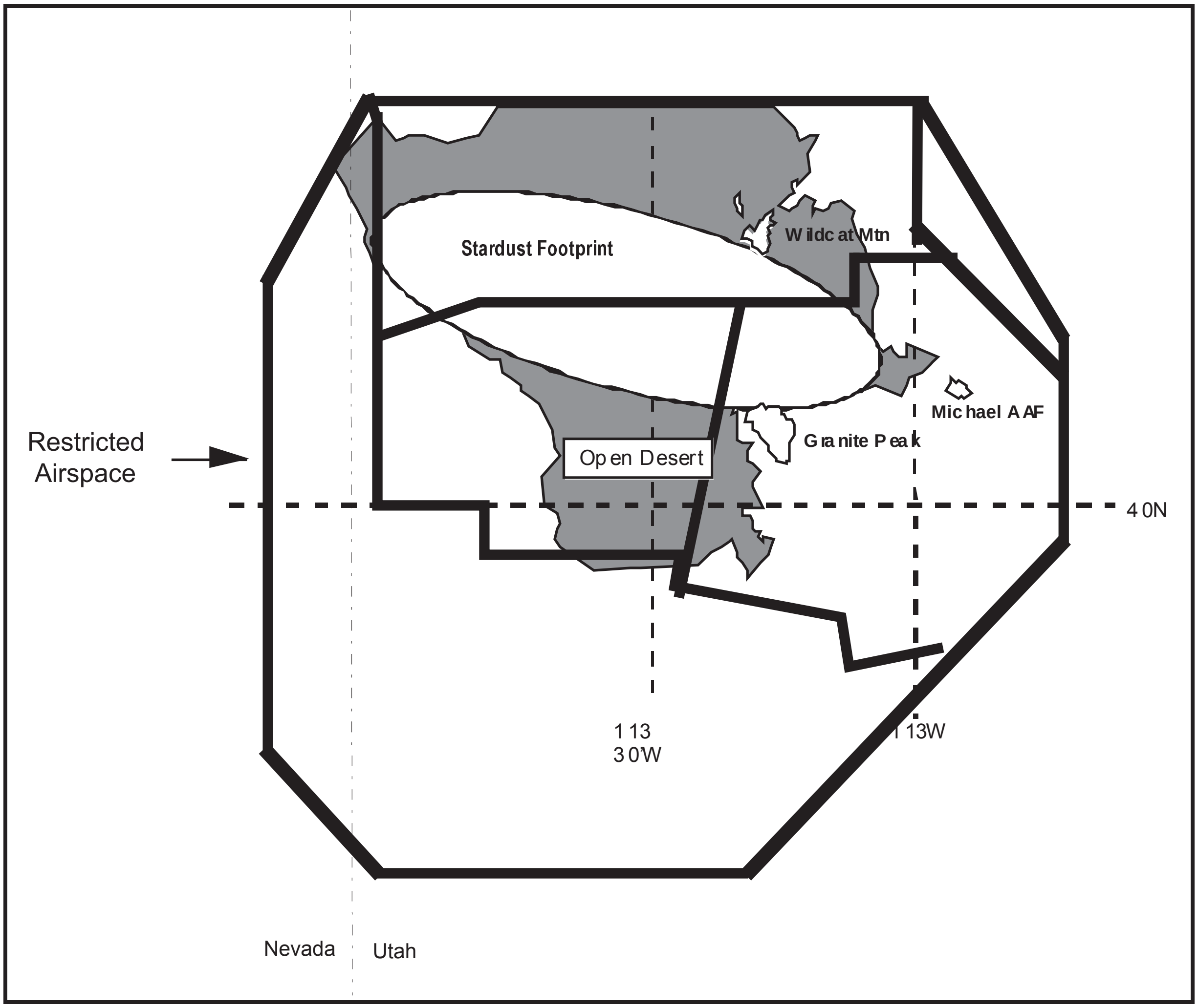
- Water recovery sites have been rejected due to unacceptable risk to the returned science, higher risk of capsule loss, and higher cost of recovery

- U.S. landing sites were chosen in order to ensure the integrity, safety, and security of the samples.

- Of the possible U. S. landing sites considered, only Nellis Air Force Range, China Lake/Fort Irwin, and UTTR meet the required footprint area. Both Nellis Air Force Range and China Lake/Fort Irwin have large areas of mountainous terrain which represent an unacceptable risk to a successful science return.

- UTTR has the largest overland special use airspace (measured from the surface or near surface, 43,126 sq km [16,651 sq mi]), as well as the largest overland contiguous block of supersonic authorized, restricted airspace in the contiguous United States (See Figure 2-9). [USAF 1997-D]

UTTR has been identified as the proposed Stardust project recovery operations site because it uniquely satisfies all of the preceding selection criteria.



Source: [JPL-1996-E]

Figure 2-9. 84 km x 30 km (3 sigma) Footprint for SRC Entry, Descent, and Landing Superimposed on South UTTR

2.2.3. 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. Stardust is the culmination of more than a decade's quest for a comet coma sample return mission. The scientific value of having actual bona-fide comet samples is high. Comets are unique objects that play a special role in our quest to understand the origin and earliest history of the Solar System. They appear to be well-preserved relics of the preplanetary material that gradually accumulated in the outer solar nebula. Their orbital and thermal histories are clearly different from all other solar system objects, including asteroids. Comet 81P/Wild-2, the target for the Stardust mission, is a 'fresh' comet which has been recently (1974) deflected by the gravitational action of Jupiter from its previous orbit much further out in the Solar System. Samples from Wild-2 would offer an exciting glimpse of the best preserved fundamental building blocks out of which our Solar System formed. While environmental impacts would be avoided by cancellation of the proposed mission, the loss of the scientific knowledge and database from carrying out the mission could be significant.

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

Cape Canaveral Air Station (CCAS) accommodates various ongoing space programs and is managed for the United States Air Force (USAF) by Patrick Air Force Base (PAFB). The cumulative environmental effects associated with these programs have been included in the baseline environmental conditions, which are detailed in the following sections. 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, as well as for discussion of required permits and facilities issues.

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.

CCAS is located in Brevard County on the east 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 (KSC), 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).

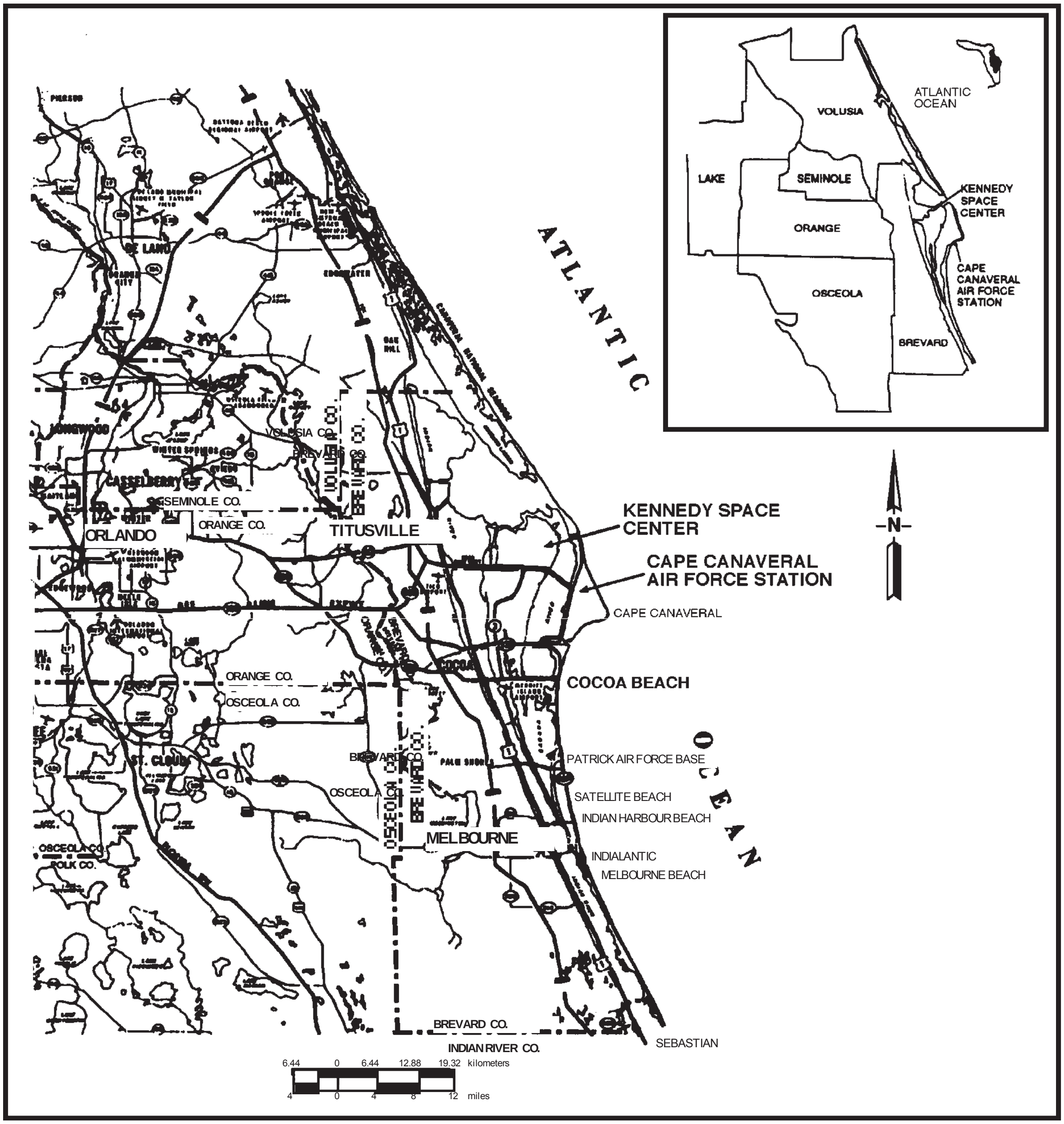
3.1.1 SOCIOECONOMICS

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 urban centers includes Titusville (20 km [12 mi] northwest, population 40,978), Cocoa (12 km [7 mi] southwest, population

17,826), Melbourne (48 km [30 mi, population 65,583)], and Cape Canaveral (0.8 km [0.5 mi] south). The nearest significant residential areas are Cocoa Beach (13 km [8 mi] south), and Merritt Island. [USAF 1996-C] All military personnel serving at the station are assigned to Patrick Air Force Base, 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



Source: [NASA 1986]

Figure 3-1. Regional Area of Interest

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 1995-D] 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 1995-D]

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. 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. KSC occupies almost 560 sq km (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]

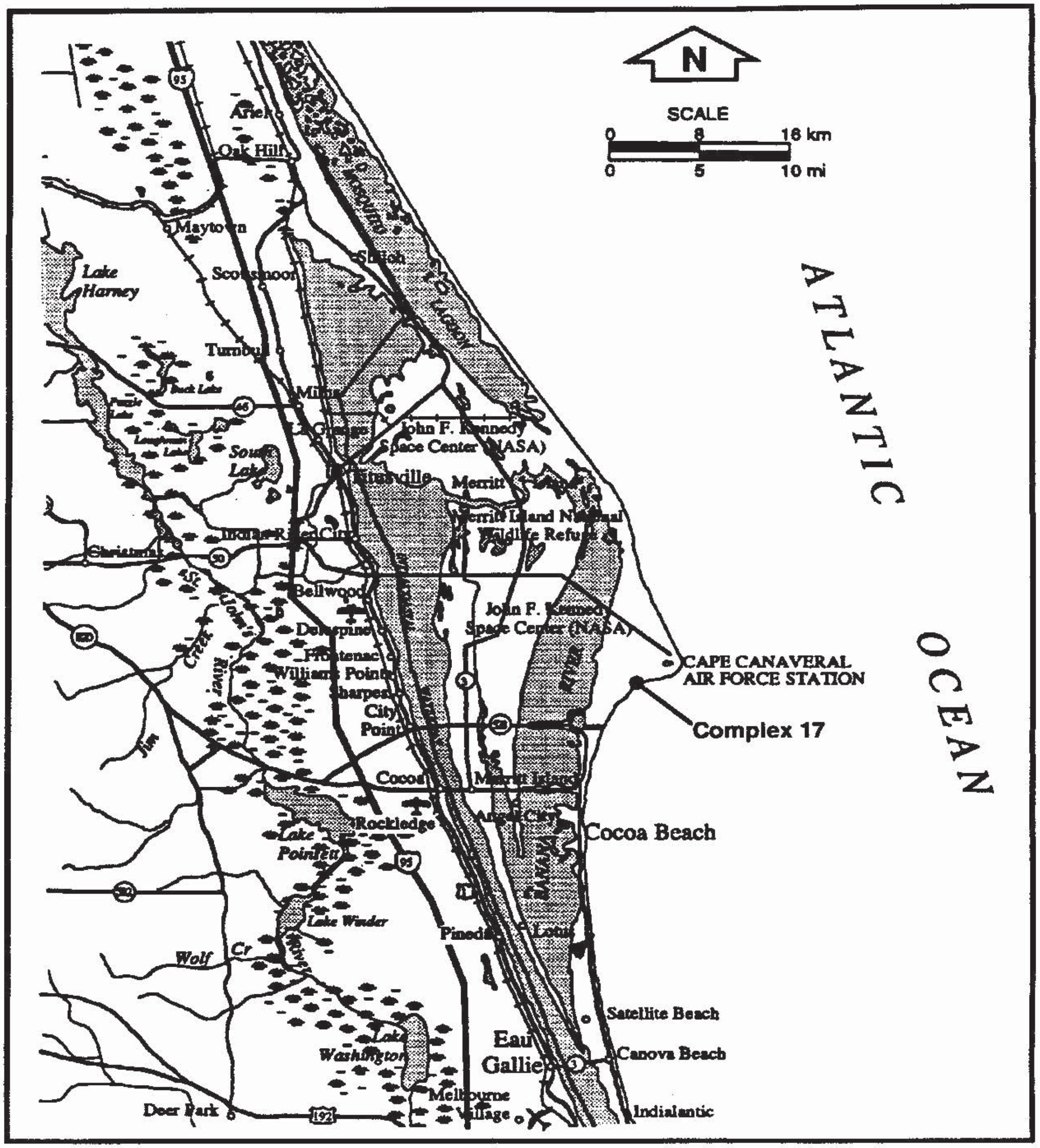
LC-17 (Figure 3-4) is located in the southern portion of CCAS, approximately 0.8 km (0.5 mi) west of the Atlantic Ocean, 2.5 km (1.5 mi) east of the Banana River, and roughly 5.7 km (3.4 mi) from the station's South Gate. The complex consists of two launch pads, 17A and 17B, each with its own mobile Missile 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 7426 launch do not require a water deluge system acoustic mitigation measure. [JPL 1995-C]

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.

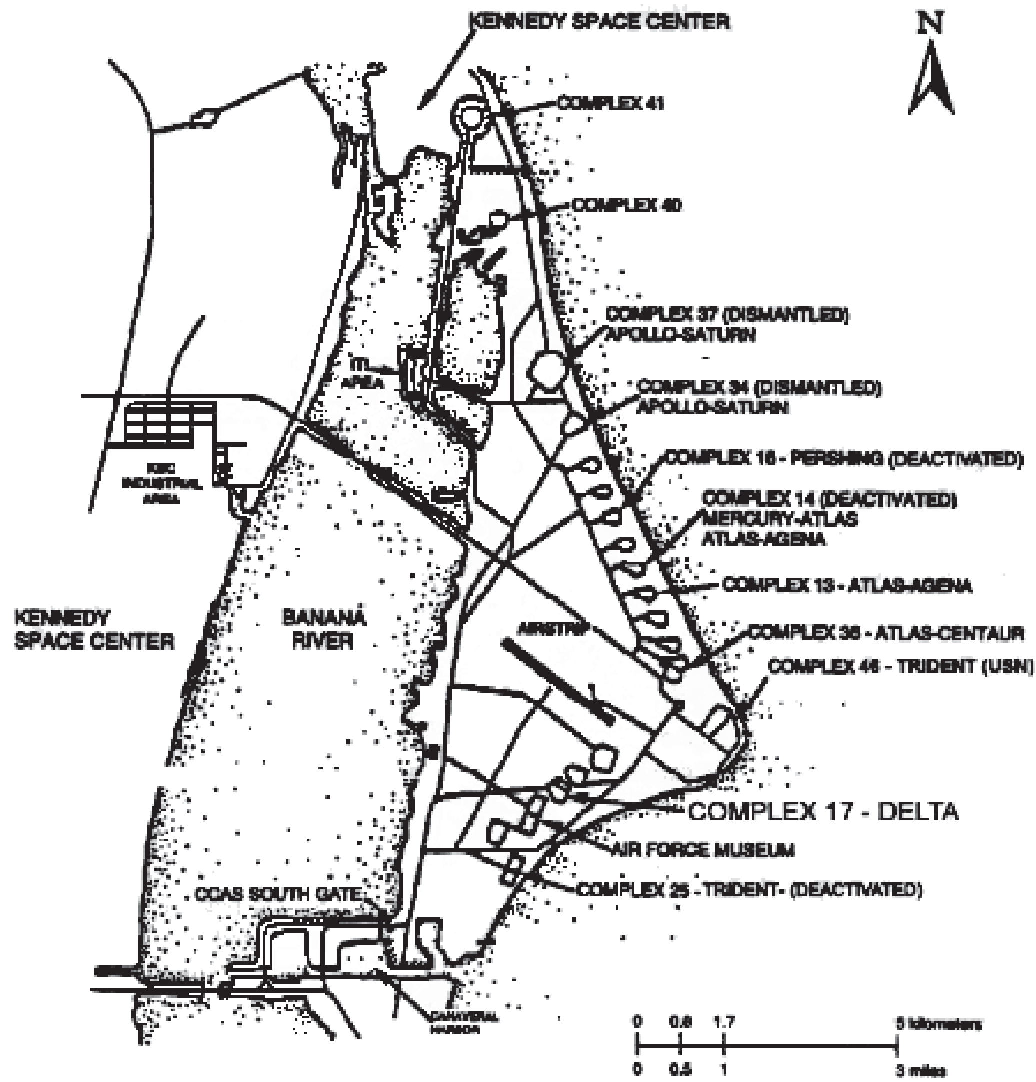
3.1.3 ECONOMIC BASE [NASA 1990]

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.



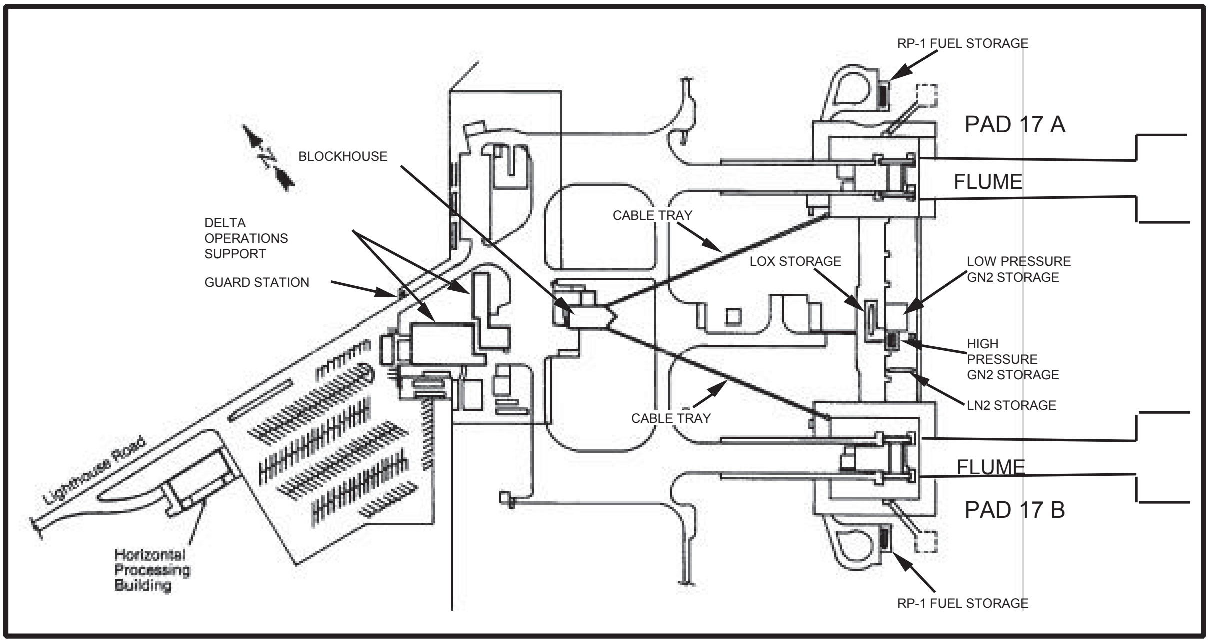
Source: [NASA 1986]

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



Source: [USAF 1986]

Figure 3-3. Land Use at CCAS



Source: [USAF 1988]

Figure 3-4. Launch Complex 17

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 ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," focuses Federal attention on the environmental and human health conditions in minority communities and low-income communities. The NASA Environmental Justice Strategy requires the identification and consideration of disproportionately high and adverse human health or environmental effects of NASA programs on minority populations and low-income populations. (See Section 3.1.1 for a discussion of the population distribution of the region of interest.) NASA has identified no disportionately high and adverse human health or environmental effects of its programs on minority or low-income populations.

3.1.5 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 167 million liters (l) (44 million gallons [gal]) per day, and average daily consumption is about 99 million l (26 million gal) per day.

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 treatment plants, some of which have reached capacity.

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 424 people, and fire protection has one full-time officer per 461 people. Health care within the area is available at 28 general hospitals, three psychiatric hospitals, and two specialized hospitals.

There were 185,150 housing units in Brevard county as of 1990. Vacancy rates over Brevard County averaged 12.2 percent, with a vacancy rate of 29.2 percent in the Cape Canaveral area. The average household in Brevard County in 1991 included 2.42 persons. There are no permanent residents at CCAS. The nearest significant residential areas to CCAS are Cape Canaveral, Cocoa Beach, and Merritt Island.

Public schools in Brevard County are part of a county-wide, single district school system with seventy-three schools and over 60,421 students in the 1992-1993 academic year. The school system has been growing since 1982, and capacity has been exceeded in some parts of central Brevard County. Growth in the district is expected to average four percent through 1996, the last year of school board projections. [USAF 1994]

Transportation in the region is served by highway, rail, airport, and harbor facilities. Federal, state and local roads provide highway service for Brevard County. Principles routes are Interstate 95, US Highway 1, and State Routes A1A, 407, 520, and 528. Bridges and causeways link the urban areas on the beaches to Merritt Island and the mainland. The Florida East Coast Railway affords rail service to the county, with a main line through the cities of Titusville, Cocoa, and Melbourne. Spur rail lines serve other parts of the county, including CCAS. Several commercial and general aviation airports are located in the vicinity of CCAS, the closest being Melbourne Regional Airport, approximately 30 miles south of the base. Port Canaveral, located at the southern boundary of CCAS, is the area seaport. Industrial and commercial facilities are located at the port, and cruise ship use is increasing.

The CCAS road system, which is linked to the regional highway system by the NASA Causeway to the west, State Route 402 to the north, the CCAS south gate and State Highway A1A to the south, serves launch complexes, support facilities, and industrial areas. An airstrip near the center of the base is used by government aircraft and for delivery of launch vehicles and spacecraft. CCAS is closed to the public. [USAF 1994]

3.1.5.1 Emergency Planning and Community Right-To-Know Act

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 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]

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] CCAS carries out its own sewage disposal with a consolidated wastewater treatment plant on site. [USAF 1994]

All nonhazardous solid waste that meets the requirements goes to the Brevard County Landfill. Other non-hazardous solid wastes are usually disposed through the Defense Reutilization and Marketing Office (DRMO). Hazardous wastes are accumulated at a number of locations throughout CCAS pending disposal. Wastes are accumulated at either 90-day or satellite storage sites before transfer to one of two CCAS hazardous waste storage facility, 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 according to the 45th Space Wing (45SW) 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 45SW Hazardous Materials Response Plan

(OPlan 32-3). 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 32-3.

The Launch Base Support (LBS) Contractor conducts all security 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] Disaster control is performed in accordance with 45SW OPlan 32-1, Disaster Preparedness Operations Plan. [USAF 1994]

3.1.7 CULTURAL RESOURCES

Within the region, there are 81 sites that are listed in the National Register of Historic Places (NRHP) [DOI 1997], 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 launch complexes 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]

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 cm (51 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, owing to CCAS's location adjacent to the Atlantic Ocean and the Indian and Banana Rivers. The average annual temperature at CCAS is 22 ºC (71 ºF). Average monthly temperatures range from 16 ºC (60 ºF) during January to 27 ºC (81 ºF) during July. 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 one in twenty. [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 and freezing in the region are rare. Temperature inversions are infrequent, occurring approximately two percent of the time. [USAF 1994]

Summer weather typically lasts about nine months of the year, starting in April. The Cape Canaveral area has the highest number of thunderstorms in the United States, and one of the highest frequencies of occurrence in the world during the summer. On average, thunderstorms occur 76 days per year at Cape Canaveral, commonly in the afternoon 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] Rainfall distribution is seasonal, with a wet season occurring from May to October, while the remainder of the year is relatively dry. Average annual rainfall for CCAS is 48.5 inches, seventy percent of which occurs from May through October at the rate of approximately five inches per month. [USAF 1994]

The wind rose in Figure 3-5 shows the annual average frequency distribution of average wind speed and direction in the vicinity of CCAS. 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 due to a predominant easterly sea breeze, (Figure 3-5). CCAS is located in the federally defined Central Florida Intrastate Air Quality Control Region (AQCR 48), which is classified by the EPA as an attainment area for all of the criteria pollutants. There are no Class I or nonattainment areas for criteria pollutants (ozone [O_3], nitrogen oxides [NO_x], sulfur dioxide [SO_2], lead [Pb], carbon monoxide [CO], and particulates) 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]

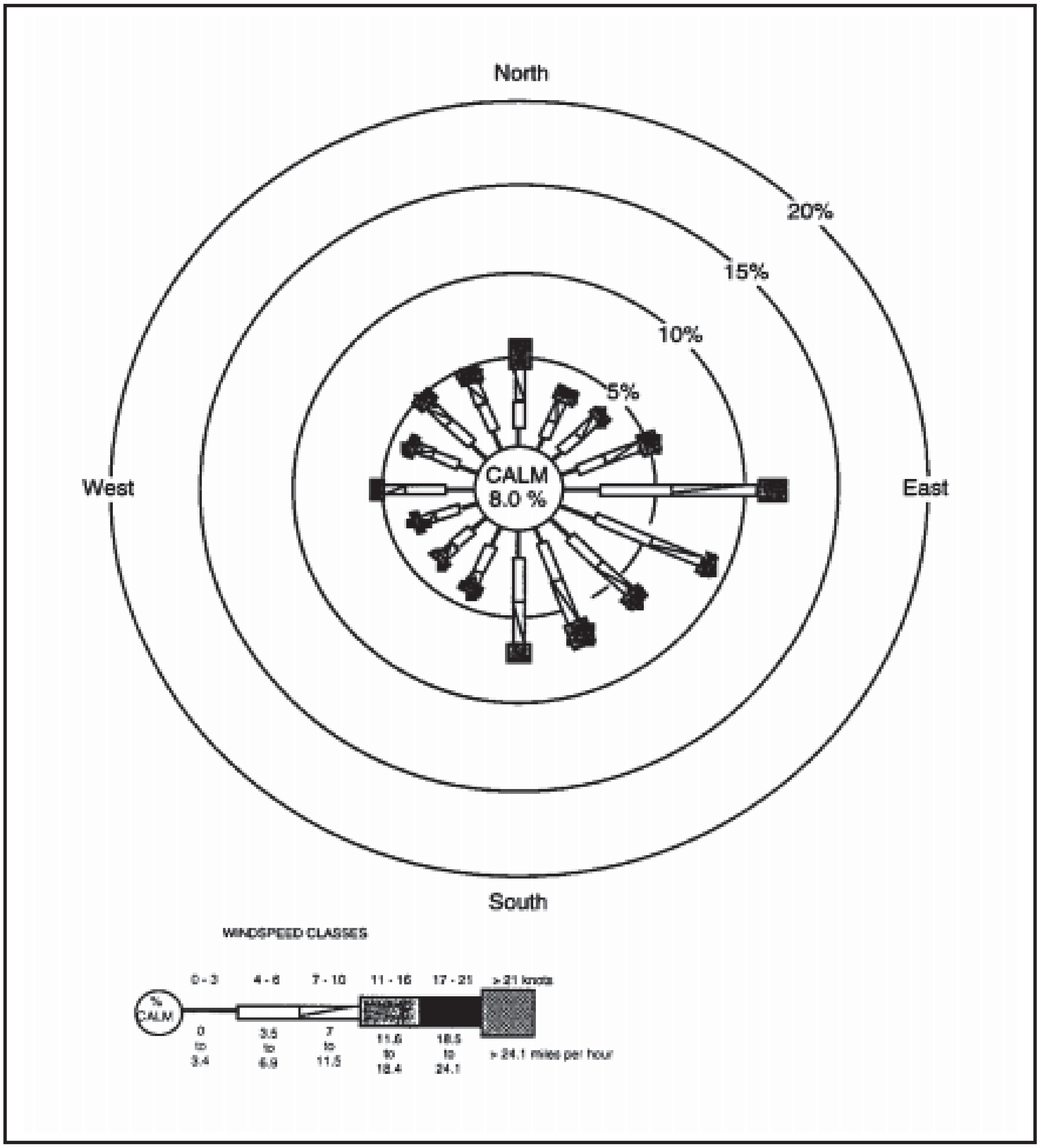
The station and its vicinity are considered to be "in attainment" or "unclassifiable" with respect to National Ambient Air Quality Standards (NAAQS) for criteria pollutants. [USAF 1990] The criteria pollutants and the federal and state standards are listed in Table 3-1. NAAQ primary and secondary standards apply to continuously emitting sources, while a launch is

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.



Source: [USAF 1990]

Figure 3-5. Wind Rose Indicating Wind Speed and Direction — Lower Atmospheric Conditions: Cape Canaveral 1968 - 1978 Annual Averages 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 1996-C]

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]

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 1995-C]

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 1996-C] Some launch vehicle related noise levels measured at KSC are shown in Table 3-2.

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]

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]

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 Hawthorn 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 meters (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 Resource 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. 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. The North Banana River is a sanctuary for the endangered manatee.

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 (232 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 (kph) (1 to 3 miles per hour [mph]). Beyond about 26 km (16 mi), 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 seven sites. Other monitoring stations in the general area are maintained by Brevard County, the U.S. Fish and Wildlife Service, and the 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, USAF 1994]

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 Floridan Aquifer.

This unconfined surficial aquifer 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 typically 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]

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.

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

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 1996-C]

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.

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.

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*)		FT	T	T	O
Piping plover (*Charadrius melodus*)	X	FT	T	SSC	O
Arctic peregrine falcon (*Falco peregrinus tundrius*)		FT	T	E	O
Southeastern American kestrel (*Falco Sparverius paulus*)		UR2	T	T	O
Bald eagle (*Haliaeetus leucocephalus*)	X	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*)				T-FDA	N/O
Prickly pear cactus (*Opuntia stricta*)	X			T-FDA	O
Beach star (*Remirea maritima*)	X			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.

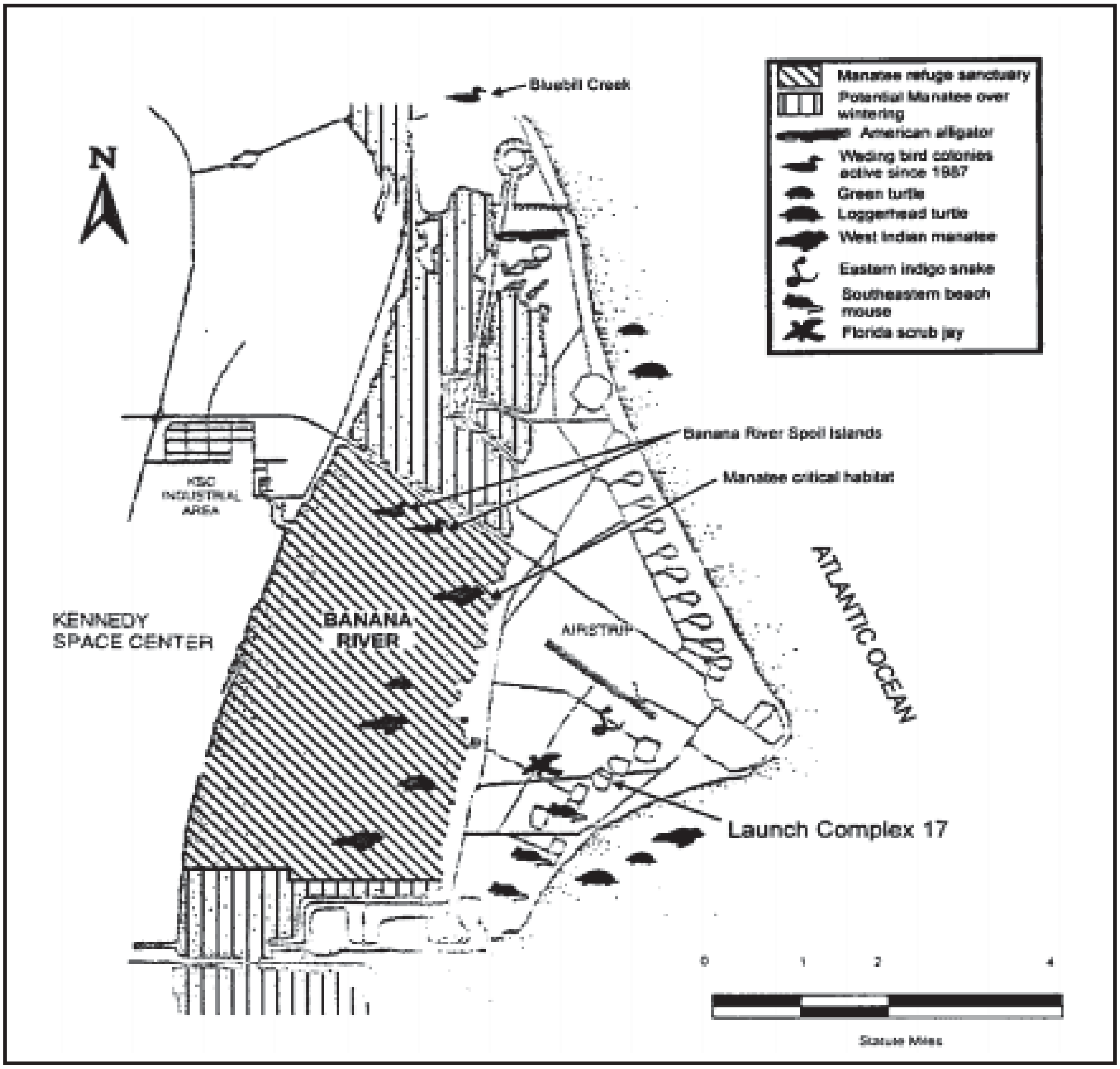
SPECIES Candidate Species	Potential Occurrence[a] LC-17	STATUS[b] Federal USFWS	State FGFWFC	Other[c] FCREPA	Cape Canaveral
REPTILES/AMPHIBIANS					
Gopher tortoise (*Gopherus polyphemus*)	X	UR2	SSC	T	O
Gopher frog (*Rana areolata*)		UR2	SSC		N/O
BIRDS					
Roseate spoonbill (*Ajaia ajaja*)			SSC		O
Snowy egret (*Egretta thula*)			SSC		O
Louisiana heron (*Egretta tricolor*)			SSC		O
Little blue heron (*Florida oaerules*)			SSC		O
American oyster catcher (*Haematopus palliatus*)	X		SSC		O
Osprey (*Pandion haliaetus*)	X		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 1995-C], [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



Source: [JPL 1996-D]

Figure 3-6 Potential Occurrence of Threatened or Endangered Species Near LC-17

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SECTION 4

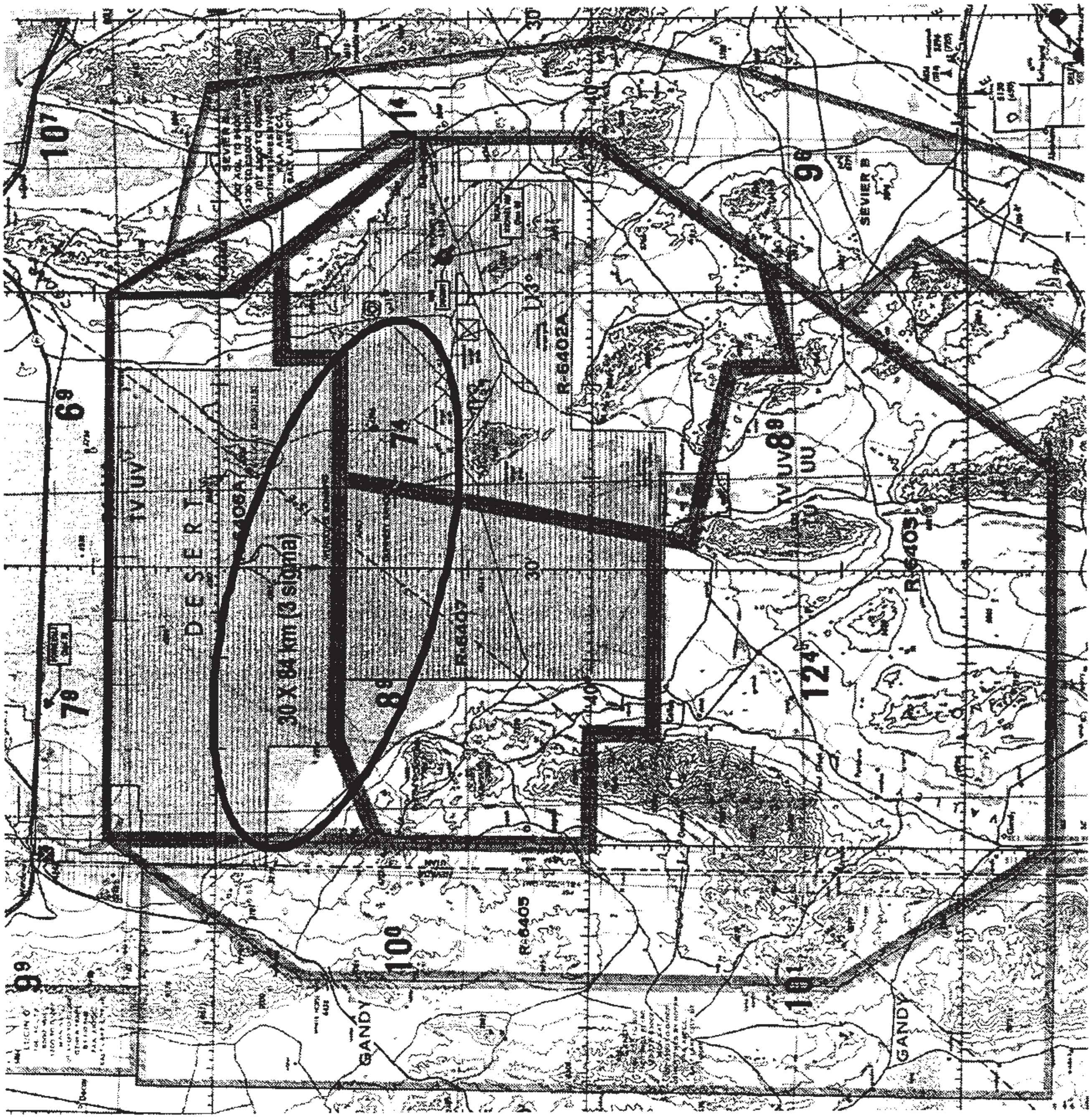
GENERAL ENVIRONMENTAL CHARACTERISTICS OF UTAH TEST AND TRAINING RANGE AND SURROUNDING AREA

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, as well as for discussion of Utah State Environmental regulations, required permits, and facilities issues. The level of detail provided herein is commensurate with the potential for impacts from the proposed action and alternatives. This document relies heavily on the following references: Final Environmental Assessment, Comet Space Vehicle Retrieval at the Utah Test and Training Range, [USAF 1993]; Environmental Impact Statement for Commercial Reentry Vehicles [DOT 1992]; and for in-depth information on UTTR and the surrounding area, the reader is referred to the Final Range Management Plan for the Hill Air Force Range and Wendover Air Force Range of the Utah Test and Training Range, dated 4 December 1996. [USAF 1996-A]

4.1 REGIONAL AND LOCAL ENVIRONMENT [USAF 1993, USAF 1996-A]

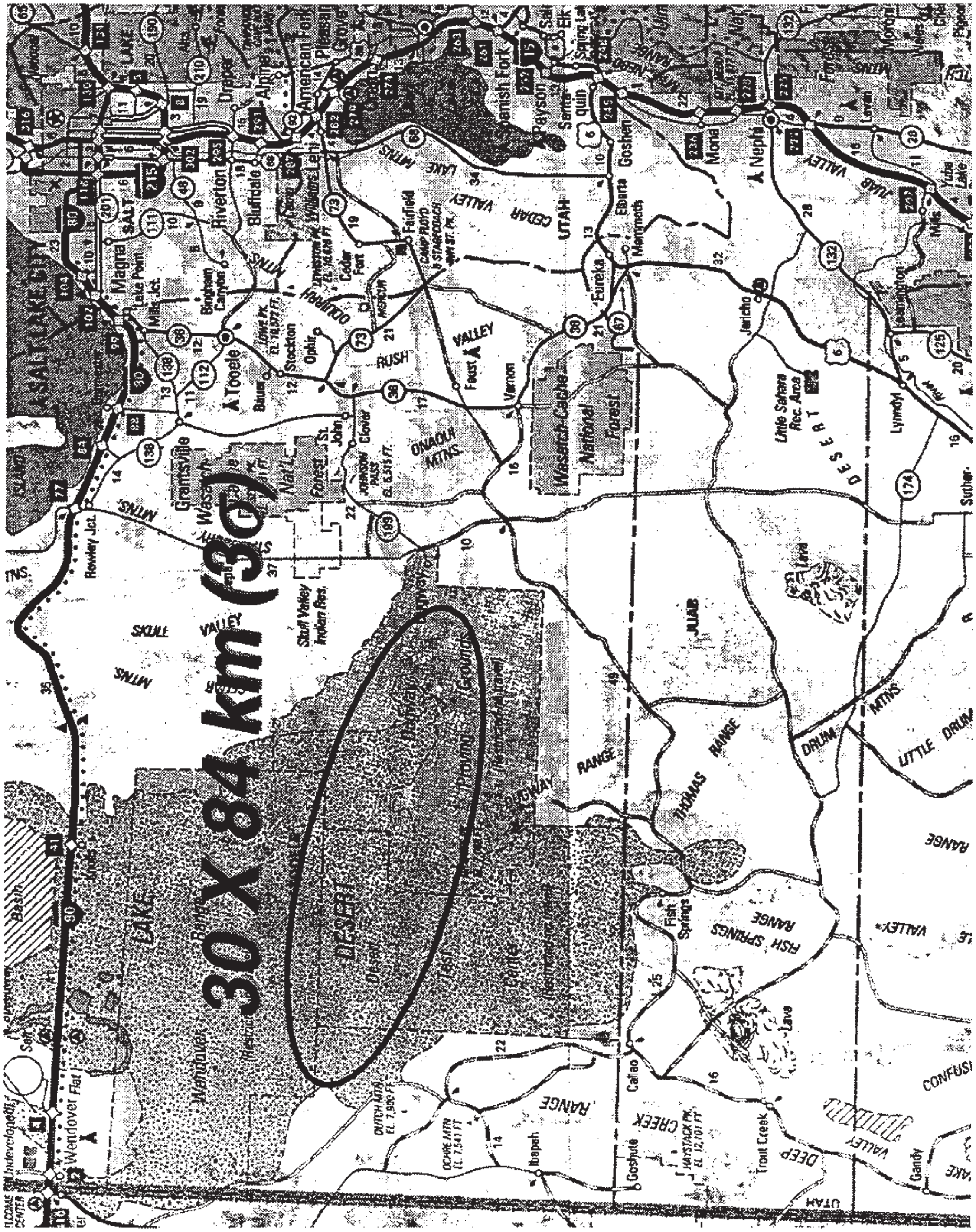
Utah Test and Training Range (UTTR) is in Northwestern Utah, between the Great Salt Lake and eastern Nevada, and covers an area approximately 338 km (210 mi) long and 161 km (100 mi) wide. Formerly called the Ogden Air Logistics Center (ALC) Test Range, UTTR is composed of both airspace and ground withdrawn from public use by the U.S. Department of Defense (DOD). It consists primarily of special-use airspace designated for military flight activities. The special-use airspace includes restricted areas, generally reaching to a height of 17.7 km (58,000 ft) mean sea level (MSL), and military operations areas (MOAs) varying in height from 2 km (6,500 ft) MSL up to, but not including 5.5 km (18,000 ft) MSL. Strictly defined, North UTTR (NUTTR) and South (SUTTR) refer to the UTTR airspace north and south of Interstate Highway 80 between Salt Lake City and eastern Nevada and above the UTTR ground components managed by the U.S. Air Force (USAF or AF), as well as above Dugway Proving Ground (DPG), (managed by the U.S. Army), other nearby public lands (primarily managed by the Department of the Interior’s Bureau of Land Management [BLM]. A supersonic operating area overlies a portion of the South Range restricted area and MOAs where the proposed Stardust recovery area is located (Figures 4-1 through 4-3).

A portion of UTTR includes lands owned by the USAF and the US Army. The remainder of the land underlying the special-use airspace consists of public land administered by the BLM, and the U.S. Fish and Wildlife Service, the State of Utah, the State of Nevada, the Goshute Nation, the Skull Valley Band of Goshutes, and numerous private holdings. The land within the Region of Interest (ROI) for the proposed Stardust mission footprint is that mostly controlled by DOD. An extremely small section of land is controlled by the BLM.



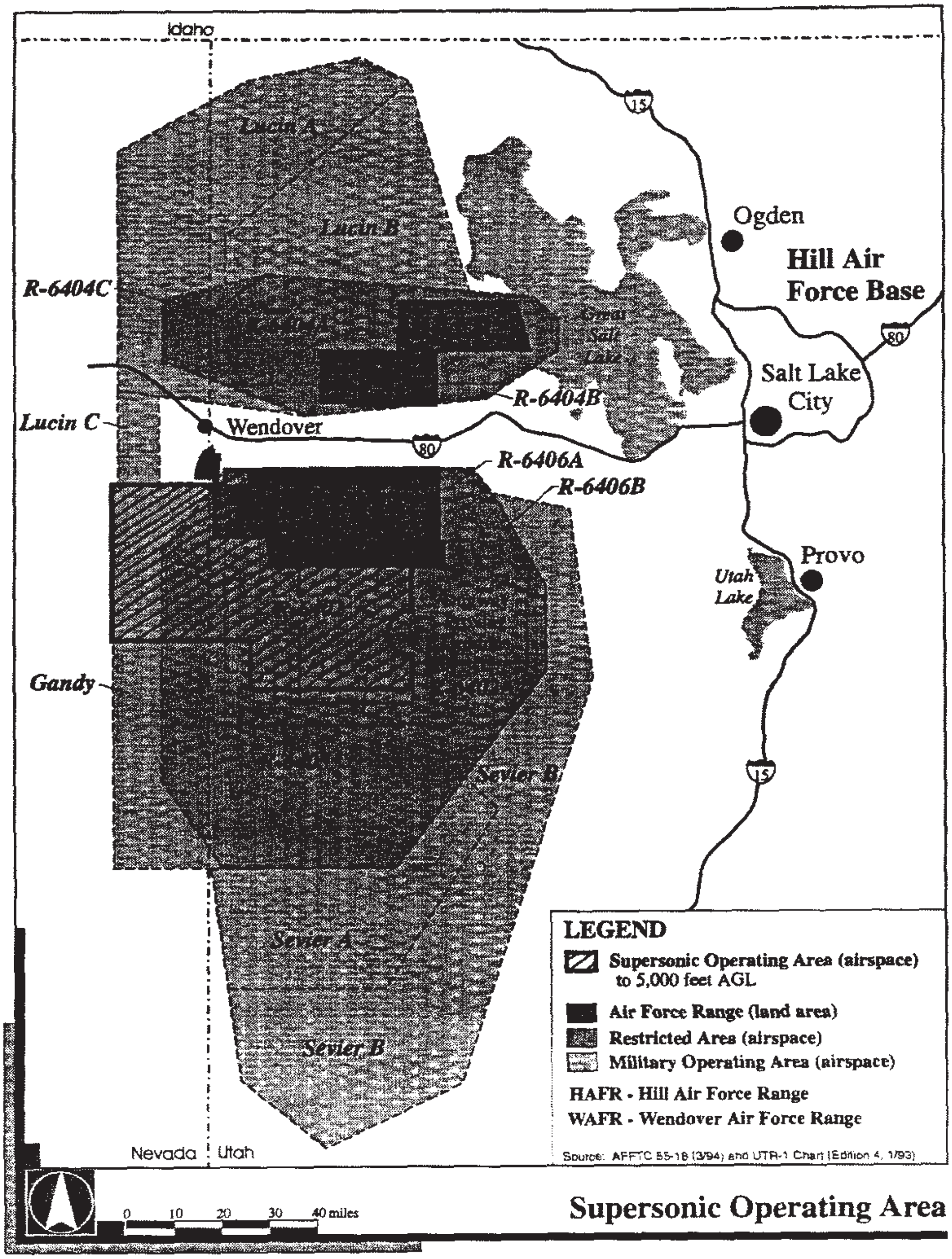
Source: [JPL 1997-D]

Figure 4-1. UTTR with Proposed 3-Sigma Landing Footprint Superimposed



Source: [JPL 1997-D]

Figure 4-2. Location of UTTR Relative to Region of Interest - Stardust Recovery Footprint Superimposed



Source: [USAF 1996-A]

Figure 4-3. UTTR Supersonic Operating Area

Since World War II, the UTTR area has been used for military training and bombing. The North Range, previously known as Hill Air Force Range (HAFR), was consolidated with Wendover Bombing Range in the South Range to form UTTR. At the present time, UTTR supports a variety of Air Force test and training missions, including ordnance testing, air-to-ground training, air-to-air combat training, and laser targeting. Dugway Proving Ground underlying a portion of the South Range (which includes Wendover Air Force Range [WAFR]), supports a variety of Army activities, including artillery training and testing of obscurants. The safety zone area (i.e., 3-sigma landing footprint) identified for the proposed action includes the Wildcat/Kittycat air-to-ground target complex, ordnance emergency jettison/salvo area, emergency fuel dump area, and laser training targets.

UTTR has unique characteristics, such as its large size and therefore, large safety footprint; its somewhat simplistic ecosystems and therefore, relatively diminished environmental resources to sustain impacts from range activities; and its isolation from population centers and therefore, avoidance of public annoyance and safety concerns. In this age of military base closures, it is considered extremely unlikely that all current activities would be transferred from UTTR.

4.1.1 POPULATION DISTRIBUTION

There is no civilian population within the proposed Stardust recovery area. The nearest populated areas are Wendover to the northwest, Goshute and Callao to the southwest, and Dugway to the east. A total of 1,761 people live on Dugway in 471 households. Nine hundred seventy-seven of those work on the base, 418 work for the federal government, 210 work for private companies, and the remainder work for local or state Governments or are self-employed. There are 443 children between the ages of 3 and 17 enrolled in schools on the base. [NASA 1997-B] Dugway is located in Tooele County, which has a total resident population (as of 1995) of 29,263 people. The civilian labor force is 12,515 people, and the unemployment rate is 4.8 percent. Personal per capita income is just over $15,000. [NASA 1997-B]

Other settlements in the area include a number of small communities near NUTTR. Although official census estimates are unavailable, population estimates are as follows: Park Valley (200), Grouse Creek (175), Lin (10), Etna (15), Montello (200), Oasis (west of Wendover, 400-500). Near SUTTR are Ibapah (100), the Goshute Indian Reservation (100), Gold Hill (12), Callao (50), Trout Creek (35), Partoun (200), Gandy (4), Pleasant Valley (also known as Uvada, 25), and Eskdale (utopian community, 300). There is a remote repair site for the railroad near Lakeside, therefore, on any given night, there might be up to twenty railroad people staying there for the night. Several ranches and agricultural and mining operations may be found near these small communities. (See Figure 4-2.)

4.1.2 LAND USE [USAF 1993, USAF 1996-A]

The majority of lands within the WAFR and HAFR boundaries are mud flats and sand dunes. Approximately 98 percent of the total land base in the ranges is unimproved. WAFR includes lands west of the Cedar Mountains, north of Dugway, and generally east of the Utah-Nevada state line. This range is mostly salt flats, which are almost completely devoid of rocks, soil, or plant life. There are no permanently staffed facilities on WAFR. An irregularly shaped, contiguous property parcel is attached to the main WAFR property, immediately adjacent to Wendover and extending into NV. This parcel includes facilities that were historically part of Wendover Field, an installation that was extensively used during World War II, as well as Wendover Air Field, which was quit claim deeded to the City of Wendover in 1977. The airfield has two runways and is still available for both military and commercial use; however, there are no repair or hanger facilities available. [USAF 1996-A]

Dugway Proving Grounds consists of a total of 803,000 acres (3,264 sq km, 1256 sq mi), 300 acres (1.21 sq km, 0.47 sq mi) of which are improved land, 536 acres (2.17 sq km, 0.84 sq mi) of semi-improved land, and the remaining acreage is unimproved. The primary mission of the facility is to research, develop, test, and evaluate chemical warfare and biological defense systems; as well as flame, incendiary, and smoke obscurant systems. Dugway is also used extensively for a wide variety of training programs. Michael Army Airfield (MAA) is an active facility used daily for numerous landings and takeoffs by aircraft as large as or exceeding the size of a Boeing 747. The airfield is also designated as an auxiliary landing facility for the Space Shuttle should conditions at all primary landing areas be unusable when the Space Shuttle must return. [NASA 1997-B]

The lands adjacent to UTTR are owned by federal, state, and tribal governments and by private individuals. They have only limited economic resources and their attractions are not readily accessible to the public. They are used to a limited extent for commercial and residential purposes and for recreation, and are supported by a limited infrastructure. Land uses include cattle and sheep grazing, mining, and recreation. The proposed recovery area (ROI) (oval in Figures 4-1 and 4-2) comprises DOD land used for military testing and training activities. The land base of HAFR and WAFR is approximately 928,000 acres (3,756 sq km, 1450 sq mi) (HAFR has 351,539 acres [1,422 sq km, 549 sq mi]; WAFR has 576,157 acres [2,331 sq km, 900 sq mi]). WAFR shares approximately 48 km (30 mi) of common boundary with DPG, which is managed by the Army. Together with DPG, these land areas comprise over 1,700,000 acres (6,879 sq km, 2,656 sq mi), while the air space of UTTR occupies approximately 3,000,000 acres (12,141 sq km, 4,688 sq mi). No grazing occurs on DOD land in the range.

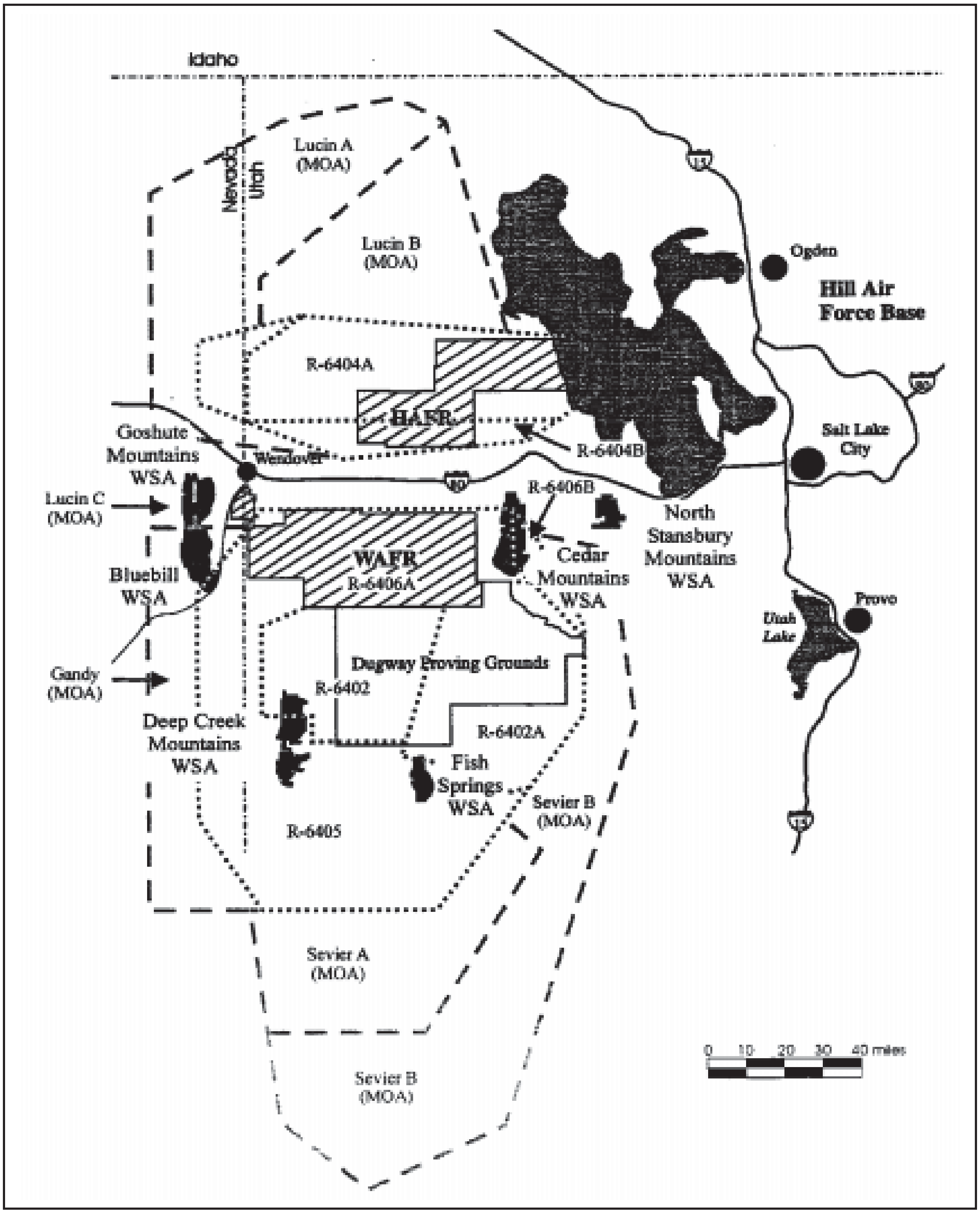
BLM lands in the vicinity of HAFR and WAFR are managed for multiple use, as directed under the Federal Land Policy and Management Act of 1976. These uses include livestock grazing, support of wildlife, dispersed and developed recreation, and mining.

Eleven parcels of federal land within Utah and within the vicinity of UTTR have been identified as Wilderness Study Areas (WSAs) for potential inclusion in the National Wilderness Preservation System. Of the 11 WSAs in the West-Central region, the 50,500-acre Cedar Mountains area approximately 8 km (5 mi) east of WAFR, the 52,500-acre Fish Springs area approximately 55 km (34 mi) south of WAFR, and the 68,910-acre Deep Creek Mountains area approximately 29 km (18 mi) south of WAFR are the closest to WAFR and are within the UTTR airspace. The Swasey Mountain, Howell Peak, Conger Mountain, Notch Peak, King Top and Wah Wah Mountain WSAs are also all within the UTTR airspace. The closest WSAs in Nevada, the Goshute Mountains WSA and Bluebell WSA, are about 97 km (60 mi) north of Ely in the Cherry Creek Mountain portion of the Egan Range, and less than 3.2 km (2 mi) west of WAFR. Other nearby areas, which were considered as WSAs in the West-Central Regional Study Group, but did not meet all of the wilderness characteristics criteria, also exhibit many wilderness qualities. These areas include the Newfoundland Mountains, the North Salt Desert, Big Creek, Dry Canyon, Big Hollow, the Onaqui Mountains, north Cedar Mountains, the Silver Island Mountains, the Dugway Mountains, and areas partially in Nevada, such as Ferber Flat (Figure 4-4).

The State of Utah owns four sections of land, each one square mile, or 640 acres. These are within most of the townships of public land (BLM) in west-central Utah. These sections are known as state school lands, and they are managed by the State for the benefit of the State's public schools. In general, these sections are offered, mostly through leases, for enterprises (e.g., mining, forestry) to generate income for the State's schools. While there were state school trust inholdings on HAFR and WAFR at one time, all of the inholdings have been acquired by DOD and there are currently no school trust inholdings within the ranges. In addition, there are some State lands adjacent to the Great Salt Lake near the eastern boundary of HAFR.

In the immediate vicinity of UTTR there is little industrial, commercial, or residential development. Some industrial uses on lands adjacent to the ranges include minerals extraction and processing, mining, landfills/waste incineration, and brine shrimp collection. Mining activity occurs just south of DOD lands, and current operations include gold, silver, barite, fluospar, and beryllium. Solid waste landfill and waste incineration facilities and a low-level nuclear waste landfill are located between HAFR and WAFR along the I-80 corridor. There are currently no producing oil or gas fields or wells in the area, and exploration activity has been sporadic.

The only significant commercial development in the immediate vicinity of UTTR is at Wendover. Casinos, hotels and motels, service stations, stores, recreational vehicle camps, and related tourist facilities are found there. Wendover is divided by the Utah-Nevada state line into Wendover, Utah (population 1,127) and West Wendover, Nevada (NV) (population 2,007); gambling is allowed in West Wendover. The city is mostly known for its casinos and entertainment, and much of the trade and economic activity is related to gambling.



Source: [USAF 1996-A]

Figure 4-4. Wilderness Study Areas Nearest UTTR

4.1.2.1 Recreation

Recreation on lands adjacent to and near UTTR boundaries is generally associated with the mountain ranges, springs, and seeps in the basin. The Deep Creek Mountain range, and the associated Deep Creek Mountains Wilderness Study Area, are administered by the BLM, but little has been done to facilitate recreationists. To date, there are no improvements. There are only five miles of trail in the entire range, and none of those five miles is maintained. There are no primitive or developed campgrounds, very few dirt roads to the base of the mountain, and no four-wheel drive vehicles are allowed access. The Knolls is a BLM recreational area along the north boundary of WAFR. Some encroachment of all-terrain vehicles from this area into the range occurs. There have been no major conflicts regarding the use of UTTR for recreational activities because the range is remote, the nearby population is sparse, and there are large tracts of nearby land available for public access. Specific areas that are popular for outdoor recreation, such as the Blue Lake area on the western edge of WAFR, have been separated out of the range boundaries and made available for public recreational activities. In general, however, UTTR lands have been closed to public use for decades.

Some livestock grazing occurs on adjacent BLM lands, and some roads on HAFR are used for access to these grazing allotments. No grazing, except for this limited-access use, is permitted within the range boundaries. Cattle and sheep are grazed over much of the public land in the vicinity of UTTR.

The Bonneville Salt Flats in Tooele County are also managed by the BLM. This area is internationally renown as a speedway, and numerous land speed records have been set here. The Salt Flats are found approximately nine miles southwest of HAFR (the race track extends even closer), and are accessed from I-80.

Hunting is a popular recreational activity in Utah, and the mountains near UTTR, such as the Stansbury and Cedar Mountains, are used very often by hunters during the October hunting season. In addition, the marshes, sloughs, and wetlands near the Great Salt Lake and the boundaries of HAFR offer opportunities to waterfowl hunters. Some upland game bird hunting may also occur near the outer fringes of the area, but this use is probably minimal. Hunting visitation for Fish Springs Northwest Reserve this past season was approximately 1200 visits. Recreational visitation to the Stansbury and Deep Creek Mountain ranges and to Fish Springs would be in excess of 5,000 visits annually.

4.1.2.2 Infrastructure

The Salt Lake City metropolitan area is the largest populated area in the region. Denver, Colorado, is about 805 km (500 mi) east; Las Vegas, NV, is about 966 km (600 mi) south, and Boise, Idaho, is nearly 644 km (400 mi) northwest of UTTR. The Salt Lake International Airport is about 81 km (50 mi) east (by air) from the eastern boundary of HAFR. Several transportation corridors are in the area, including two railroad corridors: the Southern Pacific Lucin Cutoff railway route approaches within 5 km (3 mi) of the northern boundary of HAFR near the Lakeside Mountains, and the Western Pacific railway right-of-way about 10 km (6 mi) north of and parallel to the northern boundary of WAFR. Several county roads afford public access to BLM lands and other areas in the west desert and Great Salt Lake in the vicinity of UTTR. U.S. Highway 93 near Wendover, NV, is near the western boundary of WAFR.

The main access route to both HAFR and WAFR is I-80. On both of these ranges, improved access routes are generally utilitarian and associated with specific, frequent activities. Therefore, access is good in the eastern portion of HAFR. Primarily access is provided by a county road that runs parallel to the west side of the Lakeside Mountains and across HAFR lands and connects to a network of improved roads that link facilities in this area.

Elsewhere on the ranges, ground vehicular access is difficult because the area is isolated and undeveloped, the environment is harsh, and there has been a long-term policy of limiting public access. On the Western side of the range, access is via Nevada State Highway 93A and then county roads through BLM land to the WAFR boundary. Some of the county roads that pass through BLM lands in this area follow an abandoned railroad grade. Much of the perimeter of the range is fenced. While an unimproved road runs parallel to much of the fence line, locked gates on the roads that lead into the ranges prevent unauthorized entry.

Minimal information regarding the use of fuels and utilities by WAFR and HAFR is available. When the West Desert Pumps, found just north of HAFR, were built in 1987, a natural gas line was installed. Because of the proximity of this line to existing facilities, natural gas was provided to Oasis, and HAFR is in the process of converting some of their utility use at Oasis to natural gas. In addition, a generator station that currently uses diesel fuel, is located on the west side of the WAFR/Dugway boundary road. It provides power to the Sand Island Target Complex.

Electrical power for DPG comes solely from Utah Power and Light Company in Salt Lake City and is routed from the Tooele-Stockton Distribution Center. Transmission is over a single set of aboveground lines for 110 km (68 mi). DPG consumes less than one percent of Utah's power and light annual production. [NASA 1997-B]

The DPG telephone system is owned and operated by the Division of Information Management, Dugway, and connects with U.S. West Communications. There are 24 two-way circuits to Salt Lake City, 24 two-way circuits to Tooele, and commercial long distance. There are also 17 Defense Switch Network (DSN) circuits which provide direct official communications with DSN subscribers (both CONUS and OCONUS) and 10 FTS-2000 circuits with ISDN PRI capability. [NASA 1997-B]

Heat is primarily supplied to DPG with No. 2 fuel oil, although Nos. 5 and 6 fuel oils are used if there is a critical shortage of No. 2. Propane is used to ignite oil-fired boilers, heat some residences in English Village, and heat remote trailers. Generators and heavy duty vehicles are run with diesel fuel. [NASA 1997-B]

4.1.2.3 Regional Socioeconomics

While UTTR is fairly isolated, on-site activities do affect the economies of nearby counties. The presence of Hill Air Force Base (HAFB) and supporting facilities, including UTTR, has a dramatic socioeconomic effect on the Wasatch Front specifically, and on Utah as a whole. Because UTTR is an integral part of HAFB operations, a brief synopsis of the HAFB influence on the UTTR setting is provided here. While the impact of Dugway Proving Ground to the Utah economy is not nearly as substantial as is HAFB, it contributes significantly to Tooele County, which contains most of DPG and WAFR.

In 1990, HAFB was the largest employer in Utah, retaining approximately 5,000 military personnel and approximately 14,000 civilian personnel. The civilian workforce is primarily recruited from schools, colleges, and the general Wasatch Front population. The remainder are civil service or other civilian employees. The annual payroll generated by HAFB is estimated to be $602,149,511 and local contracts inject more than $1.5 billion into Utah's economy. [USAF 1996-A] These wages are distributed throughout the community through local purchases of goods and services, state and local tax revenues, and personal individual contributions of time, money, and resources to the community at large. Other socioeconomic effects include the presence of retirees in the community and the multistate regional service that HAFB facilities provide.

Many of the civilian and military personnel who spent all or part of their careers at HAFB retire in the area. Estimates in 1990 placed approximately 20,000 civilian and an additional 8,000 military retirees in Utah. About half of the military retirees are estimated to reside in the economic zone of HAFB; the remainder reside in various locations throughout the state. One of the attractions for military retirees is HAFB, which includes amenities such as a base exchange, commissary, clubs, medical facilities, and golf course. Another of the many services HAFB provides to military personnel, their dependents, and military retirees is health care through an on-base hospital. The service area for this hospital includes Utah and parts of Idaho, Nevada, and Wyoming.

The HAFB runway is one of the busiest runway operations in the Air Force and is the busiest air traffic control tower in the Air Force Logistics Command (AFLC). Runway facilities there can serve almost every type of aircraft in the Air Force Inventory. A substantial number of the planes using the HAFB runways are headed for UTTR.

4.1.2.4 Environmental Justice

UTTR is also under the jurisdiction of the Air Force and as such falls under its policies for environmental justice. Please refer to section 3.1.4 for a discussion of this topic.

4.1.3 HEALTH AND SAFETY [USAF 1993]

The primary safety issues related to the proposed recovery area concern activities at UTTR which may pose a hazard to aircraft or ground parties. These include military aircraft operations, ordnance use, and hazardous materials contained at DPG.

4.1.3.1 Military Aircraft Operations and Ordnance Use

Hazardous military aircraft activity at UTTR is separated from civil aircraft through the designation of restricted airspace areas. These areas are under the control of UTTR air traffic control (Clover Control). Nonparticipating aircraft are restricted from flight through these areas during active periods unless clearance has been obtained from Clover Control. The proposed Stardust recovery area would be within restricted area R-6406A and sectors L, W, and 6. Use of this airspace must be scheduled through a Range Squadron within the 388th Fighter Wing.

Michael Army Airfield is currently an active military flightline with numerous military landings and departures daily. A comprehensive occupations and flight safety program managed by DPG is in place to ensure operations are conducted in a safe manner and risks are minimized. Hill AFB near Salt Lake City controls the airspace and is responsible for range safety on UTTR. There is presently sufficient fire protection and crash rescue capability at the airfield. Medical treatment is provided on Dugway by a limited medical clinic. More extensive health care services are provided by the Hill AFB Hospital approximately 161 km (100 mi) away; hospitals in Tooele, Utah, approximately 69 km (43 mi) away, and Salt Lake City approximately 137 km (85 mi) away. [NASA 1997-B]

The only proximity hazard to vehicle operations is the Carr Facility, a chemical research laboratory located 1.0 km (0.6mi) south southeast from the runway. This lab is designated a no flyover area, and is not within the Stardust 3-sigma footprint. [USAF 1996-A]

The proposed Stardust safety zone (3-sigma footprint) contains the Wildcat and Kittycat target complexes. High explosives are delivered at Kittycat. Wildcat is used only for inert weapons. Test targets TS-1, TS-2, and TS-4 lie along the southeastern edge of the safety zone. [USAF 1996-A]

4.1.3.2 Hazardous Materials and Hazardous Waste [NASA 1997-B]

Petroleum products are stored and handled in compliance with Dugway Standing Operating Procedures and Army Regulations. There are 131 tanks of No. 2 fuel oil with a total capacity of 4.2 million liter (l) (1.1 million gallon [gal]) and 125 propane tanks. The four largest tanks have a capacity of 3.775 l (997 gal) each, and the remaining have capacities of approximately 87 l (23 gal) each. Seven large petroleum storage tanks are above ground and are diked to contain a total spill. Petroleum storage facilities, with the exception of three automobile gasoline tanks at the Post Exchange station, are the responsibility of the Public Works Directorate.

Other hazardous materials at DPG include boiler blowdown chemicals (caustic soda, phosphate, and tannin), chlorine used for water treatment, pesticides, and polychlorinated biphenyls. Chemical surety materials and critical binary compounds are stored within the Carr Facility Chemical Exclusion Area. These materials include chemical agents used for test activities and unserviceable chemical munitions awaiting demilitarization.

Dugway also holds limited amounts of radioactive waste in containers stored in the East Granite Holding Area. A storage site approved by the Nuclear Regulatory Commission is not readily available. The holding area is approximately 161 acres (0.65 sq km, 0.25 sq mi) and is bounded on three sides by steep canyon walls rising 20 to 30 m (66 to 98 ft) above the canyon floor. The fourth side is cordoned off by a security fence.

Stock cultures of infectious biological agents and some toxic byproducts are stored in Building 2028 for laboratory research on biological defense and epizoological studies. These materials are stored and handled in accordance with appropriate Standard Operating Procedures for these types of materials.

Dugway Proving Grounds is classified as a large quantity hazardous waste generator (more than 1,000 kg/month [2,200 lb/month]) under the provision of the Utah Waste Management Rules. Management of hazardous wastes generated at DPG is administered by the Federal Directorate of Environmental Programs (FDEP) under the direct supervision of the installation commander. All hazardous waste generated or managed by activities on DPG is subject to and managed to achieve compliance with the Resource Conservation and Recovery Act (RCRA) of 1976, and the Hazardous and Solid Waste Amendments of 1984, as administered by the U.S. EPA, the State of Utah Department of Environmental Quality (DEQ) hazardous waste management rules, U.S. Army Regulations 200-1 and 420-74, and all other pertinent federal, state, and local laws, and Department of the Army regulations.

The Dugway Proving Ground Hazardous Waste Management Plan, completed in August 1996, prescribes policies, responsibilities, and procedures for management of hazardous wastes on Dugway. The types, quantities, and intended users of all hazardous materials that enter the installation are identified and tracked by the Compliance (Safety) Office to determine which materials are converted to hazardous waste in order to aid in their management in accordance with all applicable regulations. Material safety data sheets documenting handling and disposal information for the hazardous materials are provided and maintained in master files by the Compliance Office.

Dugway Proving Grounds presently operates two hazardous storage facilities, the Central Hazardous Waste Storage Facility located west of Fries Park, and Igloo G located in the Carr Facility. There is one hazardous waste treatment facility (the OB/OD) area, and 42 miscellaneous hazardous waste management units. These facilities and units would manage hazardous waste under Dugway's single, installation-wide RCRA permit issued by the Utah DEQ on 15 March 1994, once permit modification applications are approved.

4.1.4 CULTURAL RESOURCES [USAF 1993, USAF 1996]

A wide range of prehistoric, historic, and paleontological resources occur on and near UTTR. Cultural resource surveys have resulted in the identification of more than 130 archeological sites within 30 miles of the HAFR and WAFR boundaries. Only since 1991 have HAFR and WAFR themselves been subject to any large-scale, stratified surveys. To date, these intense, pedestrian surveys have covered 25 percent of the ranges. Seven of these higher-density areas have been recommended for nomination as National Register Districts (NRDs). All archeological sites located within an established NRD are considered contributing to that district and are therefore eligible for listing on the National Register of Historic Places (NRHP). Of the open sites located outside the boundaries of a NRD, it is likely that only those with recognizable features, diagnostic artifacts, or buried deposits will be considered eligible for inclusion on the NRHP. Proposed actions occurring within these NRDs will trigger evaluations even though they have already been surveyed. Most of the land within these districts contains no or very few resources and restricted development should be possible. Both the Wildcat and Kittycat ranges contain numerous cultural resource sites. However, most of UTTR, which consists of mud and salt flats or relatively recent eolian deposits, has virtually no potential for paleontological resources. The proposed Stardust recovery location (ROI) is in an area considered to have low potential for archaeological resources. Resources of importance to American Indians are generally coincident with high sensitivity archaeological areas.

The visual resources of the lands comprising and adjacent to UTTR are typical of the Great Salt Lake Desert. They are characterized by isolation, remoteness, expansive open space, and dramatic basin and range landforms.

4.2 NATURAL ENVIRONMENT [USAF 1993]

4.2.1 AIR QUALITY

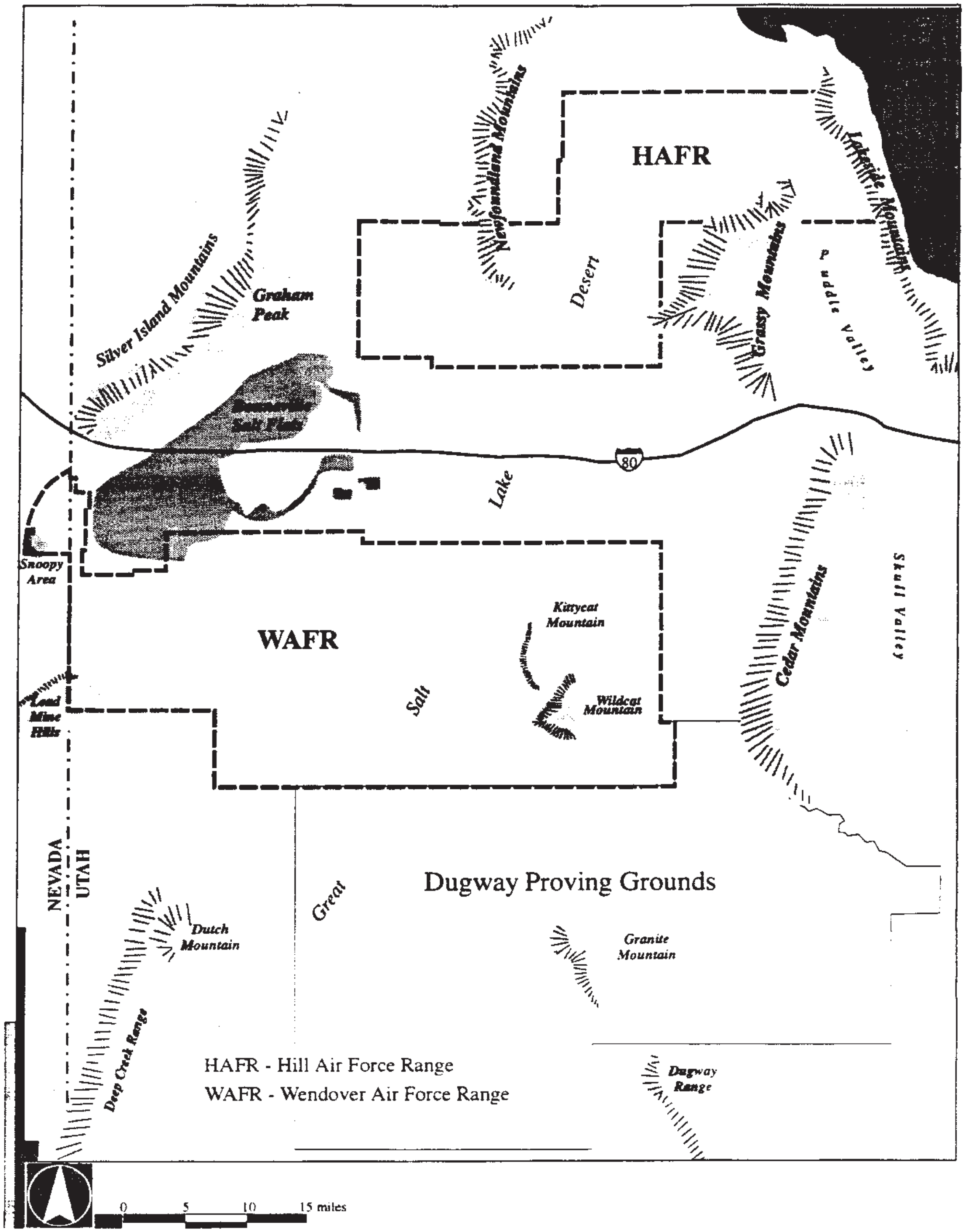
The proposed area in the UTTR South Range is located in Tooele County. Tooele County is considered to be in attainment in that it meets the NAAQS for all pollutants regulated by the Clean Air Act (CAA) and the Utah Air Conservation Act, with the exception of sulfur dioxide (SO_2). Portions of Tooele County are in nonattainment for SO_2 primarily due to emissions from the Kennecott Corporation copper smelter near Magna.

Regulations pursuant to the CAA establish air quality levels for Prevention of Significant Deterioration (PSD) in various classes of areas. Class I, or pristine, areas are the most restrictive and include national parks and wilderness areas. All other areas in the U.S. are classified as Class II. Section 169A of the CAA states that it is a national goal to prevent any further impairment of visibility in Class I areas. The nearest Class I area to the proposed recovery site is the Great Basin National Park, which is more than 161 km 100 mi) from the proposed impact area.

4.2.2 NOISE

Noise sources on UTTR include vehicle usage, military exercise, aircraft overflights and related support activities. Aircraft noise is prevalent throughout UTTR, and is the most significant source. Depending on the type of aircraft and mission, a wide range of noise levels (frequencies and loudness) can be generated, including sonic booms generated by supersonic flights (flights with maximum speeds of Mach 1 to 5). Approximately 15,000 aircraft movements were recorded in the area of the proposed action in fiscal year (FY) 1992. Average onset-adjusted day-night sound levels (Ldnmr) in the South Range are estimated to range from 50 to 64 decibels (dBA) over most of the range. Isolated areas, primarily over target complexes, are exposed to levels exceeding Ldnmr 65 dBA and, in rare cases above Ldnmr 70 dBA.

Overpressures on the ground are between 0.02 and 0.10 kPa (0.5 and 2.9 psf), with occasional focus booms between 0.19 and 0.29 kPa (4.0 and 6.0 psf). At those higher pressure, damage to windows of conventional buildings might be expected, but not damage to walls. The nearest residential community, English Village on DPG, is 16 km (10 mi) east of Michael Army Airfield. In order to reduce potential impacts to residents, aircraft avoid flying within a 6 km (3.4 mi) radius of English Village, and the number of missions flown at night is kept to a minimum. Sustained noise levels for all types of aircraft activity, even at the highest readings, are well within established EPA noise level exposure guidelines.



Source: [USAF 1996-A]

Figure 4-5. Major Physiographic Features of UTTR

4.2.3 LAND RESOURCES [USAF 1993]

UTTR is characterized by an arid climate, highly variable temperature, and low relative humidity. UTTR is further characterized by a basin and range physiography and by minimal, saline surface water flow (of water that has not transpired or evaporated) into an internal basin where it evaporates further.

4.2.3.1 Geology

UTTR lies in the Great Basin region of the Basin and Range Physiographic Province, (Figure 4-5). The geography within UTTR is characterized by mountain ranges oriented in a north-south direction between the Rocky Mountains on the east and the Sierra Nevada Mountains on the west. Between the mountain range and broad flat valleys around the Great Salt Lake is a large, flat alluvial, sedimentary plain. This Province is characterized by fault-block mountain ranges that generally trend north-south and that are separated by flat desert basins. During the late Pleistocene, the area was covered by a large fresh-water lake called Lake Bonneville. At is maximum extent, Lake Bonneville covered an area of approximately 50,000 sq km (19,305 mi) and had a depth of more than 330 m (1,083 ft). [USAF 1996-A]

Land surface elevations generally vary from a high of more than 1.8 km (5,800 ft) MSL in the Lakeside Mountains to a low of about 1.3 km (4,200 ft) MSL along the Great Salt Lake. The nearby Deep Creek Mountains to the southwest and Stansbury Mountains to the east are 3.7 km and 3.4 km (12,101 and 11,031 ft) in elevation, respectively. Most of UTTR is covered by dry mud flats, with upland areas limited to the Southern tip of the Newfoundland Mountains, northern tip of the Grassy and Lakeside Mountains on NUTTR, and Wildcat and Kittycat (Little Wildcat) Mountains of SUTTR (Figure 4-4). An upland area, called Sink Valley, occurs between the Grassy Mountains and Lakeside Mountains. Surface drainage is primarily away from the mountain areas into the mud flats, which are extremely flat with limited drainage towards the north-northeast to the Great Salt Lake.

The only rocks exposed on WAFR are the Pennsylvanian dolomite and limestone that comprise Wildcat and Kittycat Mountains. These rocks appear to be intruded by igneous rocks that are younger than Pennsylvanian. Exposed rocks are also present just west of WAFR and across the Nevada line in the Snoopy Area and in the Lead Mine Hills. The remainder of WAFR is covered by Quaternary mud flats and some eolian deposits.

4.2.3.2 Seismicity

The area around UTTR is seismically active. Historically, there have been 15 earthquakes recorded in Utah that were of Richter magnitude 5.5 or greater. Of these, four have been in the vicinity of the Great Salt Lake. Of the earthquakes that measured magnitude

4.0 or greater, the west desert region had about one-third of the number that occurred east of the Great Salt Lake near HAFB.

Analysis of the northern Utah earthquakes suggest that these earthquakes are shallow seated and affect a small area. In northern Utah, no earthquake of sufficient intensity to cause extensive damage to well-constructed buildings has been recorded.

4.2.3.3 Soils

Most of the soils within UTTR are considered to have been deposited under the prehistoric Lake Bonneville, which is thought to have covered the area to an elevation of 1.6 km (5,150 ft). The Great Salt Lake, which comprises the remains of Lake Bonneville, still influences a large part of the soils within UTTR.

UTTR is primarily covered by Playa and Playa-Saltair Complex soils, which are found primarily in the low-lying, flat portions of the range. The playas consist of barren undrained basins that are subject to repeated inundation by salt water and salinization by evaporation of the accumulated water. The surfaces of Playas are often thinly covered by salt crystals and patterned by cracks when dry. The Playa soils have low permeability and drain slowly. Their available water capacity is very low.

The Saltair soil is formed in alluvium and lacustrine sediments derived from mixed rock sources. The surface layer is typically very pale brown, strongly saline silt loam 20 cm (8 in) thick. The underlying material to a depth of 1.5 m (60 in) or more is white, strongly saline silt loam and silty clay loam. The Saltair soils also have low permeability and drain slowly. Their available water capacity is very low to low.

Most of the remaining soils found covering the slopes and upland areas consist primarily of silt loam, sand, gravelly-sandy loam, thin cobbly loams, and rock outcrops. Most of these soils are alkaline and covered with sparse vegetation. Very few of the soils that cover UTTR are suitable for livestock grazing, rangeland seeding, cropland, recreational uses, or homesite development, due to low forage quality, alkalinity, and frequent flooding. Less than 6 percent of the soils on HAFR are considered fair or good for livestock grazing. Less than half of a percent are fair for range seeding. Nine percent are considered suitable for irrigated crops. Less than half of a percent of the soils are considered suitable for road or building sites. All of these soils are concentrated along the slopes of the northeastern corner of HAFR. Of the soils on WAFR, less than 6 percent are considered fair or better for livestock grazing. Less than 1 percent are considered fair or better for range seeding or irrigated crops. Less than 0.01 percent of the soils are considered suitable for road or building sites. All of these soils are concentrated along the slopes and upland areas on the east and west sides of WAFR. Approximately 3.5 percent of WAFR is covered with dune sand, which occurs only in its northeast corner. [USAF 1996-A]

The soils dominating most of the UTTR area are alkali-mud/salt flats with textures that are generally saline throughout. The proposed Stardust recovery area lies primarily in the Great Salt Lake Desert. Soil materials are strongly calcareous stratified lacustrine sediments of silt, clay and sand containing sufficient amounts of salt to inhibit the growth of vegetation. Silty loam soils dominate near topographic highs within the desert and along the desert margins. Active and inactive gypsum-rich sand dunes overlie the silty loam soils in the vicinity of Dugway Proving Grounds. Near Wendover, gypsum-rich sand dunes are partially covered by the Bonneville Salt Crust.

4.2.4 CLIMATE

The climate of UTTR is characteristic of the west desert region, and is characterized by hot, dry summers, cool springs and autumns, moderately cold winters, and a general lack of year-round precipitation. The valleys of this region are considered arid. During winter, storm systems are separated by 2- to 3-week periods of stagnant high-pressure systems that tend to trap cold air in the valleys and create fog. Summer thunderstorms have the potential to cause extensive flash flooding and subsequent soil erosion. [USAF 1996-A]

The average annual precipitation, which varies significantly throughout the region due to various elevations and topography, ranges from 13 cm (5 in) in the valleys and low lying mud flats to 76 cm (30 in) in the mountains.

Temperatures in the region are highly variable, although Great Salt Lake, located to the east of UTTR at an elevation of approximately 1.3 km (4,200 ft) MSL, has a moderating effect on temperature in the area. The summers are a little cooler and the winters are a little warmer on the ranges because of the lake's presence. Average daily maximum temperatures range from -1 ºC to 10 ºC (30 ºF to 50 ºF) in January and from 27 ºC to 39 ºC (80 ºF to 100 ºF) in July, while average minimum daily temperatures range from -12 ºC to -7 ºC (10 ºF to 20 ºF) in January and from 10 ºC to 21 ºC (50 ºF to 70 ºF) in July. At DPG, in SUTTR, the daily temperature can range from below 16 ºC (60 ºF) to more than 39 ºC (100 ºF) during July and August. Records from the National Weather Service at Dugway indicate that the highest recorded temperature was 41 ºC (105 ºF) and the lowest recorded temperature was -30 ºC (-22 ºF) for a period of record from January 1951 to December 1975. For this same period of record, the average annual temperature ranged from 9 ºC to 11 ºC (48 ºF to 52 ºF). The temperature difference between winter and summer may be as much as 54 ºC (130 ºF). During the summer, temperature ranges from 27 ºC to 41 ºC (80 ºF to 105 ºF). The area averaged 151 frost-free days annually between 1951 and 1964. The relative humidity in the summer fluctuates between 13 and 50 percent. In winter, the fluctuation is from 65 to 95 percent. [USAF 1996-A]

The north-south trending Wasatch Range strongly influences the wind patterns in northern Utah and forms a barrier just to the east of the Ogden area, while the Weber River

Canyon northeast of Hill Air Force Base and east of UTTR creates a predominant wind from the east-southeast throughout the year. Winds from that direction occur more than 35 percent of the time due to the strong flow of air that frequently comes down the mountain slopes and out of the canyon toward the Great Salt Lake. During the day, the return wind flow from the lake and valley floor is less unidirectional and more representative of the valley wind flow.

In the vicinity of UTTR, the general north-south orientation of the mountain ranges results in valley surface winds from the north or south. This pattern can be modified at night by downslope winds that are produced by cool, dense air flowing from higher elevations toward the valley floor. Light winds, originating locally, blow over the valley floors in a southeasterly direction by night and a northwesterly direction by day. Winds near the mountains usually have very different local effects and do not reflect the general nighttime southeast and daytime northwest patterns. The average wind speed as measured at Lakeside and Wendover Stations is 8 to 16 kilometers per hour (kph) (5 to 10 miles per hour [mph]). Spring and fall winds up to 64 kph (40 mph) and winter winds up to 80 kph (50 mph) have been recorded. Winds are from the north-northeast and south-southwest. Just south of WAFR at Dugway, wind speeds range from 3 knots in December to 6 knots from March through June. High winds are common in the area from March to June and November to December, with gusts as high as 120 kph (75 mph). [USAF 1996-A]

4.2.5 HYDROLOGY AND WATER QUALITY [USAF 1993]

4.2.5.1 Surface Waters

Surface water is primarily limited to intermittent streams and drainages. No perennial streams originate on HAFR and WAFR, although there are perennial streams in the Deep Creek Mountains to the southwest. The only flows in the stream channels on the Range are found just below perennial springs and generally infiltrate within a short distance. Most of the precipitation that falls on the area is quickly discharged by evapotranspiration or is stored temporarily as soil moisture and then discharged by evapotranspiration. Some water runs off the steep consolidated-rock slopes of the mountains during and immediately after intense summer thunderstorms and during periods of rapid snow melt. Very little of this runoff reaches the basin lowland below the consolidated areas. [USAF 1996-A]

Surface water in the ROI does not support aquatic communities because it is transitory. Blue Lake and Mosquito Willy’s Springs, which are on the west side of WAFR, support aquatic communities, but are not within the proposed Stardust recovery footprint. These are large springs surrounded by extensive wetlands -- the only know perennial springs on WAFR. The only significant water body within the proposed Stardust area is Blue Lake, a desert oasis on the Utah-Nevada border. It is relatively high in dissolved solids as is shown in Table 4-1.

Table 4-1. Water Quality Data from the Blue Lake Springs Area

	Blue Lake Springs North	Blue Lake Springs South	Worldwide River Water Mean
Date of Collection	10/5/77	10/5/77	--
Water Temperature (ºC)	27	29	--
Silica - SiO_2 (mg/l)	28	28	13
Calcium - Ca (mg/l)	140	130	15
Magnesium - Mg (mg/l)	60	56	4.1
Sodium - Na (mg/l)	1,400	1,600	6.3
Potassium - K (mg/l)	110	110	2.3
Bicarbonate - HCO_3 (mg/l)	300	290	58
Sulfate - SO_4 (mg/l)	240	250	11
Chloride - Cl (mg/l)	2,300	2,500	7.8
Hardness as $CaCO_3$ (mg/l) (calcium, magnesium)	600	560	55
Hardness as $CaCO_3$ (mg/l) (noncarbonate)	350	320	7
Dissolved Solids (mg/l) Sum of Determined Constituents)	4,430	4,820	90
Specific Conductance (micromhos/cm @ 25ºC)	7,920	8,470	--
pH	7.7	7.5	--
Percent Sodium	81	83	--
Sodium-Adsorption Ratio	25	30	--

Source: [USAF 1996-A]

4.2.5.2 Ground Waters [USAF 1996-A]

Groundwater occurs in both the unconsolidated and consolidated rocks beneath UTTR. The range is underlain by three primary aquifers. The shallowest, lying just below the surface, is composed of crystalline salt and lakebed deposits. The fresh-water aquifer is moderately saline but is suitable for culinary use; it lies at a depth of approximately 61 m (200 ft). The third aquifer lies at depths of 306 to 488 m (1,000 to 1,600 ft) below the surface and yields brine. Table 4-2 gives properties of the aquifers beneath HAFR and WAFR.

The major groundwater reservoir is the unconsolidated to partially consolidated basin fill. This materials is more than 306 m (1,000 ft) thick, possibly ranging up to 612 m (2,000 ft) thick beneath some areas. This reservoir has been divided into three major aquifers in the region -- shallow brine, alluvial fan, and basin fill. It is best known in the vicinity of Wendover and the three aquifers defined there may be discontinuous throughout the Great Salt Lake Desert.

The shallow-brine aquifer consists of lake bed clay and silt and crystalline salt, and underlies the mud flat area of Playa soils. Although these sediments extend to a considerable depth, only the upper 7.6 m (25 ft) act as an aquifer. Brine moves through the crystalline salt and the fractures in the underlying clay. Recharge to the aquifer is primarily from infiltration of precipitation and lateral inflow from adjacent basins. Discharge from the aquifer occurs by evaporation and by flow into brine-collection ditches. Groundwater flows from the highlands into the mud flats where it evaporates. The total dissolved solids (TDS) in the water of this aquifer are generally greater than 35,000 milligrams per liter (mg/l).

The alluvial-fan aquifer consists primarily of sand and gravel. Recharge to the aquifer is primarily from infiltration of precipitation and subsurface inflow. Discharge occurs by evapotranspiration where the aquifer is shallow, by pumping and flow from wells, and by subsurface outflow. It is not known if this aquifer is present beneath HAFR or WAFR, but if so, it would be found along the flanks of the Newfoundland and Lakeside Mountains.

Table 4-2. Properties of Aquifers Beneath the HAFR and WAFR

Aquifer	Transmissivity (ft^2/day)	Coefficient of Storage
Shallow-brine	67 to 6,700	0.12 to 0.00005
Alluvial-fan	20,000 to 70,000	1 to 0.0005
Basin-fill	12,400	0.0004

Source: [USAF 1996-A]

The basin-fill aquifer consists of older alluvial sediments that underlie most of HAFR and WAFR. These deposits consist of conglomeratic deposits of clay, sand, and gravel that are unconsolidated to well cemented. Recharge to this aquifer is probably entirely by subsurface inflow from adjacent aquifers in the alluvial fans and bedrock. Discharge is primarily from pumping wells.

Information on groundwater is provided by data from two wells completed in the basin-fill aquifer for the HAFR Oasis Complex in the northern subarea of Sink Valley. These wells were completed in the early 1960s and reach a depth of between 91 and 220 m (300 and 723 ft) below ground surface, with a depth to water at the time of drilling of 55 to 58 m (180 to 190 ft) below ground surface. When completed, the wells yielded 300 gallons per minute. Water quality analysis results from samples collected during drilling are summarized in Table 4-3. As of August 1990, the depths to water were approximately 61 m (200 ft) below ground surface and the total dissolved solids in the water ranged from 5,300 to 9,300 mg/l. The water from these potable wells is treated in reverse osmosis units prior to discharge to the water distribution system. [USAF 1996-A] The groundwater at Oasis is also monitored upgradient and downgradient of Hazardous Waste Landfill No. 5, as required by the landfill's RCRA closure permit. Monitoring wells at this location indicate that the depth to water is approximately 121 m (400 ft). Water quality data for this monitoring well are also presented in Table 4-3.

Table 4-3. Water Quality Data from Oasis Complex Wells

Constituent	Oasis Water Supply Well 1	Oasis Water Supply Well 2	Landfill No. 5 Monitoring Wells[1,2]
Volatile Organic Compounds (VOCs) (µg/l)	-	-	ND
Semivolatile Organic Compounds (µg/l)	-	-	ND
Pesticides/PCBs (µg/l)	-	-	ND
Herbicides (µg/l)	-	-	ND
Organophosphorus Pesticides (µg/l)	-	-	ND
Aluminum (µg/l)	-	-	ND
Antimony (µg/l)	-	-	ND
Arsenic (µg/l)	-	-	6.1-26
Barium (µg/l)	-	-	ND
Beryllium (µg/l)	-	-	ND
Cadmium (µg/l)	-	-	ND
Chromium (µg/l)	-	-	ND
Copper (mg/l)	-	-	ND
Lead (µg/l)	-	-	ND
Mercury (µg/l)	-	-	ND
Molybdenum (µg/l)	-	-	ND
Nickel (µg/l)	-	-	ND
Selenium (µg/l)	-	-	5.5
Silver (mg/l)	-	-	ND
Thallium (mg/l)	-	-	ND
Zinc (µg/l)	-	-	11
Silica (mg/l)	7.8-4.7	22	-
Iron (mg/l)	0.02-1.9	0	0.092-0.13
Manganese (mg/l)	0.05-3.6	-	0.011-0.040
Calcium (mg/l)	18-1,470	27	19.0-38.4
Magnesium - Mg (mg/l)	29-2,530	55	10.7-24.5
Sodium - Na (mg/l)	1,310-14,900	1,540	311-379
Potassium - K (mg/l)	86	52	10.7-16.9
Bicarbonate - HCO_3 (mg/l)	152-578	348	-
Carbonate CO_3 (mg/l)	0	6	-
Sulfate - SO_4 (mg/l)	245-2,350	457	-
Chloride - Cl (mg/l)	1,600-27,800	2,060	-
Fluoride - F (mg/l)	1.3-11	2.3	-
Nitrate - NO_3 (mg/l)	17-35	55	-
Boron - B (mg/l)	1.7	1.4	-
Hardness as $CaCO_3$ (mg/l) (Ca, Mg)	164-9,320	292	-
Hardness as $CaCO_3$ (mg/l) (Noncarbonate)	0-9,200	0	-
Dissolved Solids (mg/l) (Sum of Determined Constituents)	3,550-48,100	4,500	-
Specific Conductance (µmhos/cm @ 25ºC)	6,140-62,700	7,580	1,630-2,070
pH	6.9-8.1	8.3	7.6-8.0
Percent Sodium	74-92	90	-
Sodium Adsorption Ratio	40-66	-	-

Source: [USAF 1996-A]

[1] Well 1 water temperature was 14-18ºC when sampled from March 3, 1962 through July 8, 1993. Well 2 temperature was 17ºC when sampled on August 27, 1963.
[2] Water temperature was 15-16ºC when sampled from September 28 through September 30, 1992
ND means not detected

4.2.6 BIOTIC RESOURCES

4.2.6.1 Terrestrial Biota

The primary plant communities in the UTTR include salt desert shrub, Great Basin sagebrush, pinon-juniper woodland, and upper montane. Vegetation in the salt flats of the proposed recovery area is sparse to nonexistent, especially along mudflats and playas. Infrequent precipitation, occasional flooding, high salinity, and fine-grained soils limit the establishment of vegetation. Some salt-tolerant plants such as iodinebush (*Allenrolfea occidentalis*), pickelweed (*Saliconria rubra*), alkali sacaton (*Sporobolus airoides*), and saltgrass (*Distichlis spicata*) can be found in the salt flat areas.

4.2.6.2 Wildlife

UTTR provides a wide variety and diversity of wildlife habitats, ranging from alkaline basins to alpine mountain environments. A general description of wildlife present at the range can be found in the Composite Natural Resource Plan for Hill Air Force Range, Wendover Air Force Range, and Little Mountain Test Facility. Due to lack of water, food, and cover, the salt-desert shrub area proposed for the Stardust recovery operations supports little wildlife, limited primarily to reptiles, such as lizards and snakes, and small mammals. Pronghorn range throughout the area. Birds, including several species of raptors, also utilize the area.

The proposed Stardust SRC impact area contains little sensitive or unique wildlife habitat. The Blue Lake area at the western edge of the range provides riparian habitat for fish and migratory water fowl. This oasis and 874 sq m (216 acres) of recreation land was deeded to the state of Utah in 1974. Fish Springs National Wildlife Refuge lies approximately 16 km (35 mi) south of the proposed recovery area. [USAF 1993]

4.2.6.3 Threatened and Endangered Species

Two federally listed endangered species, the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco peregrinus*), occur within the South Range of UTTR. UTTR is a migratory route and wintering area for the bald eagle. There is a roost-tree in Skull Valley near DPG, and sightings have occurred in Snake Valley, Goshute Mountains, and the Fish Springs National Wildlife Refuge. Peregrine falcons utilize hacking towers on the perimeter of the Great Salt Lake. One tower is located at Timpie Point. Sightings have also occurred in Snake Valley, Goshute Mountains, and Fish Springs. Blue Lake is an historical nesting site for peregrine falcons. Two endangered fish species, the least chub (*Iotichthes phlegethontis*) and the Bonneville cutthroat trout (Salmo Clark Utah), may occur in the area, but none have been found on UTTR property. The least chub has been found within two miles of UTTR lands.

A number of candidate plant species occur in the region. The ones most likely to occur in the proposed recovery area include the compact catseye (*Cryptantha compacta*) and sand-loving buckwheat (*Eriogonum ammophilum*). Candidate animal species in the area include western snow plover (*Charadrius alexandrinus nivosus*), long-billed curlew (*Numenuis americanus*), white-faced ibis, and ferruginous hawk (*Buteo regalis*). Tables 4-4 through 4-7 list the endangered and threatened species, as well as species of high federal concern that potentially occur in Utah.

Table 4-4. Endangered or Threatened Fish Species, and Fish Species of High Federal Concern Potentially Occurring on UTTR Lands

Common Name (*Scientific Name*)	**Potential Occurrence at UTTR**	**Status**
Colorado squawfish (*Ptychocheilus lucius*)	NO	FE
Bonytail chub (*Gila elegans*)	NO	FE
Humpback chub (*Gila cypha*)	NO	FE
Woundfin (*Plegopterus argentissimus*)	NO	FE
Lahontan cutthroat trout (*Salmo clarki henhawi*)	NO	FT
Virgin River bonytail chub (*Gila robusta seminuda*)	NO	ST
June sucker (*Chasmistes liorus mictus*)	NO	ST
Razorback sucker (*Xyrauchen texanus*)	NO	ST
Least chub (*Iotichthys phlegethontis*)	NO	SD
Virgin River spinedace (*Lopidomeda mollispinus*)	NO	SD
Leatherside chub (*Gila copei*)	NO	SQ
Longnose dace (*Rhinichtys cataractae*)	NO	SQ

Source: [USAF 1996-A]

FE = Federal Engangered   SE = State Endangered   SD = State Declining
SQ = Status Questioned   HFI = High Federal Interest   FT = Federal Threatened
ST = State Threatened   SL = State Limited   EX = Extirpated
NO = Not Observed

Table 4-5. Endangered Mammal Species, Threatened Mammal Species, and Mammal Species of High Federal Concern Potentially Occurring on UTTR Lands

Common Name (*Scientific Name*)	Sighted	Status
Utah prairie dog (*Cynomys parvidens*)	NO	FE
Black-footed ferret (*Mustela nigripes*)	NO	FE
Wolf (*Canus lupus*)	NO	FE
Grizzly bear (*Ursus horribilis*)	NO	EX
Fisher (*Martes pennanti*)	NO	EX
Dwarf shrew (*Sorex nanus*)	NO	SL
Desert shrew (*Notiosorex crawfordi*)	NO	SL
Ringtail (Bassariscus astutus)	NO	SL
Red bat (*Lasiurus borealis*)	NO	SL
Mexican big-eared bat (*Plecotis phyllotas*)	NO	SL
Spotted bat (*Euderma maculatum*)	NO	SL
Big free-tailed bat (*Tadarida macrotis*)	NO	SL
Abert squirrel (*Sciurus aberti*)	NO	SL
Belding ground squirrel (*Spermophilis beldingi*)	NO	SL
Richardson's ground squirrel *(Spermophilis richardsoni*)	NO	SL
Thirteen-lined ground squirrel (*Spermophilis tridecemlineatus*)	NO	SL
Spotted ground squirrel (*Spermophilis spilosoma*)	NO	SL
Yellow pine chipmunk (*Eutamias amoenus*)	NO	SL
Rock pocket mouse (*Perognathus intermedius*)	NO	SL
Wyoming pocket mouse (*Perognathus fasciatus*)	NO	SL
Merriam's kangaroo rat (*Dipodomys merriami*)	NO	SL
Desert kangaroo rat (*Dipodomys deserti*)	NO	SL
Cactus mouse (*Peromyscus eremicus*)	NO	SL
Rock mouse (*Peromyscus difficilis*)	NO	SL
Southern grasshopper mouse (*Onychomys torridus*)	NO	SL
Stephen's woodrat (*Neotoma stephansi*)	NO	SL
Mexican meadowmouse (*Microtus mexicanus*)	NO	SL
Wolverine (*Gulo gulo*)	NO	SL
River otter (*Lutra canadensis*)	NO	SL
Canada lynx (*Lynx canadensis*)	NO	SL

Source: [USAF 1996-A]

FE = Federal Engangered
SQ = Status Questioned
ST = State Threatened
NO = Not Observed
SE = State Endangered
HFI = High Federal Interest
SL = State Limited
SD = State Declining
FT = Federal Threatened
EX = Extirpated

Table 4-6. Reptiles, Amphibians, Insects, and Plants -- Endangered and Threatened Species, and Species of High Federal Concern Potentially Occurring on UTTR Lands

Common Name (*Scientific Name*)	Potential Occurrence at UTTR	Status
Reptiles and Amphibians		
Desert Tortoise (*Gopherus agassizi*)	NO	FT
Gila monster (*Heloderma suspectum*)	NO	SL
Desert iguana (*Dipsosaurus dorsalis*)	NO	SL
Chuckwalla (*Sauromalus obesus*)	NO	SL
Desert night lizard (*Xantusia vigilis*)	NO	SL
Western banded gecko (*Coleonyx variegatus utahensis*)	NO	SL
Zebra-tailed lizard (*Callisaurus draconides*)	NO	SL
Many-lined skink (*Eumeces multivirgatus*)	NO	SL
Plateau whiptail (*Cnemidophorus velox*)	NO	SL
Arizona toad (*Bufo microscaphous*)	NO	SL
Pacific tree frog (*Hyla regilla*)	NO	SL
Relict leopard frog (*Rana onca*)	NO	SL
Speckled rattlesnake (*Crotalus mitchelli pyrrhus*)	NO	SL
Mojave rattlesnake (*Crotalus scutulatus scutulatus*)	NO	SL
Sidewinder rattlesnake (*Crotalus cerastes cerastes*)	NO	SL
Utah black-headed snake (*Tantilla planiceps utahensis*)	NO	SL
California kingsnake (*Lampropeltis getulus californiae*)	NO	SL
Desert glossy snake (*Arizona elegans*)	NO	SL
Utah blind snake (*Leptotyphlops humilis utahensis*)	NO	SL
Mojave patched-nose snake (*Salvadora hexalepis mojavensis*)	NO	SL
Arizona lyre snake (*Trimorpodon lamda*)	NO	SL
Utah mountain kingsnake (*Lampropeltis pyromelena*)	NO	SQ
Utah milk snake (*Lampropeltis triangulum*)	NO	SQ
Great Plains rat snake (*Elaphe guttata emoryi*)	NO	SQ
Western smooth green snake (*Opheodrys vernalis blanchardi*)	NO	SQ
Western spotted frog (*Rana pretiosa pretiosa*)	NO	SQ
Insects		
Great Basin silverspot butterfly (*Speyeria nolomis nokimis*)	NO	SL
Plants		
Bear poppy (*Arctomecon humilis*)	NO	FE

Source: [USAF 1996-A]

FE = Federal Engangered
SQ = Status Questioned
NO = Not Observed
SD = State Declining
HFI = High Federal Interest
ST = State Threatened
FT = Federal Threatened

Table 4-7. Endangered and Threatened Bird Species, and Bird Species of High Federal Concern Potentially Occurring in Utah

Common Name (*Scientific Name*)	Seasonal Use Status	Abundance	Status
Bald eagle (*Haliaeetus leucocephalis*)	W	FC	FE
Peregrine falcon (*Falco peregrinus*)	T	R	FE
Whooping crane (*Grus americana*)			FE
California condor (*Gymnogyps californicus*)			EX
Long-billed curlew (*Numenius americanus*)	O		SD, HFI
Lewis' woodpecker (*Ansyndesmus lewis*)	T	U	SD, HFI
Western bluebird (*Sialia mexicana*)	O		SD, HFI
Snowy plover (*Charadrius alexandrinus*)	T		SD
Yellow-billed cuckoo (*Coccyzus americanus*)			SD
Osprey (*Pandion haliaetus*)	T	R	SL, HFI
Spotted Owl (*Strix occidentalis*)	O		SL, HFI
White pelican (*Pelecanus erythrorhynchos*)	O		SL
Double-breasted cormorant (*Phalacrocorax auritus*)	O		SL
Caspian tern (*Hydropronge caspis*)	O		SL
Purple martin (*Pronge subis*)			SL
Bell's vireo (*Vireo bellii*)			SL
Grasshopper sparrow (*Ammondramus savannarum*)			SL
Roadrunner (*Geococcyx californianus*)			SL
Great blue heron (*Ardea herodias*)	R	U	HFI, SQ
Pileated woodpecker (*Dendrocopus pileatus*)			HFI, SQ
Golden eagle (*Aquila chrysaetos*)	R	FC	HFI
Prairie falcon (*Falco mexicanus*)	R	FC	HFI
Ferruginous hawk (*Buteo regalis*)	R	FC	HFI
Merlin (*Falco columbarius*)	W	R	HFI
Cooper's hawk (*Accipiter cooperi*)	R	U	HFI
Burrowing owl (*Athene cunicularia*)	S	C	HFI
Flammulated owl (*Otus flammeolus*)	O		HFI
Williamson's sapsucker (*Sphyrapicus thyroikeus*)			HFI
Band-tailed pigeon (*Columba fasciata*)			HFI
Sandhill crane (*Grus canadensis*)	T	U	HFI
Black swift (*Cypseloides niger*)			HFI
Scott's oriole (*Icterus perisorum*)			HFI
Grace's warbler (*Dendroica graciae*)			HFI
American bittern (*Botaurus lentiginosus*)	T	U	SQ
Western grebe (*Aechmorphus occidentalis*)	O		SQ

Table 4-7. Endangered and Threatened Bird Species, and Bird Species of High Federal Concern Potentially Occurring in Utah, con'd

Common Name (*Scientific Name*)	Seasonal Use Status	Abundance	Status
Black-crowned night heron (*Nycticorax nycticorax*)	T	O	SQ
Mountain bluebird (*Sialia currocoides*)	S	FC	SQ
Yellow-breasted chat (*Icteria virens*)	S	FC	SQ
Fox sparrow (*Passerella iliaca*)			SQ

Source: [USAF 1996-A]

All bird species in Utah are protected

FE = Federal Endangered
SQ = Status Questioned
ST = State Threatened
SE = State Endangered
HFI = High Federal Interest
SL = State Limited
SD = State Declining
FT = Federal Threatened
EX = Extirpated

Seasonal Use Status:
R= Resident
S = Summer
W = Winter
T = Transient

Abundance:
O = Occurring on or near HAFR and WAFR
C= Common, observed anytime
FC = Fairly common, observed most of the time
U = Uncommon, observed infrequently
R = Rare, observed rarely
VR = Very Rare

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SECTION 5

ENVIRONMENTAL IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

The activities associated with completing the preparations of the Stardust spacecraft primarily involve refining the spacecraft and mission designs at Jet Propulsion Laboratory (JPL) and Lockheed Martin Astronautics (LMA), and spacecraft fabrication, assembly, and component testing at the LMA Denver facility. 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. The potential environmental impacts to the baseline recovery site, UTTR, are also discussed herein. Facilities at JPL, LMA, KSC, CCAS, and UTTR are in compliance with all federal, state, and local regulations; therefore, the reader is referred to the environmental compliance offices of each respective facility for facilities topics not addressed herein, including the site-specific Pollution Prevention Plans and applicable permits.

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 normal launch of the Stardust spacecraft.

The following sections summarize the environmental effects of a normal Delta II 7426 launch and flight, and the effects of possible abnormal spacecraft operations or flight conditions for the launch of the Stardust spacecraft. They also detail potential environmental impacts of the entry, descent, landing, and recovery (EDL&R) operations at UTTR.

5.1 ENVIRONMENTAL IMPACTS OF A NORMAL DELTA II 7426 LAUNCH AT CCAS

5.1.1 AIR QUALITY

5.1.1.1 Emissions

For a normal Delta II launch, airborne emissions are typically generated by prelaunch, launch, and post-launch operations. Emissions resulting from Delta II operations include fuel and oxidant vapors which may escape to the atmosphere during prelaunch or post-launch operations. All CCAS facilities involved in normal prelaunch activities have been either permitted or exempted by the Florida Department of Environmental Protection (FDEP), and will not be discussed in this document. Please refer to reference USAF 1994 for further information. 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 are loaded while the vehicle is on the launch pad.

Typically, RP-1 and liquid oxygen are 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 loaded to full capacity 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. 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 handled in accordance with 45th Space Wing (45SW) OPlan 32-3.

Table 5-1. Combustion Products for the GEM Solid Rockets

Combustion Product	Product Mass Fraction	Product Mass per GEM		Total Product Mass for 4 GEMs 47,480 kg	
		kg	lb	kg	lb
AlCl	0.0002	2.4	5.2	9.6	21.1
$AlCl_2$	0.0002	2.0	4.4	8.0	17.6
$AlCl_3$	0.0001	1.0	2.2	4.0	8.8
AlClO	0.0001	1.0	2.2	4.0	8.8
Al_2O_3 (soluble)	0.2959	3,512.0	7,726.4	14,048.0	30,905.6
Al_2O_3 (insoluble)	0.0628	745.0	1,639.0	2,980.0	6,556.0
CO	0.2208	2,621.0	5,766.2	10,484.0	23,064.8
CO_2	0.0235	279.0	613.8	1,116.0	2,455.2
Cl	0.0027	32.0	70.4	128.0	281.6
H	0.0002	2.0	4.4	8.0	17.6
HCl	0.2109	2,503.0	5,507.0	10,012.0	22,026.4
H_2	0.0228	271.0	596.2	1,084.0	2,384.8
H_2O	0.0773	918.0	2,019.6	3,672.0	8078.4
N_2	0.0823	977.0	2,149.4	3,908.0	8597.6
OH	0.0002	2.0	4.4	8.0	17.6

Source: Adapted from [USAF 1996-C]

Table 5-2. Exhaust Products for the Delta II 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 1996-C]

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 45SW 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.

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.

The majority of launch emissions are produced by the four graphite epoxy motor (GEMs) solid rockets on the Delta II 7426 vehicle and the liquid first stage of the Delta II vehicle during launch, which are ignited during lift-off. The primary products of GEM combustion are 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 GEMs are listed in Table 5-1. 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 5-2.

5.1.1.2 Impacts

In a normal launch, exhaust products from the Delta II 7426 (Tables 5-1 and 5-2) are distributed along the launch vehicle's flight path (Figures 5-1a and 5-1b). 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. It consists of the rocket exhaust effluents and deluge water. Prior to launch all personnel are evacuated from the launch site to areas a minimal distance outside the facility perimeter until the area has been monitored and declared clear. [USAF 1988]

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. Using Delta II 7425 mass fractions, data obtained during early Delta launches, and rocket engine chamber tests, REEDM was run to calculate peak ground level concentrations of various pollutants in ground clouds. For this assessment, Air Force personnel from 45SW 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 six 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 B. The Delta II 7425 differs from the 7426 in that it has a Star 48 upper stage, which has 2010 kg (4422 lb) of propellant compared to the Star 37 FM motor which has 1077 kg (2368 lb) of the same propellant. The Delta II 7425 is considered to bound the upper limit of propellants for the 7420 series of Delta II launch vehicles.

For the nominal launch scenario the launch cloud was assumed to be 100 m (328 ft) in diameter at ground level. The area directly impacted by flame from the rocket exhaust would be approximately 80 m (262 ft) in diameter. [USAF 1994] The cloud height was calculated to be a minimum of 672 m (2200 ft) above the ground, with a minimum time of rise of about 450 seconds. [USAF 1996-B]

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 carbon monoxide, carbon dioxide, chlorine (Cl), aluminum oxide, and hydrochloric acid 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 mi) downwind of LC-17 for the first weather scenario and 5 to 8 km (3 to 5 mi) 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 (NAAQS) have not been adopted for HCl, National Academy of Sciences (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. The Short-Term Public Emergency Guidance Level (SPEGL) is the acceptable standard for public exposure and environmental protection. The SPEGL for HCl is based on a ceiling concentration level of 1 ppm. 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 mi) 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 (O_3) 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 of a Delta II 7400 vehicle 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 7426s 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.

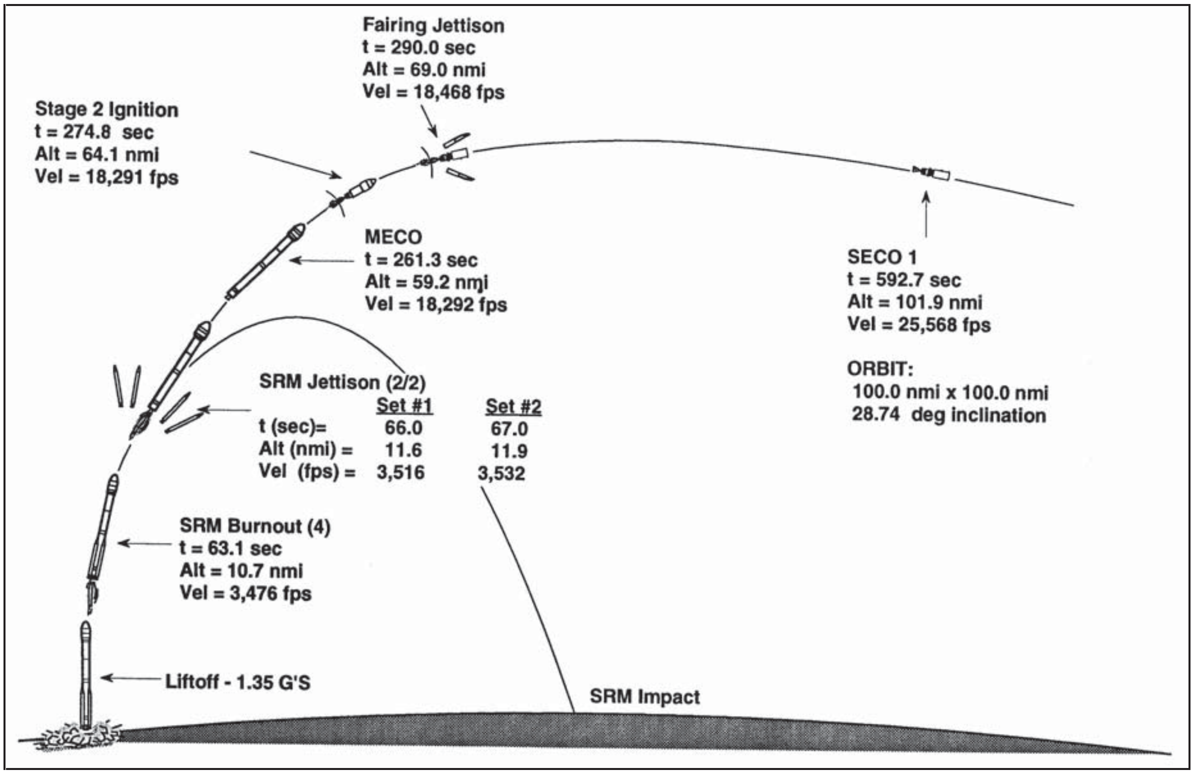
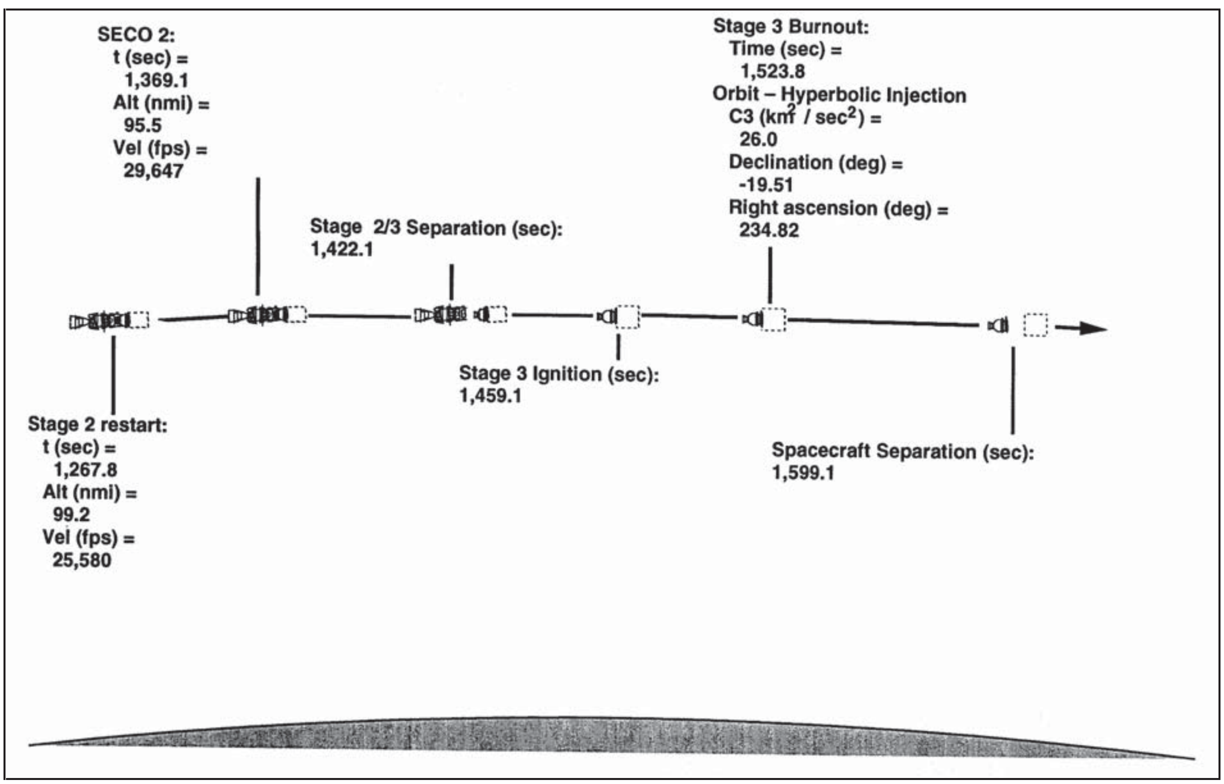


Figure 5-1a. Delta II Boost Profile for Stardust



Source: [JPL 1996-C]

Figure 5-1b. Delta II Injection Profile for Stardust

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 328 ft) [USAF 1996-B], concentrates around the launch pad, and disperses quickly, there should be no substantial amount of acidic deposition beyond the near-pad area.

During launch, gases are exhausted at temperatures ranging from 1093 to 1650 ºC (2,000 to 3,000 ºF). Most of the gases then immediately rise to an altitude of about 610 m (2,000 ft), where they are dispersed by the prevailing winds. Unprotected individuals within 100 m (327 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 2-km (6,500-ft) 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. Additionally, a 850-km (2,780-ft) blast danger zone is established. In the event of a catastrophic launch failure, no personnel would be in the blast area. [USAF 1994]

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 ppm for CO, 0.018 ppm for CO_2, and 0.001 ppm for Cl. All maximums occurred approximately 10 km (6.2 mi) 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 μg/m^3. The maximum 24-hour Al_2O_3 concentration beyond the distance of the nearest CCAS property boundary predicted by the REEDM for a Delta II 7425 launch, was 3.5 μg/m^3, which is well below the 24-hour average PM-10 NAAQS for PM-10 of 150 μg/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.

5.1.2 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 deposition. 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]

5.1.3 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.

5.1.4 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, since the small amount of residual propellants will quickly disperse. [USAF 1988]

5.1.5 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.

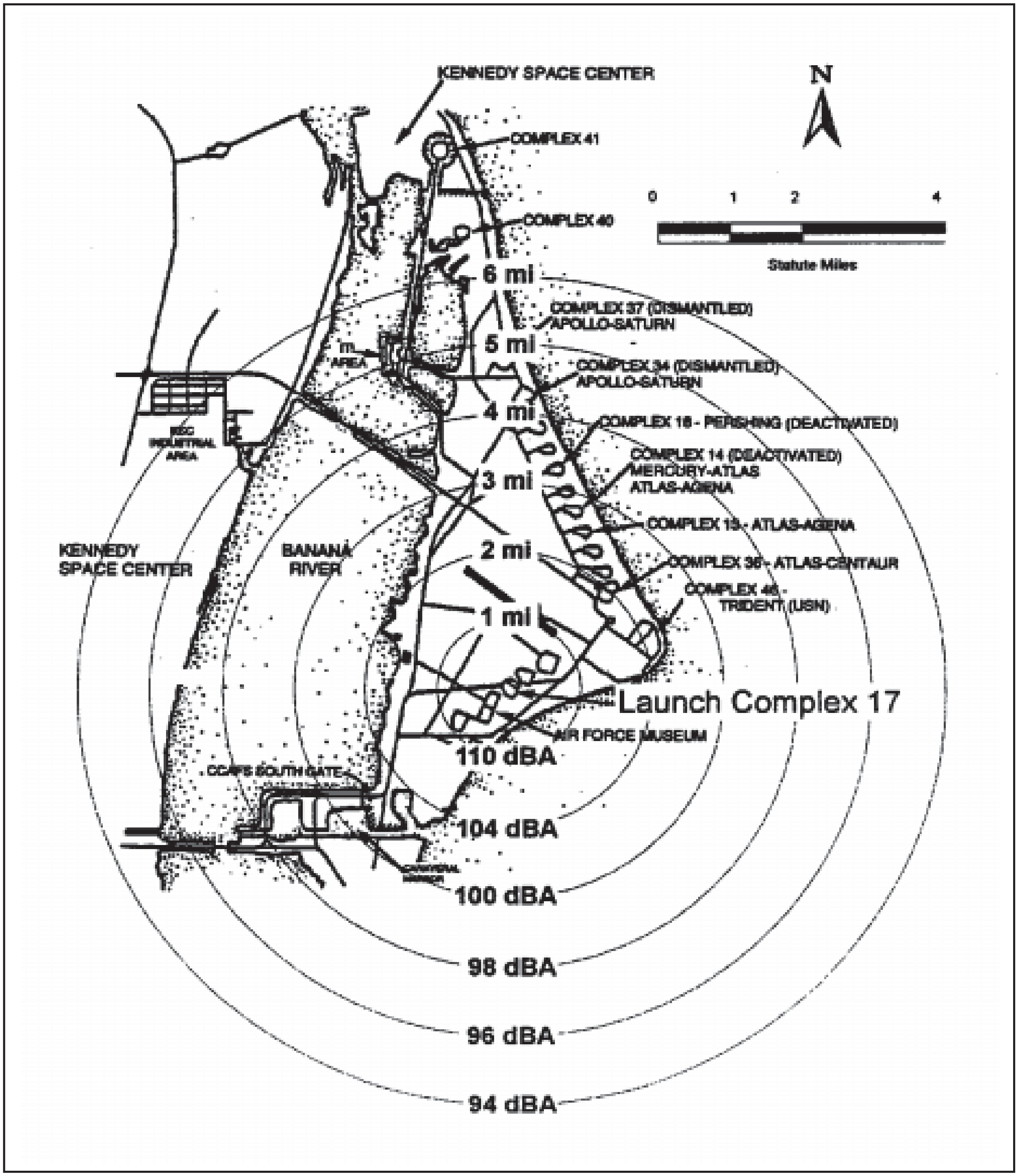
5.1.6 THREATENED AND ENDANGERED SPECIES

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 U.S. 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. [USAF 1988, NASA 1994]

5.1.7 DEVELOPED ENVIRONMENT

5.1.7.1 Population and Socioeconomics

Launching the Stardust 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 Stardust mission would cause no additional adverse impacts on community facilities, services, or existing land uses.



Source: Adapted from [USAF 1994]

Figure 5-2. Noise Generated by a Delta II 7925 Launch from LC-17

5.1.7.2 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] Figure 5-2 shows the noise generated by a Delta II 7925 launch (which is comparable to a Delta II 7426) from LC-17 at CCAS.

5.1.7.3 Pollution Prevention

5.1.7.3.1 NASA [NASA 1995-B]

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.

5.1.7.3.2 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]

5.1.7.4 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 Stardust mission, analysis indicates little or no potential of substantial environmental effects on any human populations outside CCAS boundaries.

5.1.7.5 Cultural Resources

Since no surface or subsurface areas would be disturbed, no significant archaeological, historic, or other cultural sites are expected to be affected by launching the Stardust spacecraft.

5.1.7.6 Cumulative Impacts [USAF 1994]

CCAS accommodates various ongoing space programs. The environmental effects associated with these programs have been included in the baseline environmental conditions described in section 3.

5.2 ACCIDENTS AND LAUNCH FAILURES AT CCAS

5.2.1 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

45SW OPlan 32-3. 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 the Titan REEDM predictive models 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.

5.2.2 LAUNCH FAILURES

In the unlikely event of a launch vehicle destruction, either on the pad or in-flight, the liquid propellant tanks and GEM casings would be ruptured. Due to their hypergolic (ignite on contact) nature, a launch failure would result in a spontaneous burning of 10 to 30 percent of the liquid propellants, and a somewhat slower burning of GEM propellant fragments. [USAF 1997-A]

Table 5-3. Combustion Products for Delta II 7426 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]

Table 5-4. 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-B]

Tables 5-3 and 5-4 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 mi) downwind. Tables 5-5 and 5-6 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 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 5-7. The 24-hour average of Al_2O_3 resulting from this failure mode would be 4.5 µg/m^3, which is well below the 150 µg/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.

For a deflagration scenario, additional species such as UDMH, nitrogen dioxide (NO_2), ammonia (NH_3), hydrazine (N_2H_4), nitrosodimethylamine (NDMA), formaldehyde (FDH), and nitric acid (HNO_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 5-6. These peak concentrations were predicted to occur approximately 7 km (4 mi) downwind from LC-17. Maximum 60-minute mean concentrations resulting from deflagration are predicted to occur approximately 8 km (5 mi) 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.

Table 5-5. Combustion Products for Delta II 7426 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 5-6. 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)	0.15 $\mu g/m^3$	0.003
UDMH	0.067	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-B]

If there was an early flight termination and failure of the vehicle destruct system, it is remotely possible that the entire stage 2 propellant quantity 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 entire 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. Aerozine 50 and N_2O_4 contaminants could exceed allowable concentrations for an approximate radius of 241 m (800 ft) in water depths exceeding 3 m (9 ft) deep. However, the impacts to ocean systems would be localized and/or transient in nature, and expected to recover rapidly due to dispersion and buffering in such a large amount of ocean water. [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 the area prior to launch, there would 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 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 1997-B] The vast bulk of the plume generated by the explosion was out over water; and maximum concentrations of HCl and NO_2 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 1997-A, USAF 1997-B]

Table 5-7. Health Hazard Quantities of Hazardous Launch Emissions

Compound	ERPG (ppm) 1	ERPG (ppm) 2	ERPG (ppm) 3	EEGL (ppm)	SPEGL (ppm)	PEL (ppm)	STEL (ppm)	TLV (ppm)	IDLH (ppm)
Dimethyl Hydrazine (UDMH)	0.03	8	80	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	24 for 1 hr 1 for 24 hr	0.5 (skin)		0.01 (skin)	15
Hydrazine (N_2H_4)	0.03	8	80		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	1 (skin)		0.01 (skin)	50
Hydrochloric Acid or Hydrogen Chloride (HCl)	3	20	100	100 for 10 min 20 for 1 hr 20 for 24 hr	1 (ceiling)	5 (ceiling)		5 (ceiling)	50
Nitrogen Tetroxide as NO_2				1 for 1 hr (ceiling) 0.04 for 24 hr (ceiling)	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	5 (ceiling)		5 (STEL) 3 (TWA)	20
Ammonia (NH_3)	25	200	1000			50	35	25	
Nitric Acid (HNO_3)	4	10	100			2	4	2	
Nitrogen Dioxide (NO_2)*				1 for 1 hr (ceiling) 0.04 for 24 hr (ceiling)	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	5 (ceiling)		5 (STEL) 3 (TWA)	20
Aluminum Oxide (Al_2O_3)	15 mg/m^3	15 mg/m^3	15 mg/m^3	50 mg/m^3 for 10 min 25 mg/m^3 for 30 min 15 mg/m^3 for 60 min					

Source: [USAF 1994]

ERPG Emergency Response Planning Guidelines - Developed by the American Industrial Hygiene Association, ERPGs are the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour: ERPG-1 - without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor; ERPG-2 - without experiencing or developing irreversible or other serious health effects of symptoms that could impair their abilities to take protective action; and ERPG-3 - without experiencing or developing life-threatening health effects.

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. The TLV is the airborne concentration of the substance which represent conditions under which it is believed nearly all workers may be repeatedly exposed to day after day without adverse effect. There are three categories of TLVs: 1) Time Weighted Average (TWA) is the concentration of a normal 8-hour work day or 40-hour week; 2) STEL is the maximum concentration to which workers can be exposed for a period of up to 15 minutes; and 3) ceiling is the concentration that should not be exceeded even instantaneously.

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

*National primary and secondary ambient air quality standard for nitrogen dioxide - annual arithmetic mean for nitrogen dioxide (NO_2) is 0.053.

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]

5.3 ENVIRONMENTAL IMPACTS OF RECOVERY OPERATIONS AT UTTR [USAF 1993, USAF 1996-A]

Impacts are described for the environmental resource areas presented in Section 4. The level of treatment given each resource area is related to the potential for environmental impacts. The primary areas of concern are effects on the physical environment and health and safety. Air quality considerations and potential impacts on biological and cultural resources are also identified. Other resources are treated more briefly.

5.3.1 AIR QUALITY

Emmisions of criteria pollutants would occur as a result of helicopter and ground vehicle activity during Stardust SRC recovery operations. The SRC itself would not generate any air pollutants in the lower atmosphere (the area subject to NAAQS), nor is it expected that it would contain any chemicals or substances that could emit hazardous air pollutants regulated under National Emission Standard for Hazardous Air Pollutants (NESHAPs). Given that the Stardust mission is a single sample return, the quantities of helicopter emissions would be extremely small. Furthermore, when affected sectors would be scheduled for the Stardust recovery operation, other aircraft would be curtailed, thereby resulting in lower short-term emission levels. It is unlikely that overall emissions in the area would be greater during Stardust recovery operations than under baseline conditions. The proposed action is not expected to result in any violations of the NAAQS or to interfere with Tooele County's ability to reach or maintain attainment.

NAAQS and effects on the air quality of the UTTR area relate to lower atmosphere. Upper altitude emissions associated with reentry of the SRC would include ablation products of the thermal protection system (TPS) on the forebody. The SRC would enter the earth's atmosphere with a velocity of approximately 13 km/s (8 mi/s) - the fastest earth entry of a man-made object ever attempted. It would decelerate to 600 m/s (1962 ft/s) in two minutes. At approximately 3 km (2 mi) above the earth, a parachute would be deployed for a land based recovery at UTTR's South Range. Because of the rapid deceleration and high entry velocity, the vehicle would experience large aerothermal and structural loads during reentry. Thus, the SRC would require a heat shield that could survive the extreme reentry heating environment. The temperature of the carbon composite structure must be kept low enough to prevent structural degradation, and the sample canister containing the captured cometary and interstellar dust particles must not exceed 343 K (75 ºC, 167 ºF) during any portion of the reentry. The material baselined to be used for the forebody heatshield is Phenolic Impregnated Ceramic Ablator (PICA) recently developed at NASA's Ames Research Center by Tran et. al. [NASA 1996-B] It is less dense than carbon/phenolic and has a much lower thermal conductivity with a similar ablation performance. The heatshield and insulation mass requirements for a heatshield utilizing PICA are significantly reduced compared to a carbon/phenolic heatshield. PICA is an enabling technology for Stardust because the mission cost and weight constraints cannot be met using a heavier carbon/phenolic heatshield. The SRC would be the first flight application of the material.

During the descent of the SRC the PICA material comprising its forebody heatshield would ablate due to frictional heating. The peak heating would occur at approximately 54 seconds after reentry begins, which corresponds to an altitude of approximately 60 km (196,860 ft) above the earth. The ablation would continue for about twenty seconds. Models conservatively predict that less than 22 percent of the total PICA material would ablate during reentry, and that ablation would cease at approximately 46.5 km (152,566 ft) above the earth. The total mass of the PICA material would be about 8.5 kg (18.7 lb); of this a maximum of 1.86 kg (4.09 lb) would be ablated during reentry. The chemical species that would be produced during ablation of the PICA material are shown in Table 5-8, along with their mass fractions. These chemical species would be dissipated in the shock wave behind the SRC. Two of the chemical species produced during ablation are hydrogen cyanide and cyanide (37 g and 149 g, respectively). These chemicals are

Table 5-8. Chemical Species Produced During Ablation of PICA Heatshield

Chemical Species	Mass Fraction	Total Mass of Species Produced During Ablation (g)	Total Amount of Species Produced During Ablation (lb)
CO_2	1.25×10^{-8}	2.34×10^{-5}	5.11×10^{-8}
CO	.26	483.6	1.06
N_2	.39	725.4	1.60
O2	1.83×10^{-14}	3.40×10^{-11}	7.49×10^{-14}
NO	1.90×10^{-8}	3.53×10^{-5}	7.77×10^{-8}
C_2	0.02	37.2	0.08
C_3	0.22	409.2	0.90
H_2	3.25×10^{-4}	0.61	1.33×10^{-3}
CN	0.08	148.8	0.32
C	0.01	18.6	0.04
N	2.29×10^{-4}	0.43	9.37×10^{-4}
O	9.27×10^{-8}	1.72×10^{-4}	3.79×10^{-7}
H	3.60×10^{-3}	6.7	0.02
HCN	0.02	37.2	0.08

Source: Adapted from [NASA 1996-B]

considered to be acutely toxic to humans when inhaled. The ablation process and thus the production of these species would cease more than 46 km (150,000 ft) above the earth. Therefore, these concentrations would disperse in the large volume of air in the upper atmosphere and would not constitute a danger to health or life on earth. The SRC heatshield would be rapidly cooling during the subsonic portion of the descent, and would not be emitting into the lower atmosphere. [NASA 1996-B]

The SRC would be entering Earth's atmosphere from space and repressurizing as it nears the surface of the earth. The SRC would be traveling at supersonic velocity during the ablation of the heatshield, and a flow field analysis of the heatshield radiation and ablation has demonstrated that only a minimal amount of hydrocarbons would gain access to the interior of the SRC through the vents located on the sides of the backshell. Most of the repressurization of the SRC would occur below 10 km (6.2 mi) MSL, during the subsonic portion of the reentry. Colorimetric tests would be performed by Safety personnel to ascertain if a potentially harmful amount of hydrogen cyanide gas might be present in the SRC after landing. If the tests so indicate, personnel opening the SRC to retrieve the sample canister would be required to wear appropriate personal protective equipment (PPE) to preclude potential health hazards. [JPL 1997-A]

Table 5-9. Chemical Species Produced During Ablation of SLA-561V Heatshield

Chemical Species	Mass Fraction	Total Mass of Species Produced During Ablation (g)	Total Amount of Species Produced During Ablation (lb)
H_2O	0.04	12.0	0.03
CO	$1.64x10^{-4}$	0.49	1.08×10^{-4}
CH_4	0.38	114.00	0.25
$C0_2$	$7.11x10^{-3}$	2.13	$4.69x10^{-3}$
CH_3OH	$3.98x10^{-10}$	1.19×10^{-7}	2.62×10^{-10}
SiO_2	$3.55x10^{-6}$	1.07×10^{-3}	2.35×10^{-6}
H2	$4.54x10^{-3}$	1.36	$3.0x10^{-3}$
SiO	0.44	132.0	0.29
SiH_4	$7.01x10^{-6}$	2.10×10^{-3}	4.63×10^{-6}
SiC_4H_{12}	0.14	42.0	0.09

Source: Adapted from [JPL 1996-E]

The Super Lightweight Ablator (SLA-561V) material comprising the TPS of the backshell portion of the SRC undergoes far less heating during reentry than does the PICA material on the forebody. Of the estimated 2 kg (4.4 lb) of SLA-561V comprising the backshell heatshield, approximately 0.3 kg (0.66 lb) would be lost during reentry. Table 5-9 gives the predominant species produced during reentry peak heating and their corresponding mass fractions (those with mass fractions greater than 1×10^{-10}). There are no toxic species produced from this heatshield material. [JPL 1996-E]

5.3.2 LAND RESOURCES

The proposed action would disturb soils in the location of the SRC touchdown and the immediate vicinity where helicopters or a land vehicle would recover the SRC. Helicopter landings are currently common on UTTR and should have no additional effect. The SRC would have a diameter of 81 cm (32 in) and would weigh approximately 42.6 kg (93.7 lb). It would have a parachute system which would slow its velocity to approximately 4.5 m/s (14.8 ft/s). The area affected would measure only a few meters. The impact would be similar to a small person parachuting to the surface. Any disturbance to the surface could easily be recovered if desired. Due to the single event nature of this recovery operation, the resulting impact would be negligible. The SRC would contain no propellant, except for the gas that would expel the drogue chute.

5.3.3 BIOTIC RESOURCES

The SRC landing and recovery operations would affect vegetation in the immediate vicinity of the touchdown. Individual plants within a localized area could be crushed. The impact to plant communities in the area would be insignificant. Ground disturbance could increase the potential for invasive species like halogeton to establish in the area, but the small size of the area disturbed would not increase this effect noticeably above the baseline conditions. The proposed Stardust impact area does not contain any sensitive habitats that could be affected by recovery operations.

5.3.4 NOISE [USAF 1996-A]

Noise from helicopter operations would not differ from baseline conditions and is therefore not anticipated to have any impact on local wildlife. The sonic boom from the SRC reentry would not have any impact due to its high altitude. The recovery area is overlain by the Gandy Supersonic Operating Area, which experiences sonic booms at lower altitudes and higher overpressures than those that would be created by the Stardust SRC.

Numerous studies have been conducted on the sensitivity of wildlife to noise and sonic boom, including studies of big horn sheep, pronghorn, and elk at UTTR. A literature survey of studies on effects of supersonic and subsonic aircraft noise on animals conducted by the USAF in 1986 revealed few effects from sonic booms. These same studies have shown that there is more potential for effects from subsonic aircraft operations, especially helicopters, and indicated that wildlife acclimated to recurring events. In any case, the proposed project area does not include sensitive wildlife species likely to be adversely affected, and any wildlife in the area is likely already acclimated to the on-going range operations.

5.3.5 THREATENED AND ENDANGERED SPECIES

No threatened or endangered species are expected to be affected by the proposed action. The probability of a collision between the SRC or a helicopter and a bald eagle or

Peregrine falcon in the area is extremely remote -- raptors have a very low incidence of airstrike. It is highly unlikely that any candidate species that could be affected occur in the project area.

5.3.6 HEALTH AND SAFETY

There would be three areas of concern with respect to health and safety during the entry, descent, and landing phase of the mission. The first involves range safety considerations; the second is concerned with SRC recovery safety issues; and the third is the inadvertent reentry of the spacecraft.

5.3.6.1 UTTR Range Safety Considerations

Scheduling procedures for use of UTTR would preclude any risk of flight hazards involving other aircraft in the area. This is a negligible risk of mishap involving helicopters should they be used in the SRC recovery operations. This risk would be comparable to currently on-going risks at the range. In the event of a helicopter accident, there are no inhabited areas in the proposed recovery area that would be exposed to hazardous conditions. There should be minimal air activity over this area at the time of SRC recovery operation as it is baselined to occur at approximately three o'clock in the morning. Therefore, potential for adverse effect to personnel or the public is considered insignificant.

The Monte Carlo analysis performed by NASA's Legley Research Center for the Stardust project shows that the risk of casualty from the SRC reentry is no greater than one in a million (1×10^{-6}). [NASA 1997-A]

The SRC would have the potential for landing anywhere within the designated safety zone (also known as the 3-sigma landing footprint - see figures 4-1 and 4-2), which includes targets and areas that may contain unexploded ordnance. In the event that the SRC landed on a target, there is a chance it could initiate an explosion. This could destroy the SRC and result in a release of any materials contained within it. The highest probability is that the experimental materials would be destroyed in the mishap. The risk of this occurrence is substantially less than the risk of a military aircraft crashing on unexploded ordnance on the range. [USAF 1993] To reduce the possibility of the SRC triggering an explosion upon landing, the AF would search out and explode any undetonated munitions in the proposed recovery site prior to the expected date of reentry.

5.3.6.2 SRC Recovery Safety Considerations [JPL 1997-A]

The SRC would weigh approximately 42.6 kg (93.7 lb), and would be touching down at 4.5 m/s (14.8 ft/s). This is comparable to a human of the same weight parachuting to Earth, or a force of half of a pound under the acceleration of gravity. Therefore, it would pose no risk to personnel or structures.

Four potential hazards in handling the SRC once it has landed have been identified. They include safing of potential unfired parachute deployment ordnance; lithium battery faults such as the production of sulfuric acid (SO_2), or a lithium fire should the battery be damaged during landing; RF emissions from the ultra high frequency (UHF) beacon; and handling of the SRC. These will be discussed in detail in the following paragraphs.

5.3.6.2.1 Ordnance Safing

There are redundant NASA Standard Initiators (NSIs) in the SRC to deploy the drogue chute and to cut the cable, thereby enabling the deployment of the main chute. In the nominal landing scenario, i.e., the parachute deploys as engineered, it would indicate that at least one NSI fired, but would not provide information that the redundant NSI also fired. Therefore, it is possible that there would be two unfired NSIs within the SRC upon landing. Stardust plans to engage a UTTR EOD expert to isolate and remove the drogue initiator outputs in an electrostatic discharge control area. The second NSI on the parachute mortar is designed to be directed toward the center of the parachute canister and parallel to the SRC surface, so that if it discharged upon opening the SRC, it would not pose a safety hazard to personnel. Likewise, the second NSI on the cable cutter releases no hazardous fragments or gases. Unexpended NSIs would be disposed of at UTTR. Off-nominal recovery conditions would be addressed by the recovery team.

5.3.6.2.2 Lithium Battery Faults

The SRC would contain 8 lithium battery cells about the size of a commercial “D” cell. These cells would be used only for the SRC return and are diode protected from reverse charging. Potential hazardous characteristics resulting from damaged batteries would be lithium fire, SO_2 production, and explosion or violent venting due to hydrogen gas production. The recovery team would include a safety inspector, who would perform colorimetric tests and pronounce that the SRC is safe for human handling prior to opening. The battery case has been designed to leak before bursting and the cables would be protected at possible abrasion points.

5.3.6.2.3 RF Emissions from the UHF Beacon

The batteries would provide power to operate the UHF beacon for a minimum of 40 hours. The UHF antenna is a wire approximately 10 inches long extending from inside the parachute canister and up the parachute bridle. The average transmitting power is 100 mW at 242.000 MegaHertz (MHz), with a duty cycle of 3 seconds on, 5 seconds off. The American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) at 242.000 MHz is 1 mW/cm^2. The safe distance is a minimum of 1.7 cm.

5.3.6.2.4 SRC Handling

The primary method of handling would be manual, except when it is secured in its handling fixture. Three persons would be required to manually carry the SRC. Gloves would be used for all handling of SRC ablated surfaces, and would also protect the teams from the hot surface.

The SRC thermal control system design calls for two ablative materials in the heatshields. On the backshell would be the SLA-561V, which is a combination of RTV 663 mixed with silica fibers, treated cork, phenolic microbolloons, and silicon microspheres packed into a phenolic honeycomb. This material is currently used on the Shuttle, and requires no special safety handling procedures. On the forebody would be the PICA material, which is composed of a carbon fiber preform impregnated with phenolic resin, including hexamethylene tetramine, water, and ethylene glycol. It is baked out to minimize volatile materials. During reentry peak heating, which occurs at least 45 km (150,000 ft) above the earth, the PICA material would generate small amounts of cyanide (CN) and hydrogen cyanide (HCN) while ablating. Although the air fluid dynamics models show that the air flow would move the ablation products away from the capsule and thus, the vents, these complex organics could enter the SRC through the two vent holes located in the backshell during repressurization of the SRC. The safety officer accompanying the SRC recovery teams would test for CN and HCN at a vent port before the backshell is removed to verify that levels in the SRC are below the permissible exposure limits for these substances. Recovery team personnel would wear appropriate personal protective equipment to prevent exposure to hot surfaces or any residual ablation products.

5.3.6.3 Inadvertent Reentry of the Spacecraft

The Stardust mission has levied a mission requirement that the design shall preclude an impact of the spacecraft with Earth during all mission phases, including Earth return after SRC separation. Extensive analysis and testing support the findings that reentry of the spacecraft is highly unlikely and would require multiple failures, including failure of the primary divert maneuver, which is to be integrated into the onboard software. As part of Stardust’s fault protection, there would be a backup divert maneuver that would utilize different components to avoid reentry. If, however, both divert maneuvers were to fail, the Stardust spacecraft would enter Earth’s atmosphere at approximately 46,000 kph (29,000 mph), which is four to seven times more destructive to this small, lightweight spacecraft than would occur if it reentered Earth’s atmosphere from low Earth orbit (LEO) (orbital speed in LEO is 27,000 kph or 17,000 mph).

Based on studies of previous spacecraft reentries from LEO (i.e., Vehicle Atmospheric Survival Test [VAST]) and analysis of the potential Stardust reentry speed, the main spacecraft composite structure is conservatively predicted to break apart at altitudes above 100 km. After breakup, aluminum components would burn up above 90 km, followed by more heat resistant steel and titanium components which are predicted to burn up above 80 km. The small quantities of produced during burnup are left at these extreme altitudes. There are no chlorofluorocarbons used in the spacecraft. The only materials expected to survive reentry would be lightweight fragments of Nextel fabric from the Whipple shields. This material would survive for two reasons: 1) it is a very high temperature material, sometimes used for thermal blankets intended to protect reentry vehicles, and 2) its low mass allows it to rapidly decelerate such that it undergoes little subsequent heating. Any Nextel fabric heated to its melting point would occur at very high altitude, and by the time pieces reach the ground, they would be at approximately the surrounding air temperature. They would flutter to the ground only a little faster than a piece of paper. These fragments, because of their very low speed descent, would not pose any danger to a person or structure on the ground.

5.3.7 CULTURAL RESOURCES [USAF 1996]

The Stardust SRC landing could have the potential for affecting cultural resources if it lands on an archaeological site eligible for the National Register of Historic Places (NRHP). There are no sites listed on the NRHP within the proposed Stardust landing footprint area. The proposed impact area is considered to have a low level of sensitivity for significant archaeological resources, so the probability of landing on a NRHP-eligible site is remote. If the SRC did land on an archaeological site, the level of ground disturbance would be slight and unlikely to affect buried materials, except in the event of a mishap. Therefore, the risk of adverse effect is considered insignificant. There are no extant historic or other cultural resources in the impact area that could be affected by Stardust operations. The Utah State Historical Society has reviewed the draft EA and has issued a letter stating it has no technical or policy comments for consideration (see Appendix A).

5.3.8 BACK CONTAMINATION

The Stardust mission would be a flyby mission to collect interstellar dust particles and material from the coma of comet Wild-2, including dust grains and molecules. Both would be captured in underdense fiberglass, primarily aerogel, and returned to Earth in a sealed reentry capsule for study by the international science community. All particles would be collected at hypervelocity -- typically 3 to 30 km/s for interstellar dust grains, and 5 to 7 km/s for cometary material. During capture, each particle would undergo transient heating to temperatures of several hundreds of degrees Celsius. Furthermore, cosmic material in the form of meteorites and dust from asteroids and comets is already entering Earth's atmosphere to the extent of an estimated forty thousand tons per year. The amount of material that would be collected by Stardust would be infinitesimal in comparison and, therefore, would not present a significant addition. For these reasons, there is little probability that back contamination of the Earth could occur due to the sample return. [JPL 1997-F]

5.3.9 SOCIOECONOMICS

The proposed action would not affect demographics, housing, or the structure of the economy in the region. The Stardust recovery operations would be compatible with the purpose and use of UTTR and the DOD land in the proposed impact area.

There is a possibility that the SRC could land on public lands administered by the BLM in the safety zone. The BLM lands involved are along the outside edges of the impact area, so the probability of a landing occurring on BLM land is small. This would not adversely affect the land or grazing if the touchdown occurred as planned and there were no mishap. Combined with the low probability of mishap, the risk of an incident involving BLM land is extremely remote, and the resulting impacts even in the event of an incident would not be significant. Emergency response procedures would be required as part of the Site Safety Plan for the project. These would ensure adequate response and remediation of any lands adversely affected. In the event the SRC should touch down on BLM land within the confines of UTTR airspace, the Air Force would use approved procedures for recovery contained in an existing Memorandum of Agreement between the USAF and the BLM. [USAF 1997-C]

Recovery could be hampered if the SRC landed in the Cedar Mountains. Based on the six-degree of freedom Monte Carlo analysis run by NASA Langley Research Center, the probability of such an occurrence is less than 3 in 1,000. [NASA 1997-A] This area lies outside the designated impact area. Given the low probability of this event, the proposed action is not expected to adversely affect the Cedar Mountains WSA.

5.3.9.1 Pollution Prevention

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]

5.3.9.2 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 characteristics of the SRC which is to land at UTTR, analysis indicates little or no potential of substantial environmental effects on any human populations outside UTTR boundaries. (See Section 4.1.1 for a discussion of the population distribution around UTTR.)

5.4 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

5.4.1 ALTERNATE LAUNCH VEHICLES

Of the alternate launch vehicle systems available, all greatly exceed the Stardust mission requirements. The Atlas II would contribute less potential environmental effects, however, its cost to launch would prohibit the launch of this cost-capped Discovery mission. All other launch vehicle alternatives would contribute potentially comparable environmental impacts.

5.4.2 ALTERNATE RECOVERY SITES

Of the potential recovery sites reviewed for the Stardust mission, all would have the same environmental impacts, due to the ablation of the PICA heatshield in the upper atmosphere, and the recovery of the SRC on land. Analysis of possible trajectories for Stardust to land at other ranges shows that only choosing UTTR would allow the SRC to enter Earth's atmosphere directly over the range and into restricted airspace. The sparse human population surrounding UTTR, adds a measure of personnel safety not readily achievable at other potential landing sites. Therefore, landing the SRC at the other sites reviewed would entail greater safety risks to commercial air traffic and to surrounding human populations, as well as risk to the science if the SRC landed in the mountainous regions bordering the other locations.

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SECTION 6

OTHER ENVIRONMENTAL REVIEWS AND CONSULTATIONS

6.1 CAPE CANAVERAL AIR STATION (CCAS)

6.1.1 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 Stardust 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.

6.1.2 WATER QUALITY

6.1.2.1 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 Stardust because the launch would not increase stormwater runoff rates or reduce the quality of the existing runoff.

6.1.2.2 Sanitary And Industrial Wastewater Discharge

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

Wastewater from LC-17 would include deluge and pad washdown water discharged during Stardust 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.

6.1.2.3 Floodplains And Wetlands

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

6.1.3 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 45th Space Wing (45SW) 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.

6.1.4 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 45th SW Hazardous Materials Response Plan (OPlan 32-3). 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 45SW OPlan 19-4, Hazardous Substance Pollution Contingency Plan [USAF 1990]. All spills/releases will be reported to the host installation per OPlan 32-3.

6.1.5 COASTAL MANAGEMENT PROGRAM

The Federal Coastal Zone Management Act of 1972 established 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 practical 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] Stardust mission processing and launch would add no substantial impact beyond those determined to be associated with the Delta II.

6.1.6 CULTURAL RESOURCES

In accordance with 36 CFR Part 800, the Florida Department of State, Division of Historical Resources, has reviewed the planned Stardust launch for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places (NRHP). Their review indicates that no significant archaeological or other historical sites are recorded in the Florida Master Site File, nor are any likely to appear there. They consider it unlikely that any such sites would be affected by the proposed action. (Please refer to response in Appendix A.)

6.2 UTAH TEST AND TRAINING RANGE (UTTR) [USAF 1996-A]

Management of UTTR has included and will include compliance with many federal laws and regulations, State of Utah Department of Environmental Quality (DEQ) regulations, Utah environmental statues, and local environmental requirements to ensure that human health and the environment are protected. The Utah State DEQ implements and enforces most of the environmental laws and regulations promulgated in Utah. Utah has been designated by EPA to administer, implement, and enforce most of the federal environmental programs and laws.

6.2.1 AIR QUALITY

Activities at UTTR are governed by the federal Clean Air Act (CAA), which is largely implemented through the Utah Air Conservation Act (Title 19, Chapter 2, U.C.A.) and Air Conservation Regulations (R307-1 U.A.C.), and by any portions of the federal regulations that have not been adopted by the State. The State of Utah has been designated by EPA for implementation and enforcement of the CAA regulations. The State implementation plan contains emission controls to ensure that State air quality control areas meet Nation Ambient Air Quality Standards (NAAQS). UTTR is located within a Class II attainment area; therefore, it is subject to regulations designed for prevention of significant deterioration (PSD) of air quality.

Potential pollutants of concern at UTTR for which federal or state ambient air quality standards have been established include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than 10 microns in aerodynamic diameter (PM-10), and lead.

The draft CAA Title V operating permit has been completed for UTTR. It provides information on UTTR emission sources, actual emissions, potential emissions, and other pertinent permitting data.

Air emissions from ground transport to and from off-range facilities (e.g., the facilities at HAFB), from overflying aircraft, from target detonation, from the Thermal Treatment Unit (TTU), from missile and other testing, and from other miscellaneous transient sources have been modeled in previous NEPA compliance documentation and the Title V permit application.

6.2.2 WATER QUALITY

Control of water quality at UTTR includes regulation of water discharges under the Clean Water Act (CWA) and under the Utah Water Quality Act (Title 19, Chapter 5, U.C.A.), Utah Pollutant Discharge Elimination System Rules (R317-8 U.A.C.) and Utah Underground Injection Control Program Rules (R317-7 U.A.C.). The State of Utah has been designated by EPA to implement and enforce the CWA in Utah. The Utah Ground Water Quality Protection Rules (R317-6 U.A.C.) do not formally apply at UTTR because the ground water there is classified as nonpotable brine. Nonetheless, UTTR personnel do take steps to comply with the spirit of these rules and file Nature of Groundwater Discharge Notification Forms when appropriate,

6.2.2.1 Stormwater Discharge

There are no stormwater discharges on UTTR; therefore a stormwater management Plan is not required. The reverse-osmosis water treatment plant on HAFR uses HTH chlorine (A high-test calcium hypochlorite product), antiscalant, and pH-adjusting chemicals such as sulfuric acid and potassium permanganate for treatment. The plant operates continuously and periodically discharges wastewater through a French drain system to a ditch that is approximately 300 yards east of the plant. A Nature of Groundwater Discharge Notification Form was submitted to the Utah Division of Water Quality (DWQ) on January 26, 1995, for *de minimus* (i.e., too small for regulation based on numerous situation-specific considerations) discharges from the treatment plant. The DWQ has indicated that continued discharge is acceptable unless they send formation notification to the contrary.

6.2.2.2 Sanitary And Industrial Wastewater Discharge

The wastewater treatment system on HAFR consists of a total containment evaporation pond that is east of the drinking water treatment plant. These is an injection well at the Eagle Tower Range maintenance facility that was once considered a de minimus discharge facility. This discharge is no longer regulated and discharges into a drain field. It is standard procedure to test wastewater prior to discharge. If the water contains plastic Kevlar chips, it is considered nonhazardous and is discharged to the wastewater treatment pond. If the water contains propellant, it is drummed and sent off-site for disposal.

6.2.2.3 Underground Storage Tanks

Underground storage tanks (USTs) and their associated piping are regulated by the RCRA UST regulations. These regulations require states to develop programs covering UST design, construction, installations, operation release reporting, and corrective action. The Utah Sate Underground Storage Tank Act and the Underground Storage Tank Rules (Title 311, Rules 200-212 U.A.C.) specify notification requirements for tanks and leaks from tanks, leak detection, spill and overfill protection, installation, removal, closure, and corrective action requirements. The Utah DEQ manages the UST compliance program, under which USTs that store hazardous chemicals or wastes are required to have secondary containment.

There are two permitted USTs at HAFR. Twenty-five USTs were removed in January 1994. Three additional tanks had been removed by April 1996. There are eleven tanks that are not regulated.

Facilities that have the potential to discharge harmful quantities of oil into or on bodies of water are required by the Oil Pollution Act, which supersedes certain sections of the CWA, to prepare a Spill Prevention Control and Countermeasure (SPCC) plan. The final HAFB SPCC plan was combined with the facilities response plan (FRP) in a single document. The SPCC/FRP details prevention and response measures to ensure that oil and hazardous material spills do not reach navigable waters. It also provides the spill prevention training requirements and the responsibilities of the Hazardous materials (HAZMAT) Team with regard to spills of hazardous materials. Emergency response (ER) and the spill response plan mission on HAFR and WAFR are performed by the 75th RANS HAZMAT Team, which has been certified by the National Fire Protection Association.

6.2.3 HAZARDOUS WASTES

HAFR is consider to be a small-quantity waste generator, and has an EPA identification number. Hazardous waste generated on HAFR includes ash residue from the TTU and other OB/OD activities, and various wastes generated in the vehicle maintenance shops and batter storage facility. Hazardous wastes that are shipped off-site are handled in accordance with DOT requirements. The DOT regulations must be applied to transportation of hazardous materials and wastes on public roads, including those on HAFR.

WAFR has no EPA identification number since hazardous waste is not generated there.

There are three RCRA-permitted activities at HAFR -- the TTU, the closure of the hazardous waste landfill (Landfill No. 5), and the Lithium Battery Facility (research, development, and disposal).

6.2.4 NOISE

The Noise Control Act (NCA) requires measures to reduce emissions. Generally, federal agencies whose activities result in increased environmental noise in the surrounding community are responsible for compliance with state and local environmental noise requirements. However, the NCA exempts military weapons or equipment for combat use from environmental noise requirements. The State of Utah has no noise control regulations, although State Code 10-8-16 give cities the authority to develop noise control regulations or standards. The Tooele County Planning Division has performance standards that regulate the sound pressure level radiated by the facilities in the county; the Box Elder County Zoning Department has no noise abatement requirements and places HAFR in zone MU-160, where most uses are permitted by a conditional permit.

The existing noise environment on UTTR consists primarily of aircraft flight activity. This includes subsonic activity on low-level training flights and high-altitude missions and supersonic events in the Supersonic Operating Area (SOA) about 1.5 km (5,000 ft) above ground level (AGL). The SOA is in SUTTR and covers all of WAFR and Dugway generally west of Granite Mountain, as well as extending into Nevada. Sonic booms generated outside the SOA and capable of generating overpressure between 1 and 4 pounds per square foot occur infrequently.

6.2.5 CULTURAL RESOURCES

Data on the cultural resources identified at HAFR and WAFR to date by surveys are on file at HAFB, but are only available on a “need to know” basis, since information on cultural resources is typically not made available to the general public in order to protect the sites from potential “pot hunters.” However, there are no sites listed on the NRHP within the proposed Stardust landing footprint area. The proposed impact area is considered to have a low level of sensitivity for significant archaeological resources, so the probability of landing on a NRHP-eligible site is remote. If the SRC did land on an archaeological site, the level of ground disturbance would be slight and unlikely to affect buried materials, except in the event of a mishap. Therefore, the risk of adverse effect is considered insignificant. There are no extant historic or other cultural resources in the impact area that could be affected by Stardust operations. The Utah State Historical Society has reviewed the draft EA and has issued a letter stating it has no technical or policy comments for consideration (see Appendix A).

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APPENDIX A

CORRESPONDENCE WITH STATE AND FEDERAL AGENCIES

NOTE:

While preparing this Environmental Assessment, NASA is soliciting comments from a range of Federal and State Agencies. A distribution list may be found at the end of the NASA Letter to Concerned Agencies dated 30 September 1996. There will be formal correspondence with Patrick Air Force Base, Air Combat Command, Kennedy Space Center, and Utah Test and Training Range.

This appendix will contain the comments received from Federal and State Agencies.

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National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Reply to Attn of: SD

SEP 30 1996

To Potentially Concerned Agencies:

The National Aeronautics and Space Administration (NASA) is seeking approval for plans to launch the Stardust spacecraft on a mission to gather material from the coma of comet Wild 2 and return samples to Earth for study by a global community of researchers. Current mission plans call for the spacecraft to be launched in February 1999 from the Eastern Test Range at the Cape Canaveral Air Station (CCAS), Cape Canaveral, Florida. In accordance with policies of NASA and requirements of the National Environmental Protection Act (NEPA), NASA is preparing an Environmental Assessment to evaluate any mission-specific environmental impacts.

NASA has initiated a series of low cost planetary science missions called the Discovery Program, as part of its Solar System Exploration Program. The Stardust mission would be designed to collect in a single mission, both ancient pre-solar interstellar particles, and nebular material believed to have been incorporated into comets at the birth of the solar system. It also could capture particles presently entering the solar system from the interstellar medium. As conceived, particles would be gathered by Aerogel, an ultra-low density glass, for return in the Stardust Sample Return Capsule. Comet dust would also be studied in real time by a mass spectrometer derived from a similar instrument carried to comet Halley on Giotto, which was a European Space Agency (ESA) mission. After flying through the coma, the spacecraft would continue on a course to return to the vicinity of the Earth. As it nears Earth, a command would be sent to the spacecraft to deploy the sample return capsule (SRC) containing the Aerogel with its captured materials in a sealed sample canister. Following deployment of the SRC, the Stardust spacecraft would be maneuvered to avoid entering Earth's atmosphere. The SRC would directly enter Earth's atmosphere, where atmospheric drag and a parachute would rapidly slow its descent to allow a safe landing. Following touchdown, the SRC would be recovered and transported to a staging area for removal of the sample canister. The sample canister would then be transported by NASA to a special planetary materials facility at Johnson Space Center. Potential landing sites are being considered against the mission criteria. After preliminary analysis, the Utah Test and Training Range (UTTR), located in the

Great Salt Lake Desert, near the Dugway Proving Grounds, in Tooele County, appears to be the baseline candidate for SRC recovery operations.

The proposed plan calls for Stardust to be designed as a spacecraft small enough to be launched on a Delta II-class launch vehicle. A solid-propellant upper stage will then place the spacecraft onto a flight path to eventually intersect the Wild-2 comet. The Stardust spacecraft will carry no radioactive materials.

Prelaunch spacecraft testing and propellant loading operations would occur at the Kennedy Space Center (KSC) and CCAS, in Florida. After processing, the spacecraft would be transferred to the CCAS Launch Complex 17 for mating with the launch vehicle. No requirements for new or modified Government or contractor facilities have been identified, and no new facilities or modifications are planned for the mission.

The Stardust Environmental Assessment will address the Proposed Action of preparing for and implementing the Stardust mission to be launched from Cape Canaveral Air Station (CCAS) using a Delta II-class launch vehicle. Options discussed will include, but not necessarily be limited to, the use of alternative launch vehicles, alternative landing sites, and the No-Action alternative.

The primary environmental impacts expected are those associated with normal ground operations and processing of the launch vehicle. Those effects would include the impact of rocket fuel combustion products on the quality of air, water, land and wetland, biotic resources, and historical sites. Other topics to be addressed in the Environmental Assessment are public safety concerns, reentry of orbital debris, planetary protection, and socioeconomic impacts of the launch and recovery operations. Although analysis of cometary materials by previous missions such as ESA's Giotto show no significant concentrations of materials hazardous to human health, the substances anticipated to be returned by the mission will be investigated to ascertain possible environmental impacts. The Environmental Assessment is expected to be released for public review and comment in 1997.

Any comments you may presently have should be sent to me within 30 days of the date of this letter, at NASA Headquarters, Code SD, 300 E. Street SW, Washington, DC, 20546. If you need further information, please contact Mr. Kenneth Kumor at NASA Headquarters at (202) 358-1112.

Kenneth W. Ledbetter
Director
Mission and Payload Development Division
Office of Space Science

Distribution:

Environmental Protection Agency
Federal Facilities Branch
401 M Street, SW
Washington, DC 20460

Mr. Barry Webster
412 Test Wing DET1/TSUR
Building 1285
Hill Air Force Base, UT 84056

Mr. R. D. Williams
Fish and Wildlife Service
Utah State Office
U.S. Department of the Interior
2060 Administrative Building
1745 West 1700 South
Salt Lake City, UT 84104-5110

Ms. Carolyn Wright
Governor's Office of Planning and Budget, Rm. 116
Utah State Clearing House
Salt Lake City, UT 84114

Mr. H. Hedrick
Salt Lake District Office
Bureau of Land Management
U.S. Department of the Interior
2370 South 2300 West
Salt Lake City, UT 84119

Ms. J. Alcott
Florida Clearing House
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100

Ms. J. Unger
St. Johns River Water Management District
P. O. Box 1429
Palatka, FL 32178-1429

Mr. D. Wesley
U.S. Fish and Wildlife Service
Kennedy Space Center, FL 32899

Mr. A. R. Hight
Merritt Island National Wildlife Refuge
Kennedy Space Center, FL 32899

Mr. W. Simpson
Canaveral National Seashore
National Park Service
308 Julia Street
Titusville, FL 32796

Mr. O. Miller
Civil Engineering
45 CES/CEV
1224 Jupiter Street
Patrick Air Force Base, FL 32925-3343

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS
EMERGENCY MANAGEMENT • HOUSING AND COMMUNITY DEVELOPMENT • RESOURCE PLANNING AND MANAGEMENT

LAWTON CHILES
Governor

JAMES F. MURLEY
Secretary

February 18, 1997

Mr. Mark Dahl
National Aeronautics and Space
Administration Headquarters
Code SD
Washington, DC 20546

RE: National Aeronautics and Space Administration Projects - Draft Environmental Assessment for the Stardust Mission - Statewide
SAI: FL9701080007C

Dear Mr. Dahl:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of State (DOS) indicates that Launch Complex 17 (LC-17) may be eligible for listing in the National Register of Historic Districts. Therefore, any modification of the Launch Complex must be coordinated with the DOS to ensure that adverse impacts are avoided, minimized, or mitigated. Please refer to the enclosed DOS comments.

Based on the information contained in the draft environmental assessment and the enclosed comments provided by our reviewing agencies, the state has determined that the above-referenced project is consistent with the Florida Coastal Management Program.

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Keri Akers, Clearinghouse Coordinator, at (904) 922-5438.

Sincerely,

Chris McCoy

for Ralph Cantral, Executive Director
Florida Coastal Management Program

RC/cc

Enclosures

cc: George W. Percy, Department of State

COUNTY: State

Message:

DATE:	01/08/97
COMMENTS DUE-2 WKS:	01/23/97
CLEARANCE DUE DATE:	02/21/97
SAI#:	FL9701080007C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs X Corrections Environmental Protection Game and Fresh Water Fish Comm State Transportation	St. Johns River WMD	Environmental Policy/C & ED

RECEIVED
JAN 21 1997
State of Florida Clearinghouse

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

__ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

__ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

__ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

NASA - Draft Environmental Assessment for the Stardust Mission - Florida.

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [ ] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: DOA / Facilities Services
Reviewer: Donald A. Esry, P.E. III
Date: 1-14-97

COUNTY: State

Message:

DATE:	01/08/97
COMMENTS DUE-3 WKS:	01/23/97
CLEARANCE DUE DATE:	02/21/97
SAI#:	FL9701080007C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Corrections X Environmental Protection Game and Fresh Water Fish Comm State Transportation	St. Johns River WMD	Environmental Policy/C & ED

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FEB 13 1997
State of Florida Clearinghouse

JAN 1997
Office of
Intergovernmental
Programs

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- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:

Division/Bureau: FDEP - OIP

Reviewer: Dan Pennington

Date: 02/10/97

COUNTY: State

Message:

DATE: 01/08/97
COMMENTS DUE-2 WKS: 01/23/97
CLEARANCE DUE DATE: 02/21/97
SAI#: FL9701080007C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Corrections Environmental Protection X Game and Fresh Water Fish Comm State Transportation	St. Johns River WMD	Environmental Policy/C & ED

RECEIVED
JAN 16 1997
State of Florida Clearinghouse

RECEIVED BY GFC
JAN 10 1997
OFFICE OF ENVIRONMENTAL SERVICES

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

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Project Description:

NASA - Draft Environmental Assessment for the Stardust Mission - Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From: GFWFC

Division/Bureau: Environmental Services

Reviewer: Douglas B. Bailey

Date: 1-13-97

COUNTY: State

Message:

DATE:	01/08/97
COMMENTS DUE-2 WKS:	01/23/97
CLEARANCE DUE DATE:	02/21/97
SAI#:	FL9701080007C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Corrections Environmental Protection Game and Fresh Water Fish Comm State X Transportation	St. Johns River WMD	Environmental Policy/C & ED

Post-it® Fax Note 7671	Date 1/31/97	# of pages ▶ 5
To Andy Cranick	From Sandra Whitmore	
Co./Dept.	Co.	
Phone #	Phone # 488-8006	
Fax # 4-0479	Fax #	

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

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Project Description:

NASA - Draft Environmental Assessment for the Stardust Mission - Florida.

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Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

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- ☐ Not Applicable

Federal Consistency

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- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: FDOT
Reviewer: Bill Ashbaker
Date: 1/30/97

CO[illegible] State

Message:

DATE: 01/08/97
COMMENTS DUE-2 WKS: 01/23/97
CLEARANCE DUE DATE: 02/21/97
SAI#: FL9701080007C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Corrections Environmental Protection Game and Fresh Water Fish Comm State Transportation	St. Johns River WMD RECEIVED JAN 22 1997 State of Florida Clearinghouse	X Environmental Policy/C & ED RECEIVED JAN 9 1997 OFFICE OF PLANNING & BUDGETING ENVIRONMENTAL POLICY UNIT

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

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Project Description:

NASA - Draft Environmental Assessment for the Stardust Mission - Florida.

To: **Florida State Clearinghouse**
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2555 Shumard Oak Boulevard
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- [ ] Comments Attached
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Federal Consistency

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- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: EOG OPB Env. Policy
Reviewer: M Vanney
Date: 1/20/97

DIVISIONS OF FLORIDA DEPARTMENT OF STATE
Office of the Secretary
Office of International Relations
Division of Administrative Services
Division of Corporations
Division of Cultural Affairs
Division of Elections
Division of Historical Resources
Division of Library and Information Services
Division of Licensing

MEMBER OF THE FLORIDA CABINET
Historic Florida Keys Preservation Board
Historic Palm Beach County Preservation Board
Historic Pensacola Preservation Board
Historic St. Augustine Preservation Board
Historic Tallahassee Preservation Board
Historic Tampa/Hillsborough County Preservation Board
Ringling Museum of Art

FLORIDA DEPARTMENT OF STATE
Sandra B. Mortham
Secretary of State
DIVISION OF HISTORICAL RESOURCES

January 31, 1997

RECEIVED
FEB 05 1997
State of Florida Clearinghouse

Ms. Keri Akers
State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

In Reply Refer To:
Scott B. Edwards
Historic Sites Specialist
(904) 487-2333
Project File No. 970133

RE: Cultural Resource Assessment Request
SAI# FL9701080007C
NASA - Draft Environmental Assessment for the Stardust Mission

Dear Ms. Akers:

In accordance with the provisions of Florida's Coastal Zone Management Act and Chapter 267, *Florida Statutes*, as well as the procedures contained in 36 C.F.R., Part 800 ("Protection of Historic Properties"), we have reviewed the referenced project for possible impact to historic properties listed, or eligible for listing, in the *National Register of Historic Places*, or otherwise of historical or architectural value.

We have reviewed the draft copy of the "Stardust Mission Environmental Assessment" and specifically reviewed the sections dealing with Cultural Resources (3.1.6/4.1.4/5.1.7.3/5.3.7). We note that Launch Complex 17 (LC-17) has been identified as potentially eligible for listing in the *National Register of Historic Places*. Please note that if modifications to the Launch Complex are required then the applicant will need to coordinate with this office in determining measures that must be taken to avoid, minimize, or mitigate adverse impacts to historic properties . Therefore, it is our opinion that the project will have no adverse effect on any sites listed, or eligible for listing , in the *National Register of Historic Places*, or otherwise of historical or architectural value. The project is also consistent with the historic preservation laws of Florida's Coastal Management Program.

If you have any questions concerning our comments, please do not hesitate to contact us. Your interest in protecting Florida's historic properties is appreciated.

Sincerely,

Laura A. Kammerer
for
George W. Percy, Director
Division of Historical Resources
and
State Historic Preservation Officer

GWP/Ese

xc: Jasmin Raffington, FCMP-DCA

State of Utah

Department of Community and Economic Development
Division of State History
Utah State Historical Society

Michael O. Leavitt
Governor
Max J. Evans
Director

300 Rio Grande
Salt Lake City, Utah 84101-1182
(801) 533-3500 FAX: 533-3503 TDD: 533-3502
ushistory.ushs@email.state.ut.us

UTAH STATE HISTORICAL SOCIETY
SINCE 1897

March 20, 1998

Mr. Mark Dahl
National Aeronautics and Space
Administration Headquarters
Code SD
Washington DC 20546

RE: Stardust Mission Environmental Assessment

In Reply Please Refer to Case No. 93-0419

Dear Mr. Dahl:

The Utah State Historic Preservation Office received the above referenced Draft EA on March 13, 1998. After consideration of the draft document, the Utah Preservation Office has no technical or policy comments for consideration.

This information is provided on request to assist NASA with its Section 106 responsibilities as specified in §36CFR800. If you have questions, please contact me at (801) 533-3555. My email address is: jdykman@state.ut.us

As ever,

James L. Dykmann
Compliance Archaeologist

JLD:93-0419 OFR

F:\CULTURAL\JIM\93-0419.wpd

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APPENDIX B

Selected REEDM Outputs for:

Normal Launch Mode

Conflagration Mode Failure

Deflagration Mode Failure

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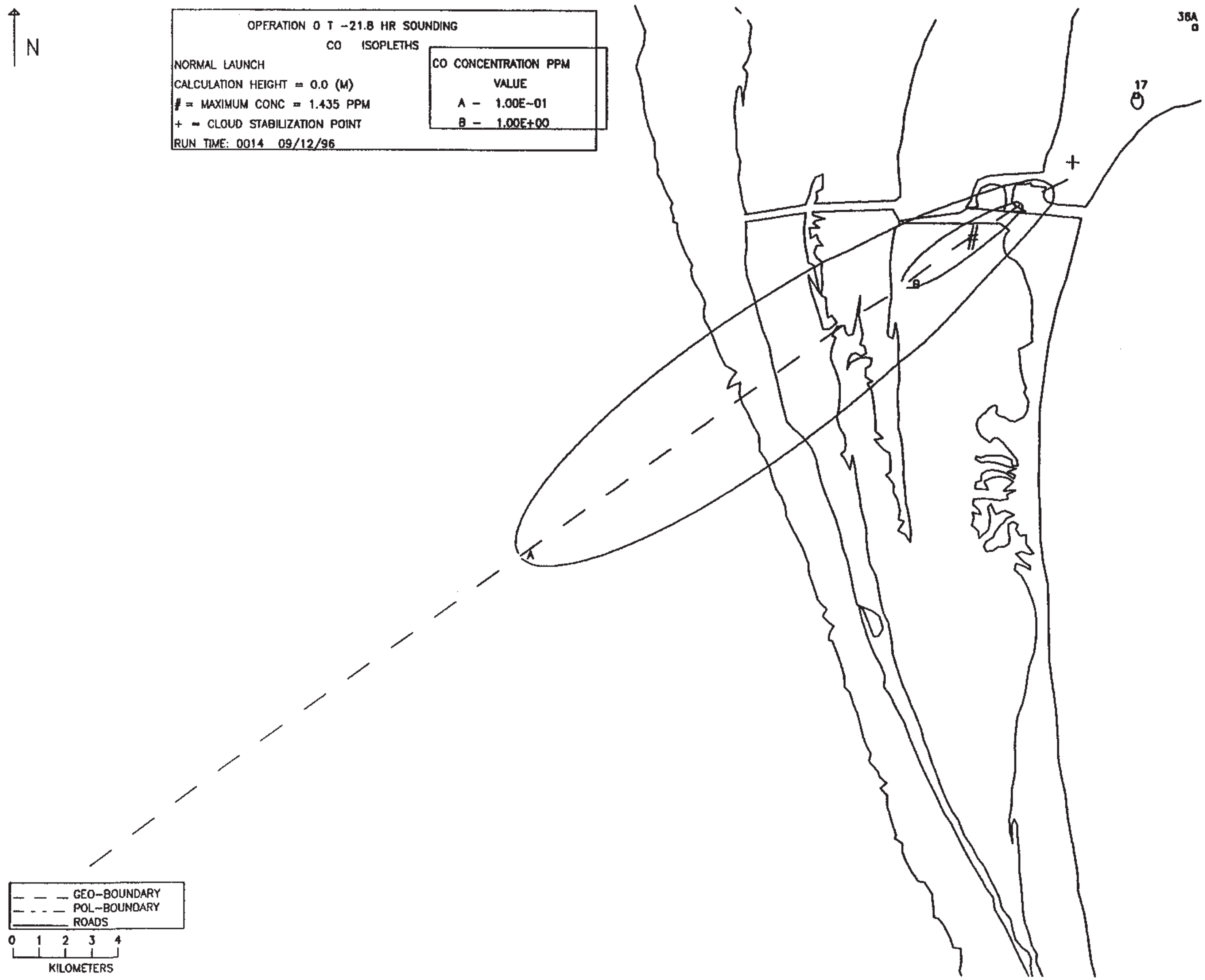
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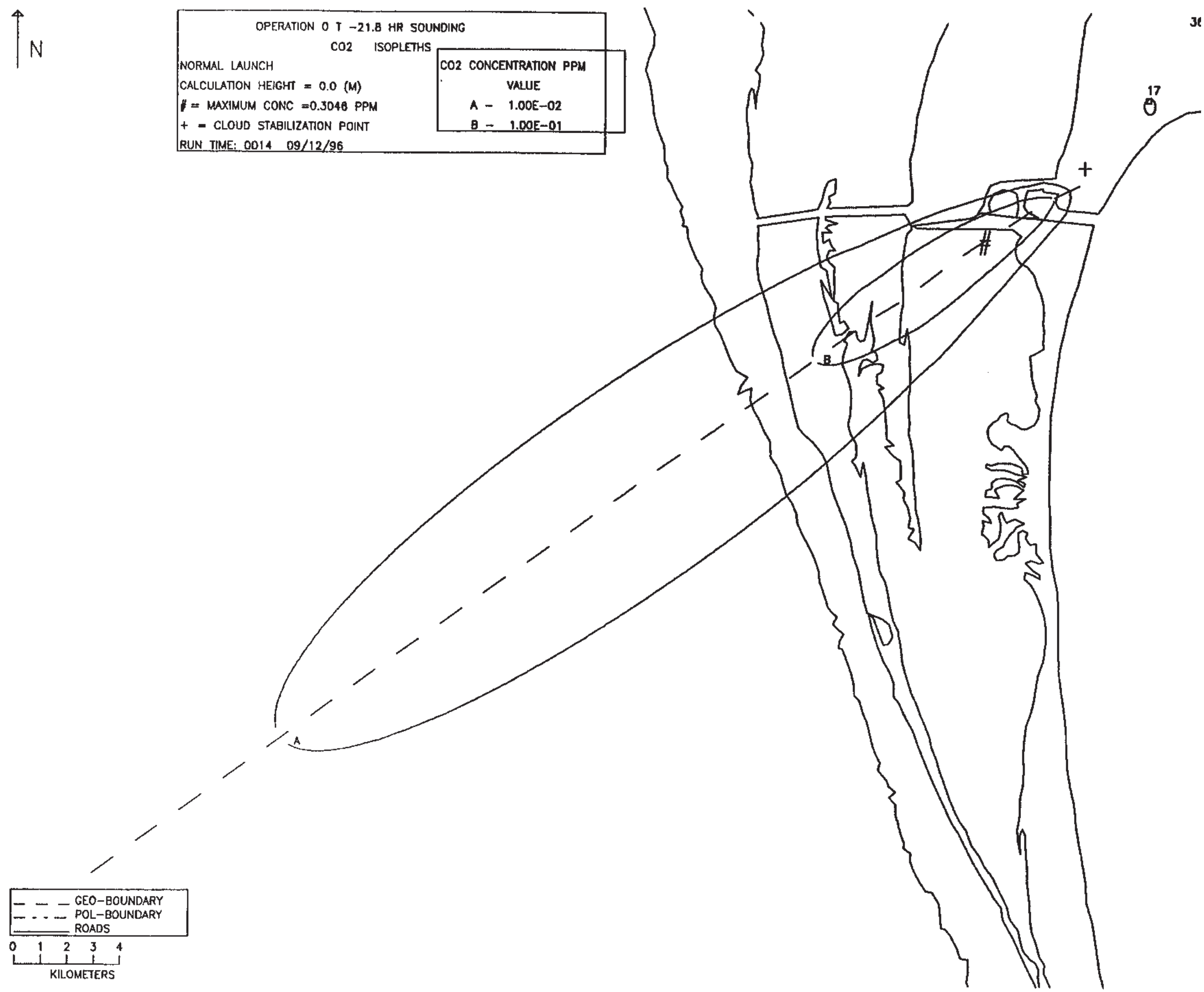
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ROADS
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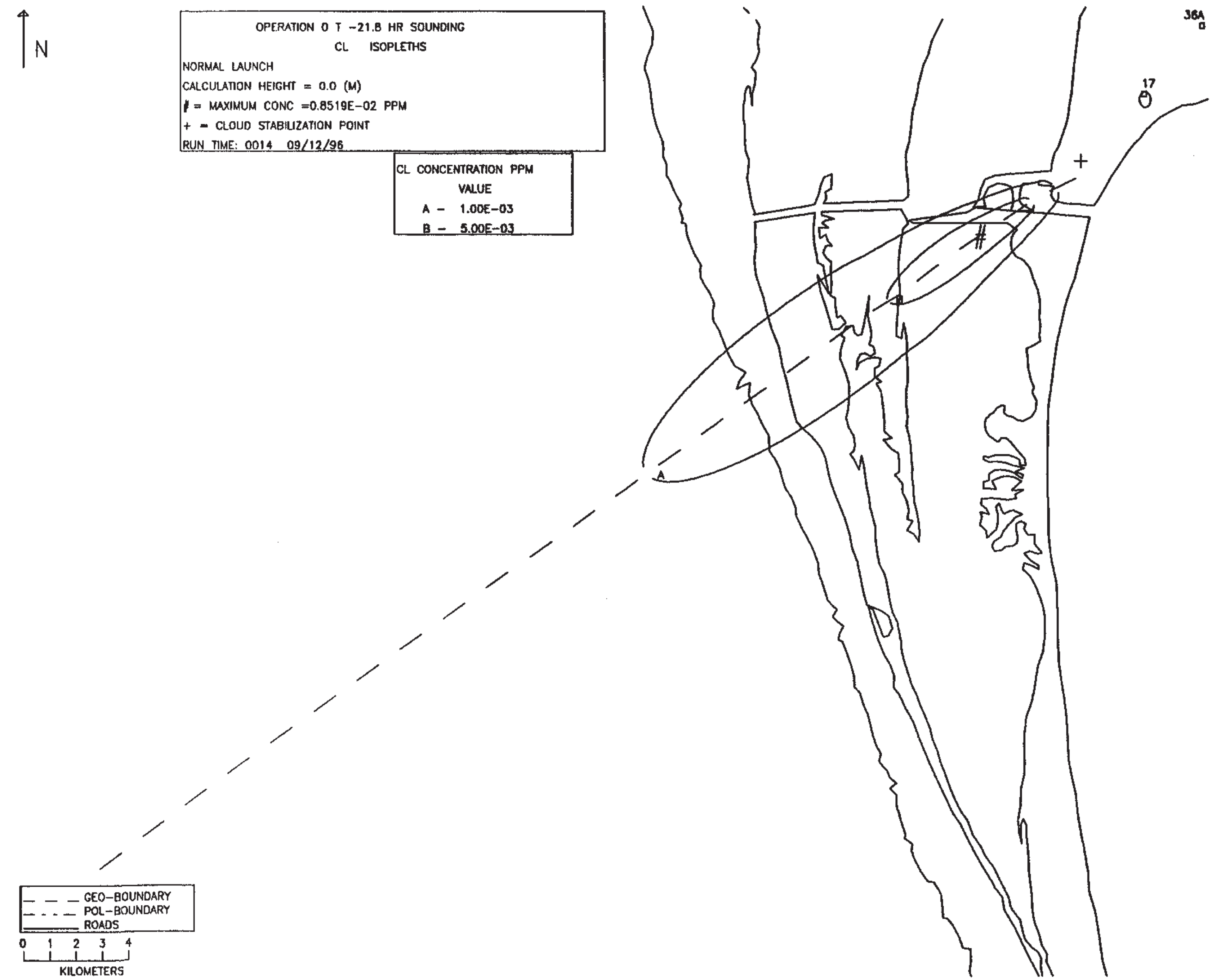
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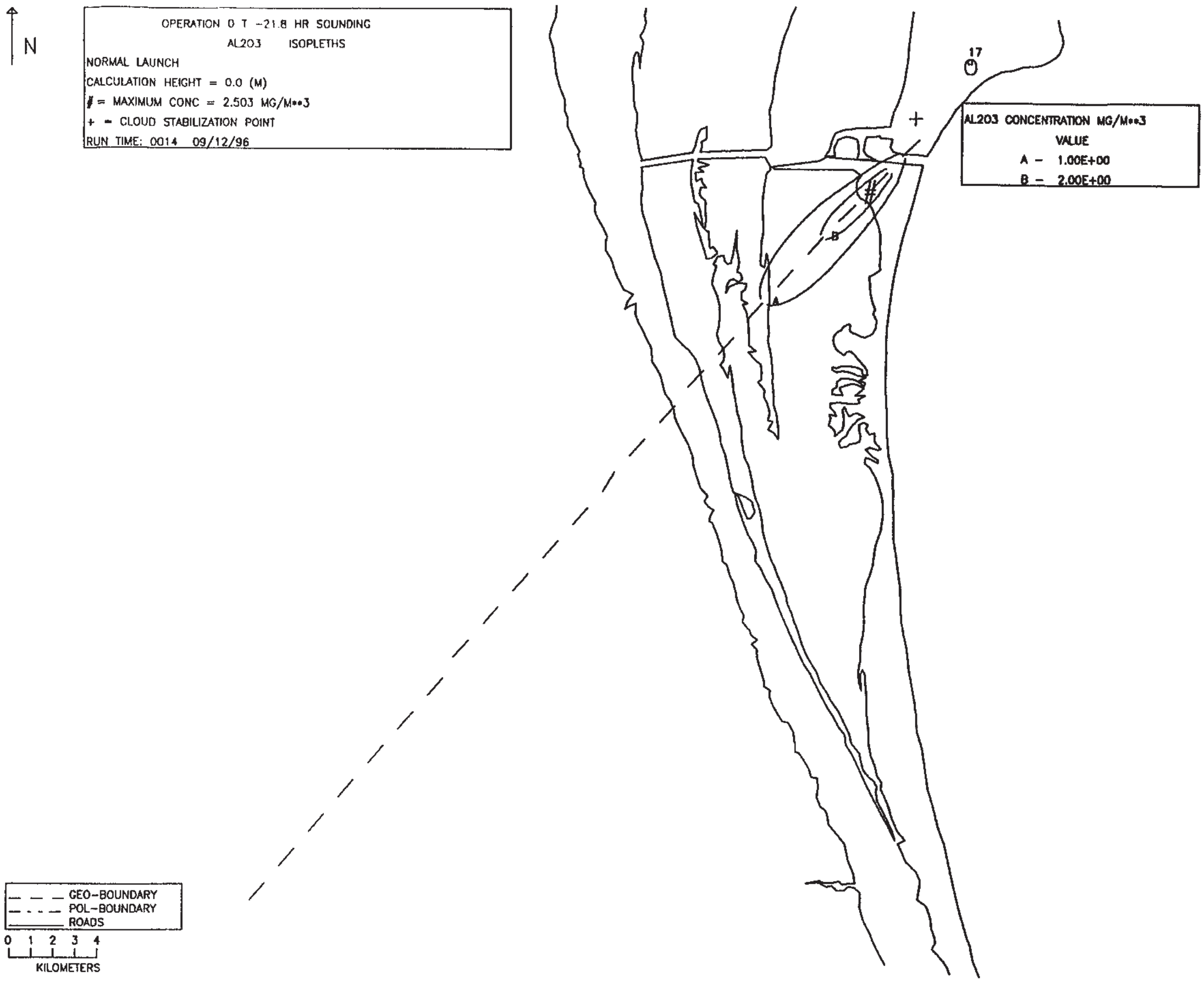
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POL-BOUNDARY
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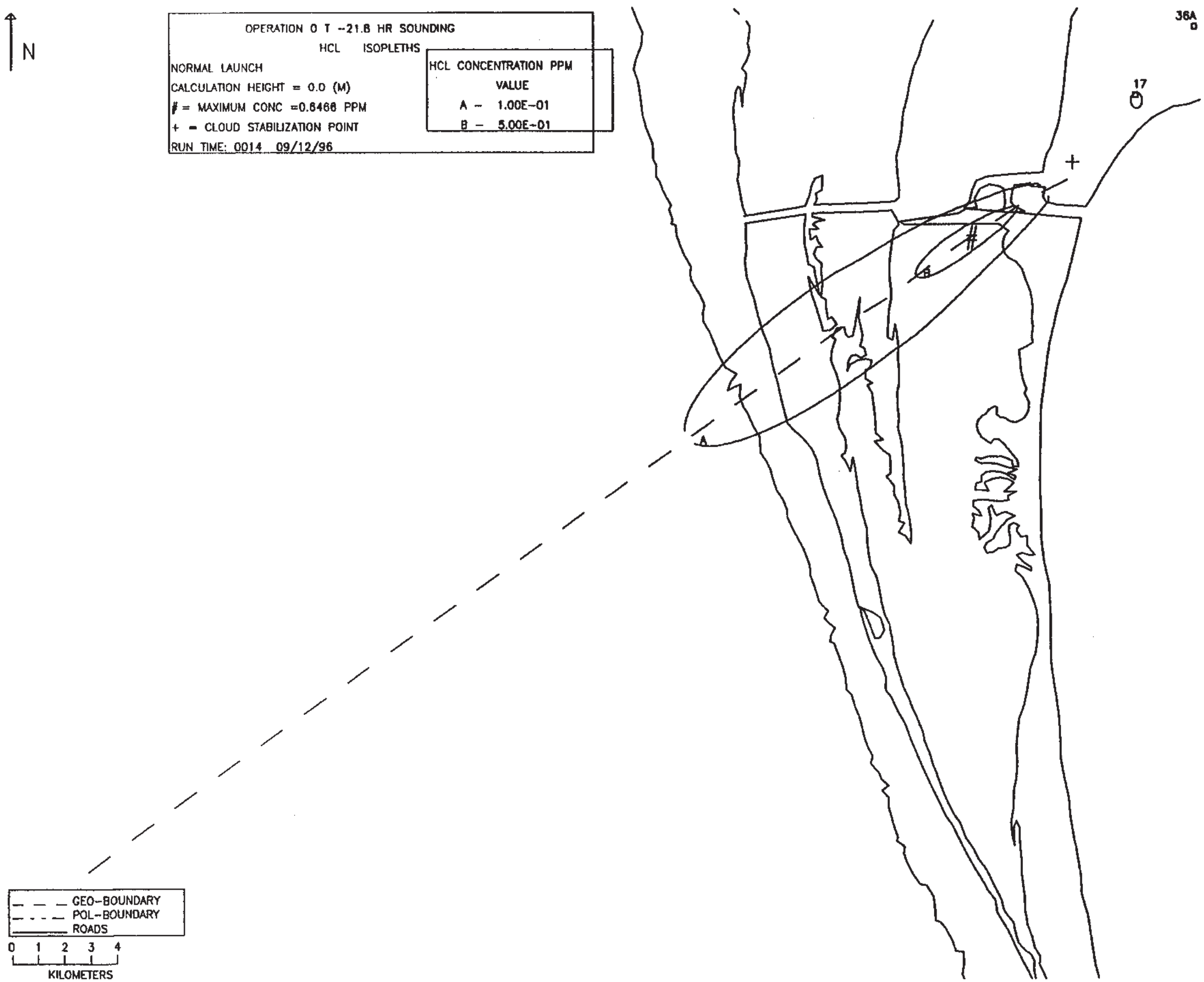
KILOMETERS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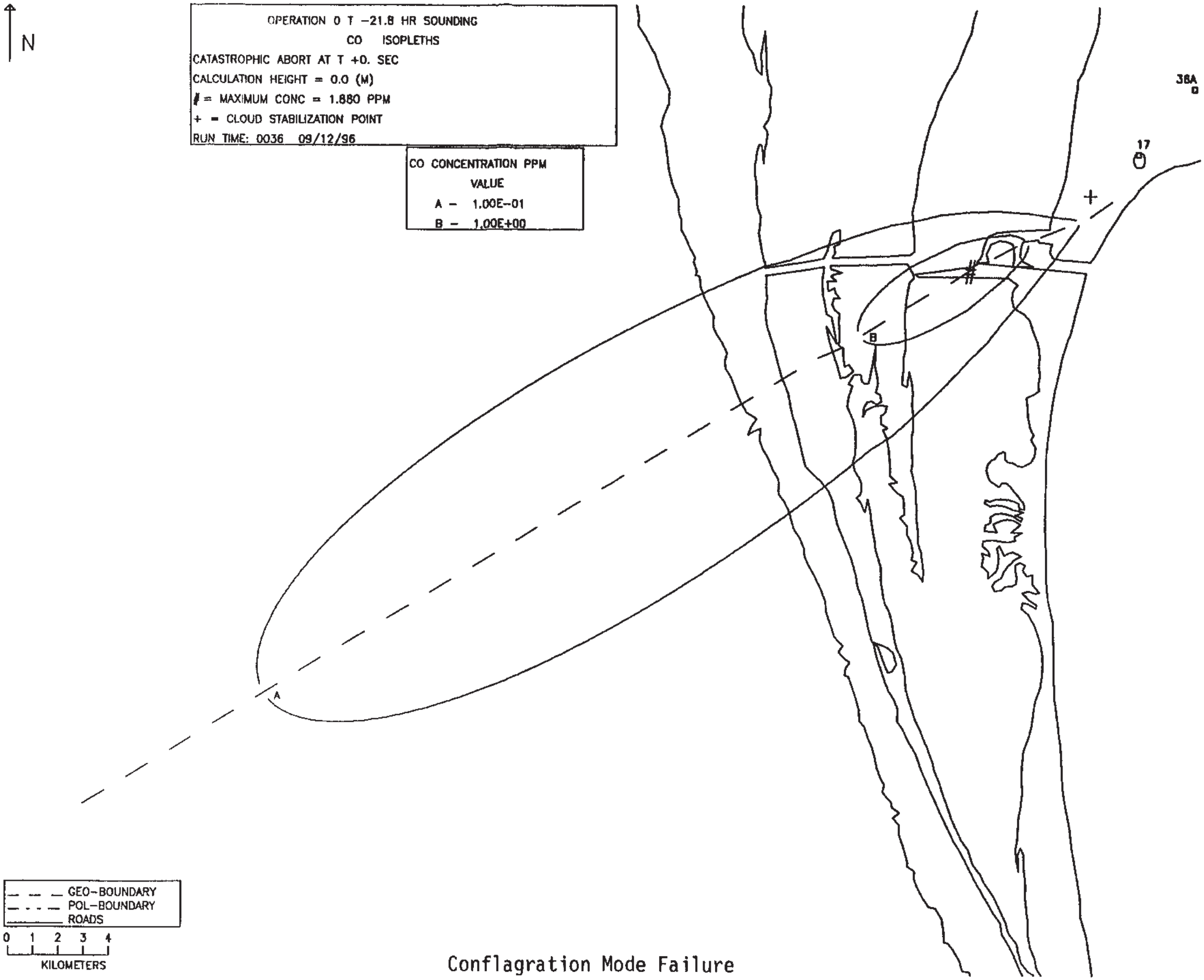

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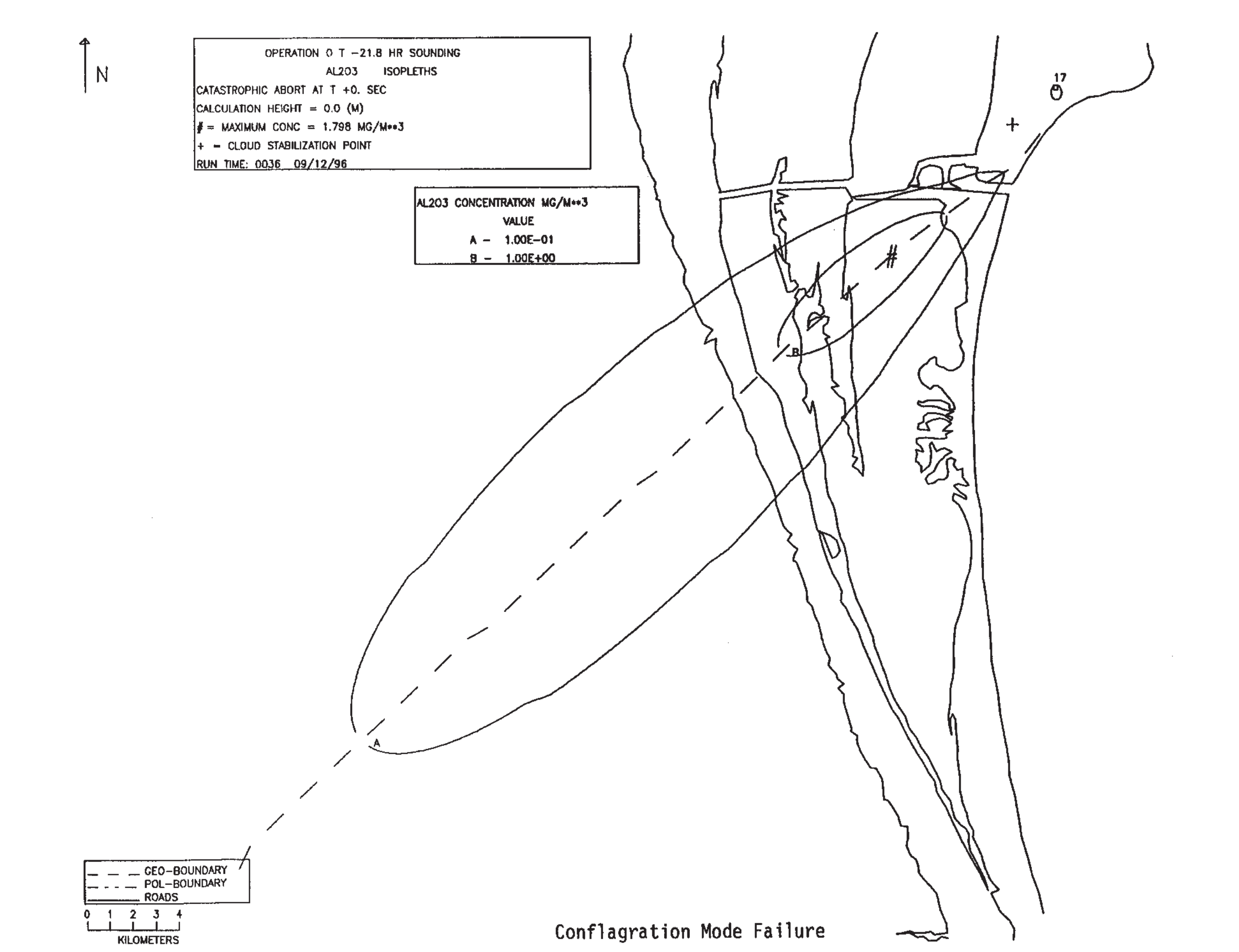

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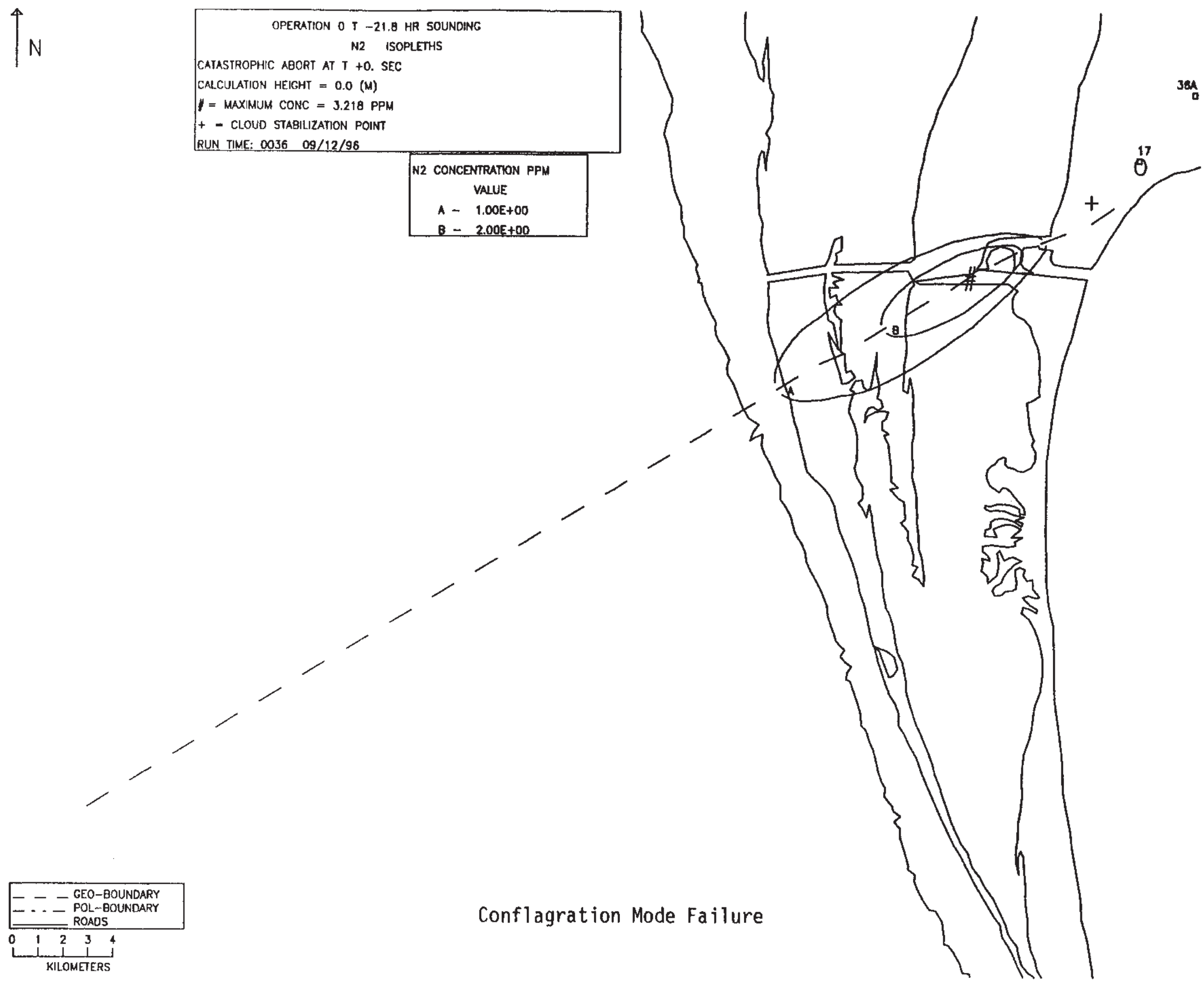

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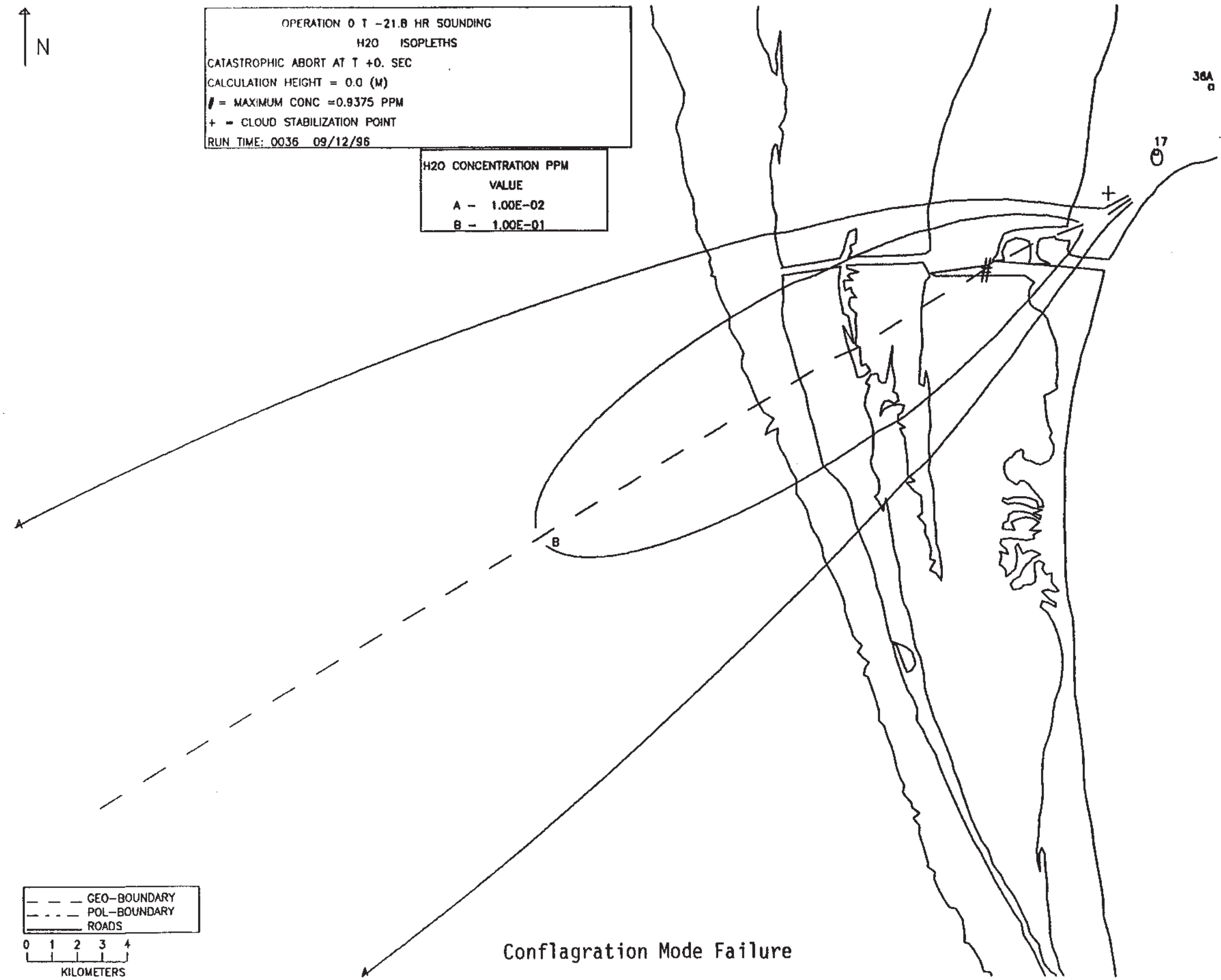

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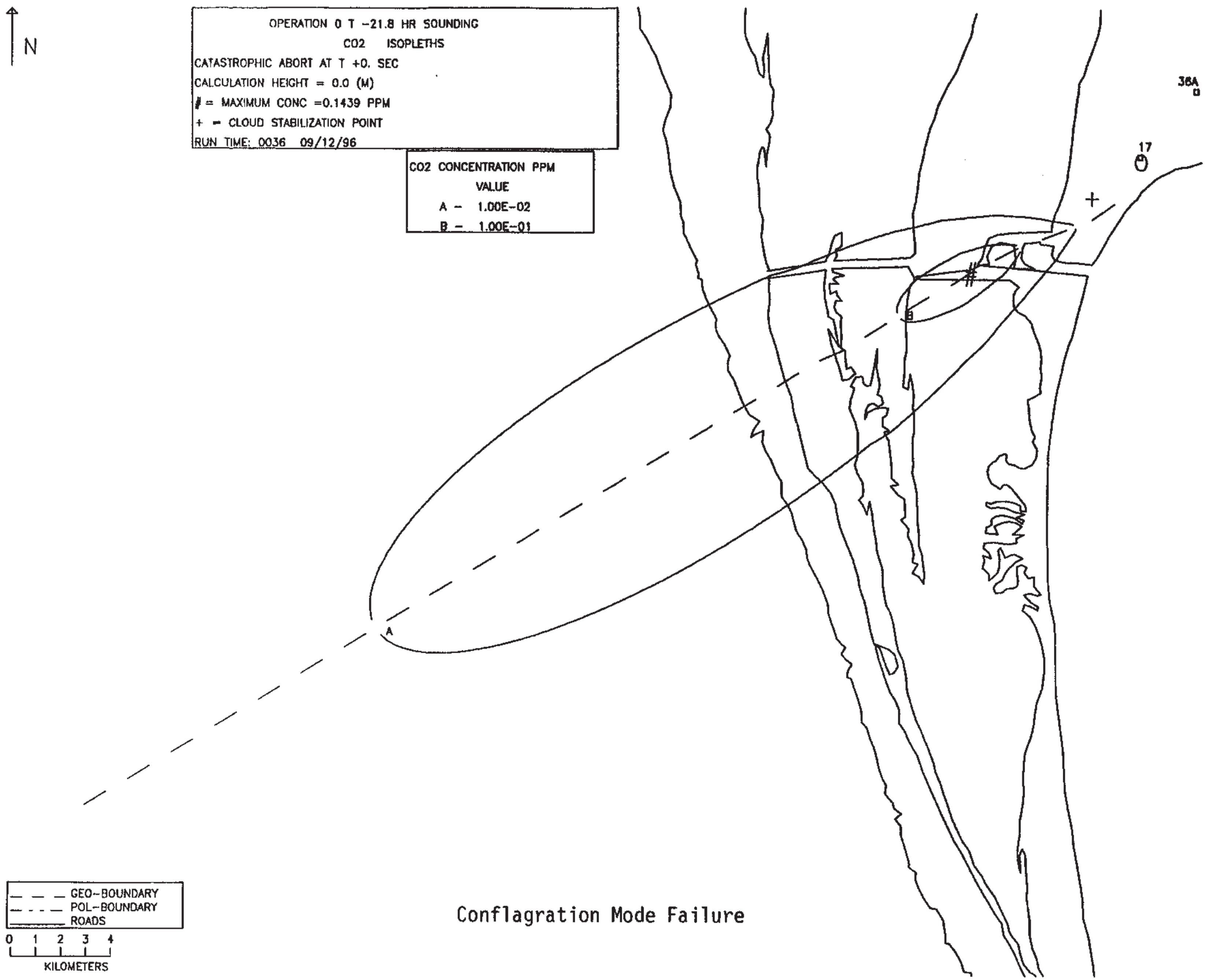

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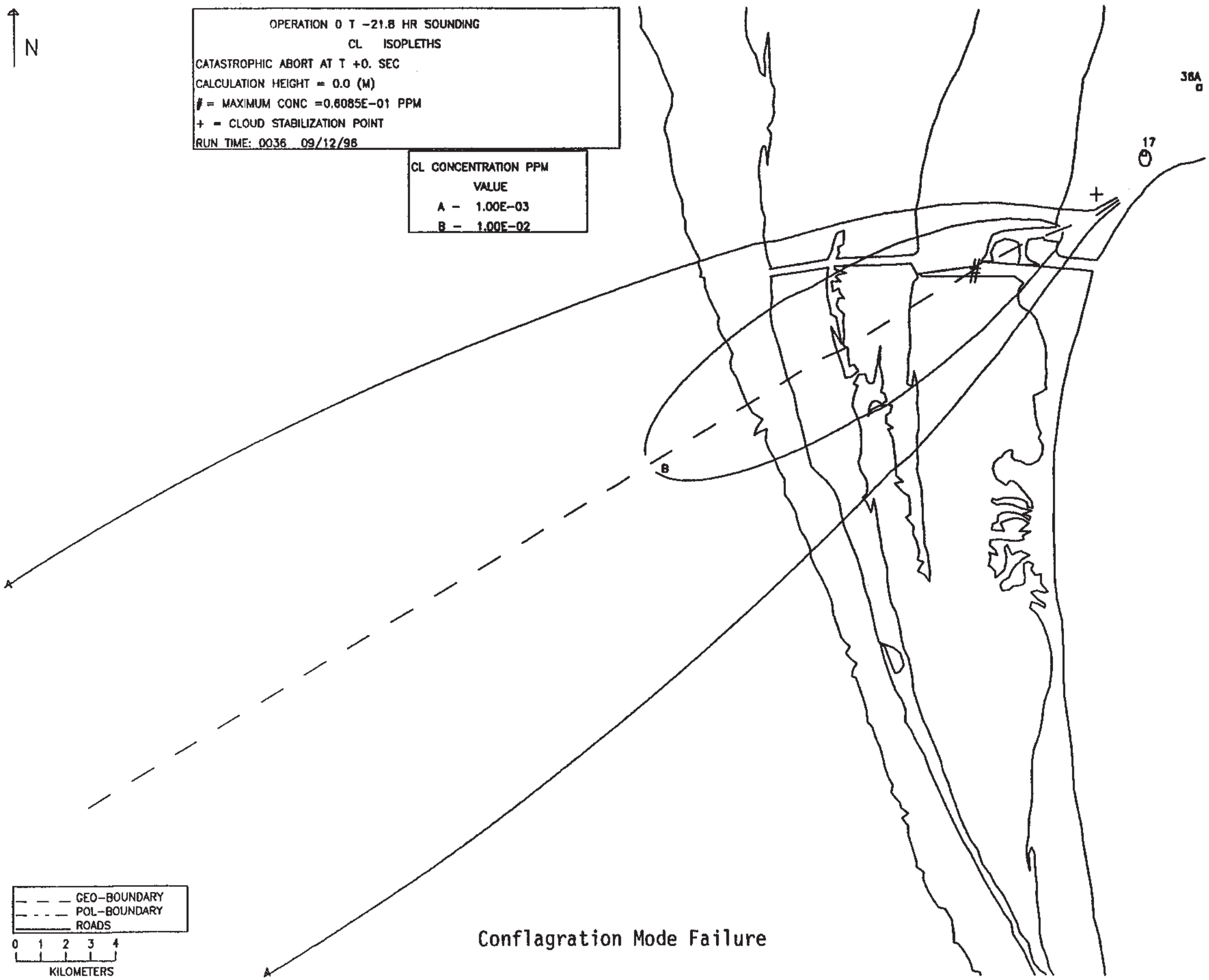

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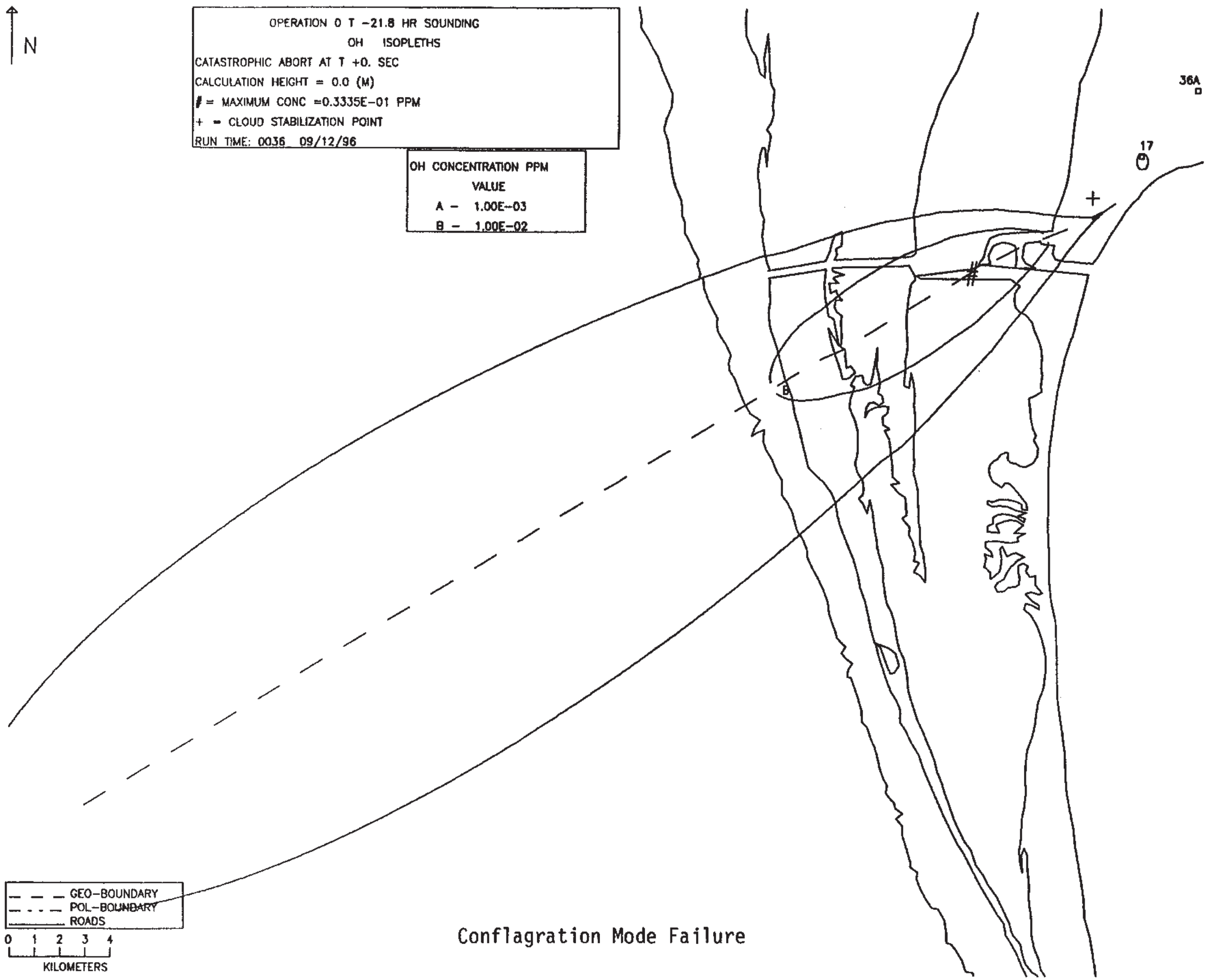

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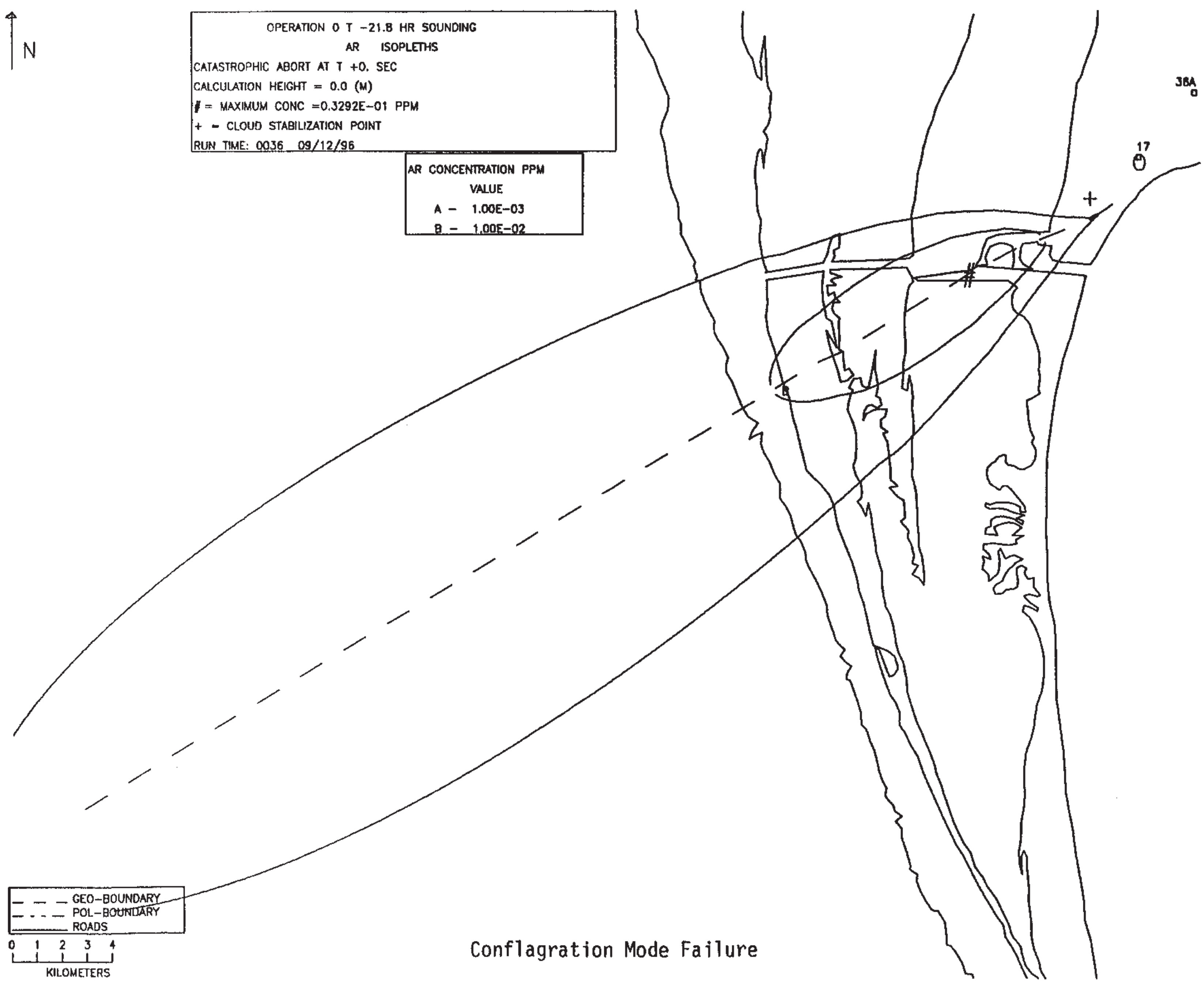
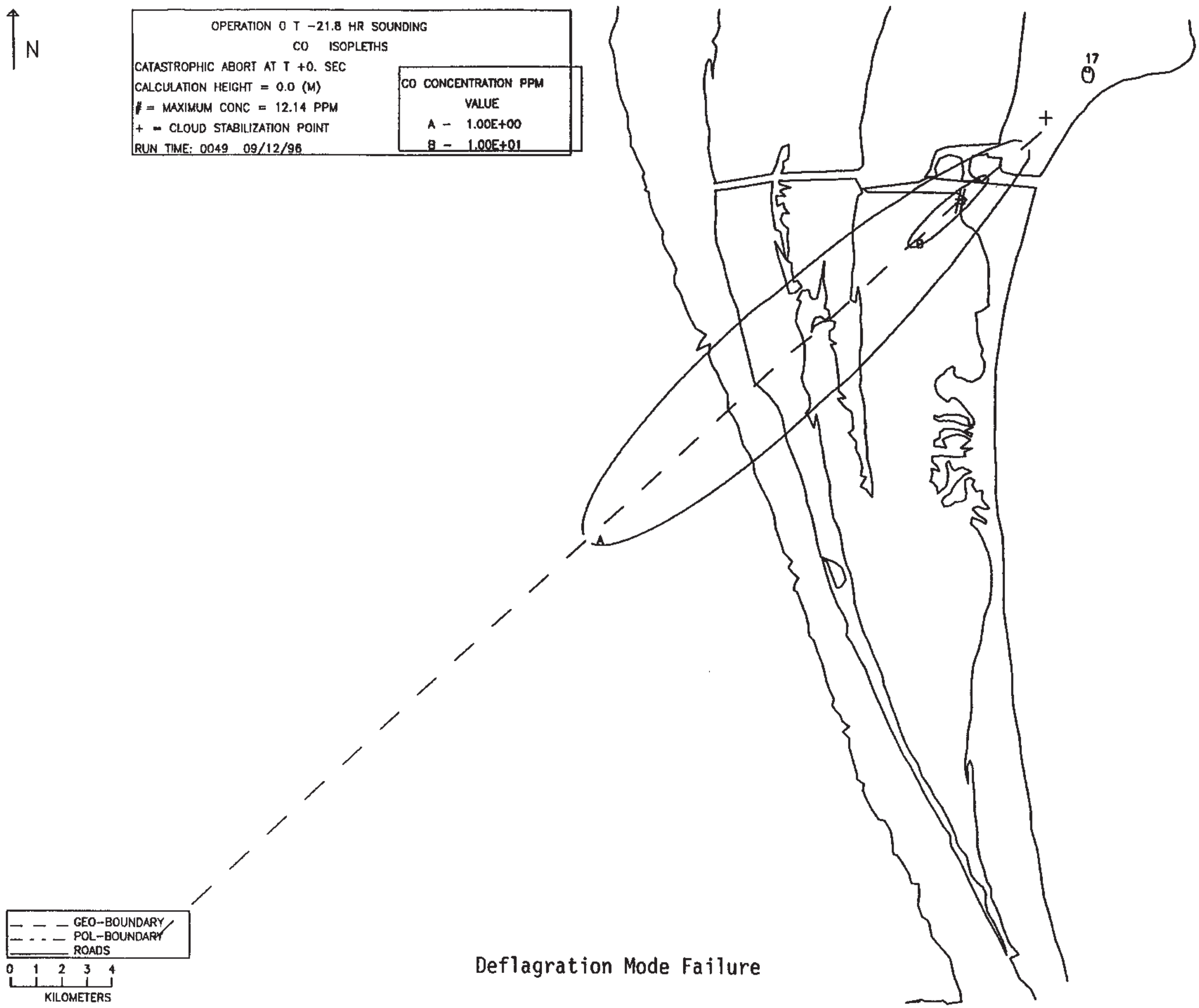


Conflagration Mode Failure



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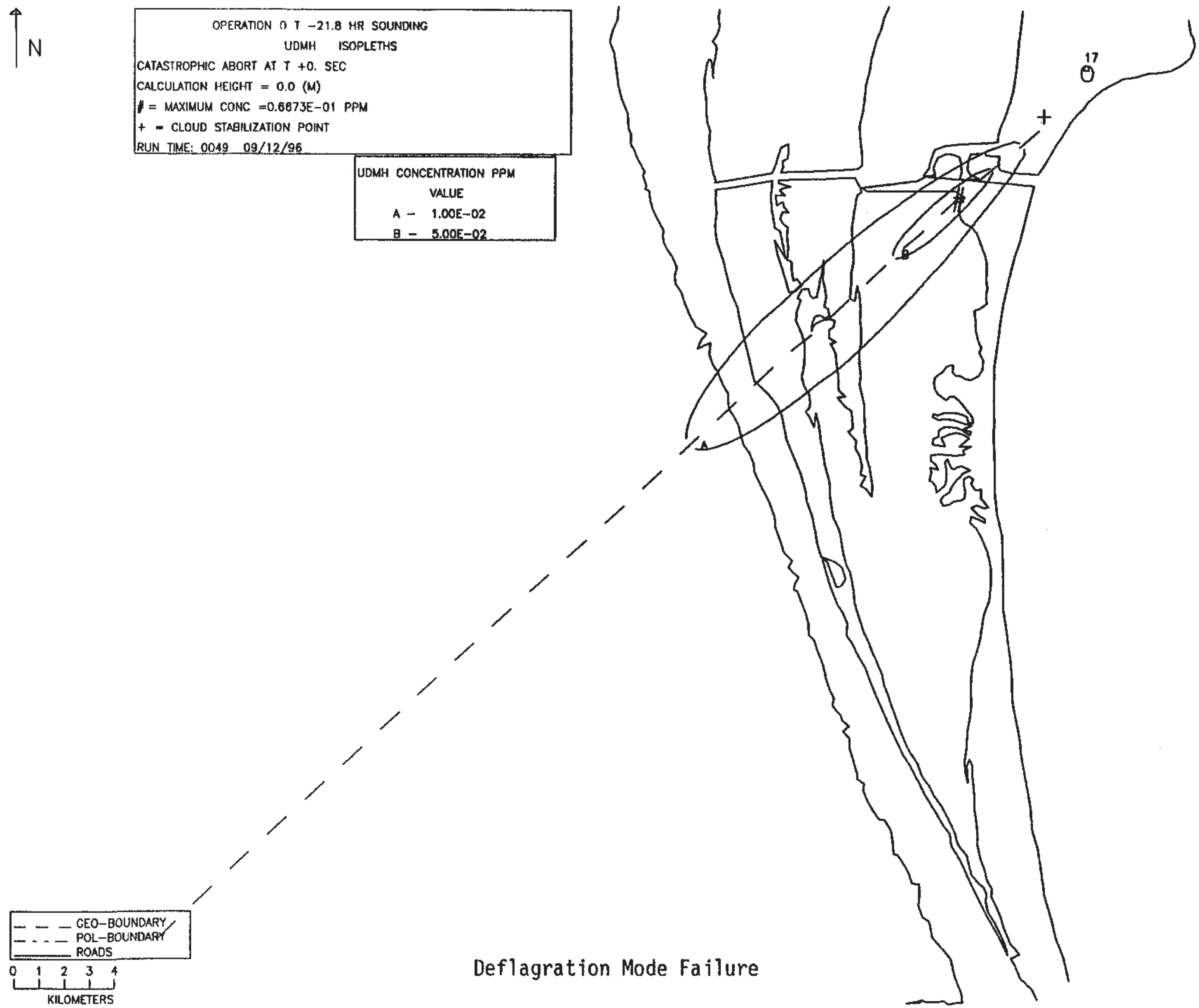

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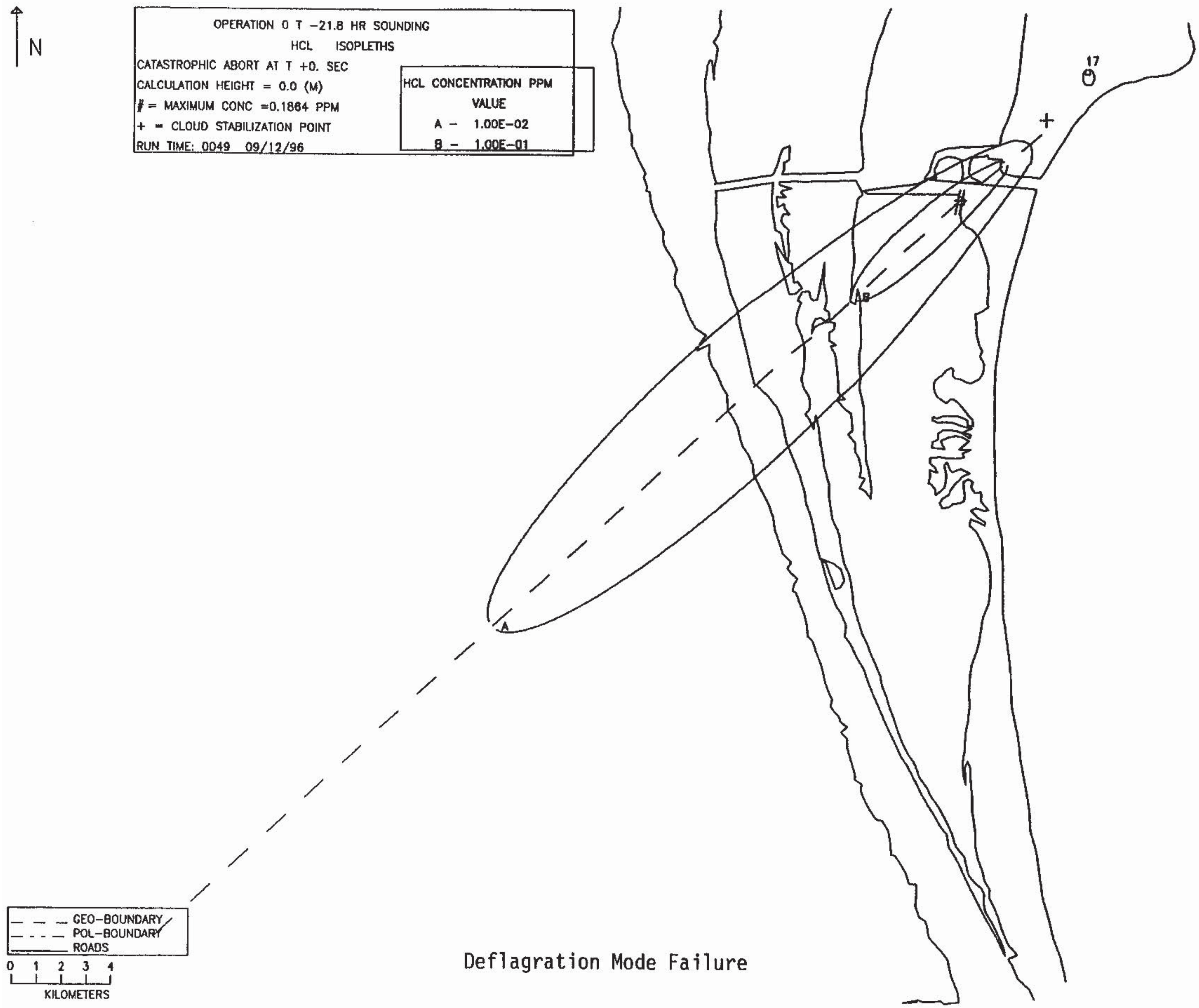

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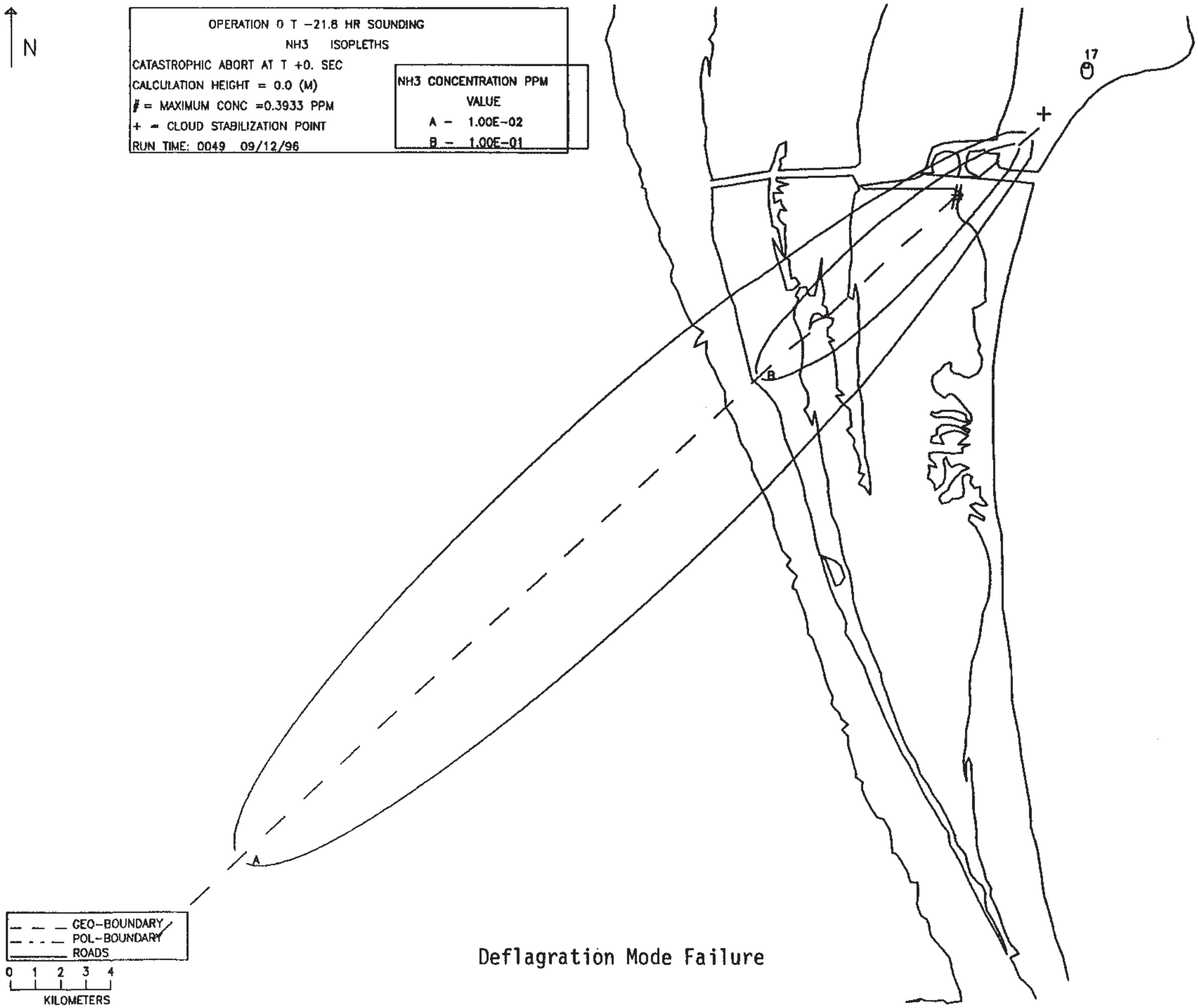

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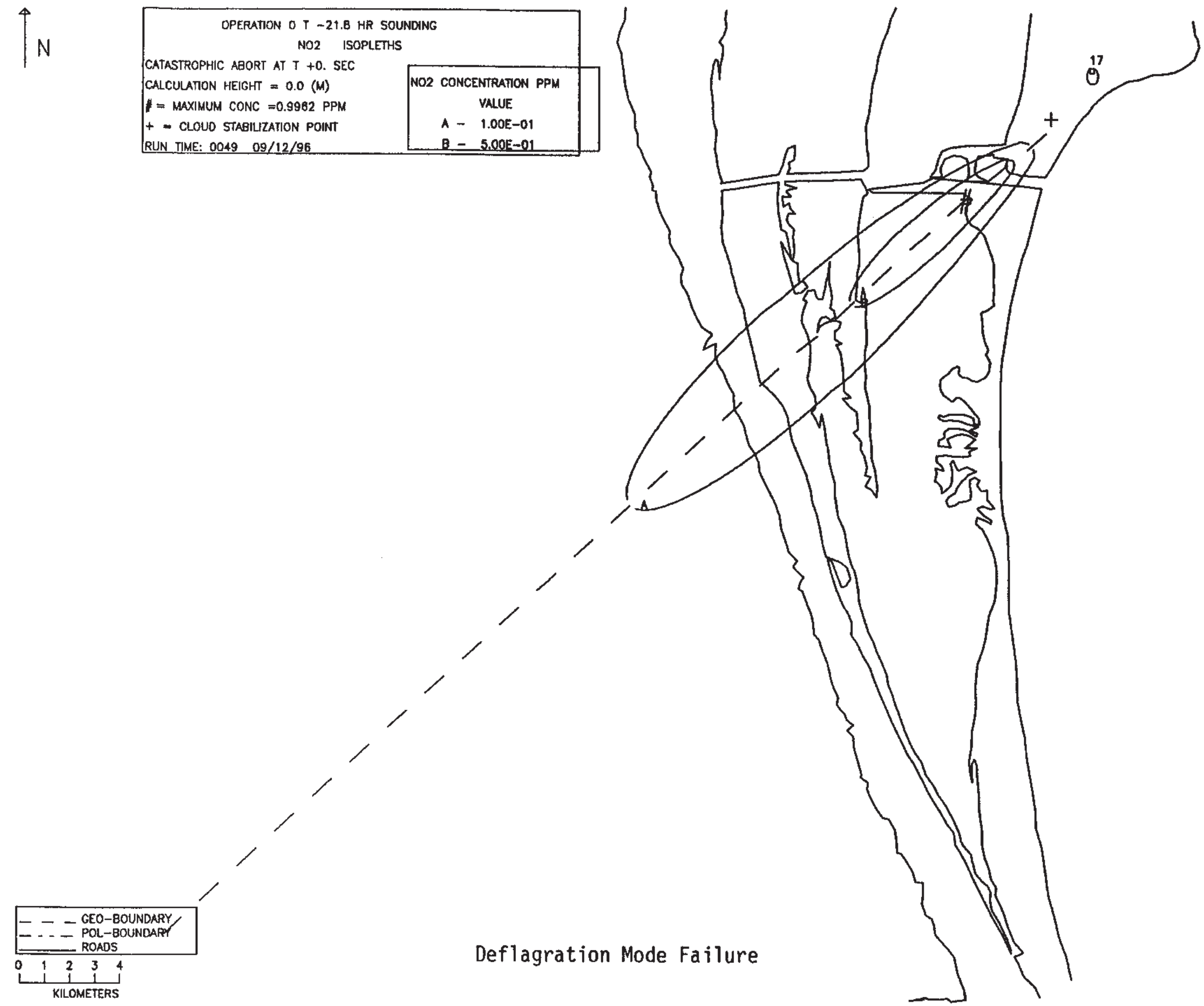

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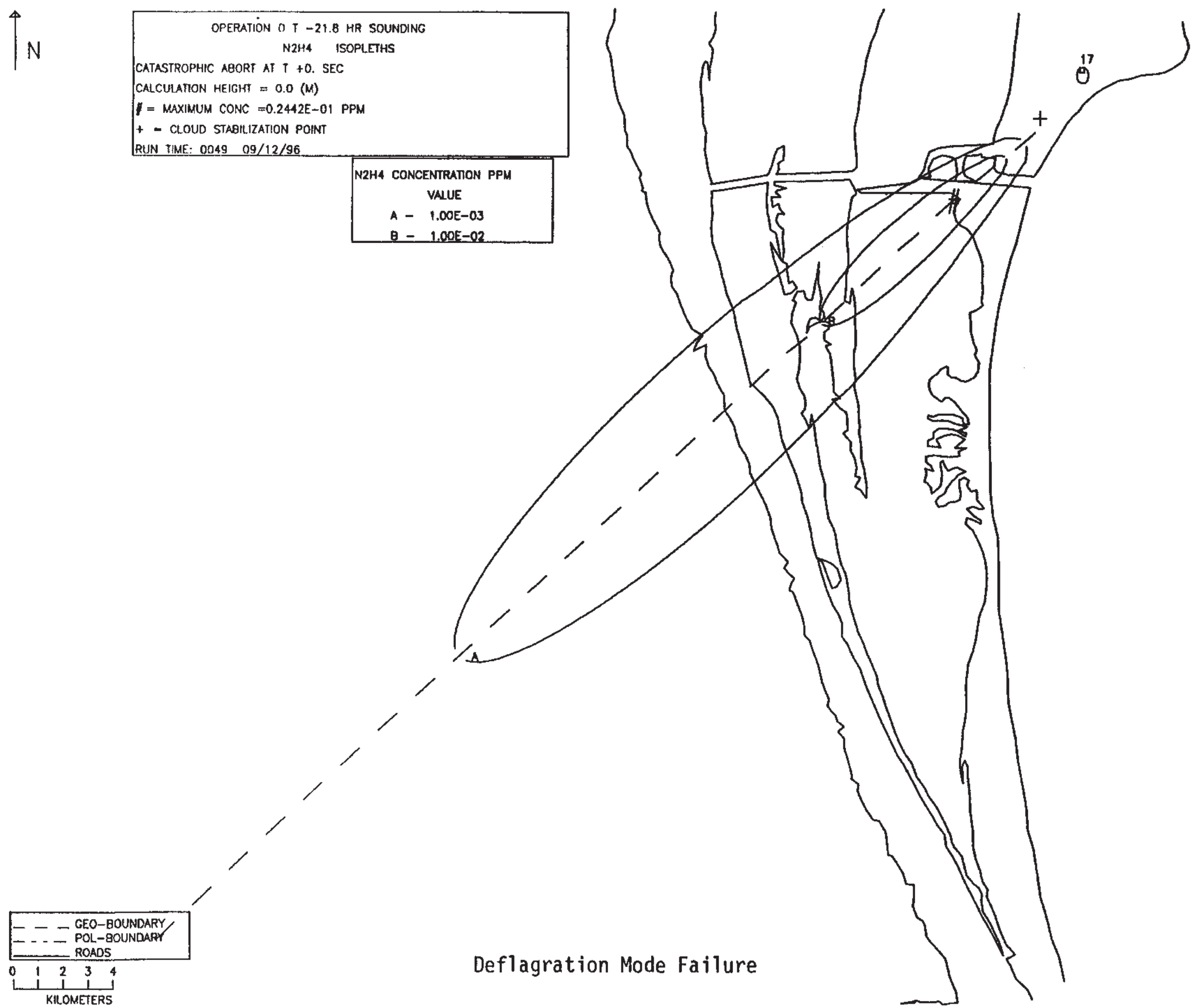

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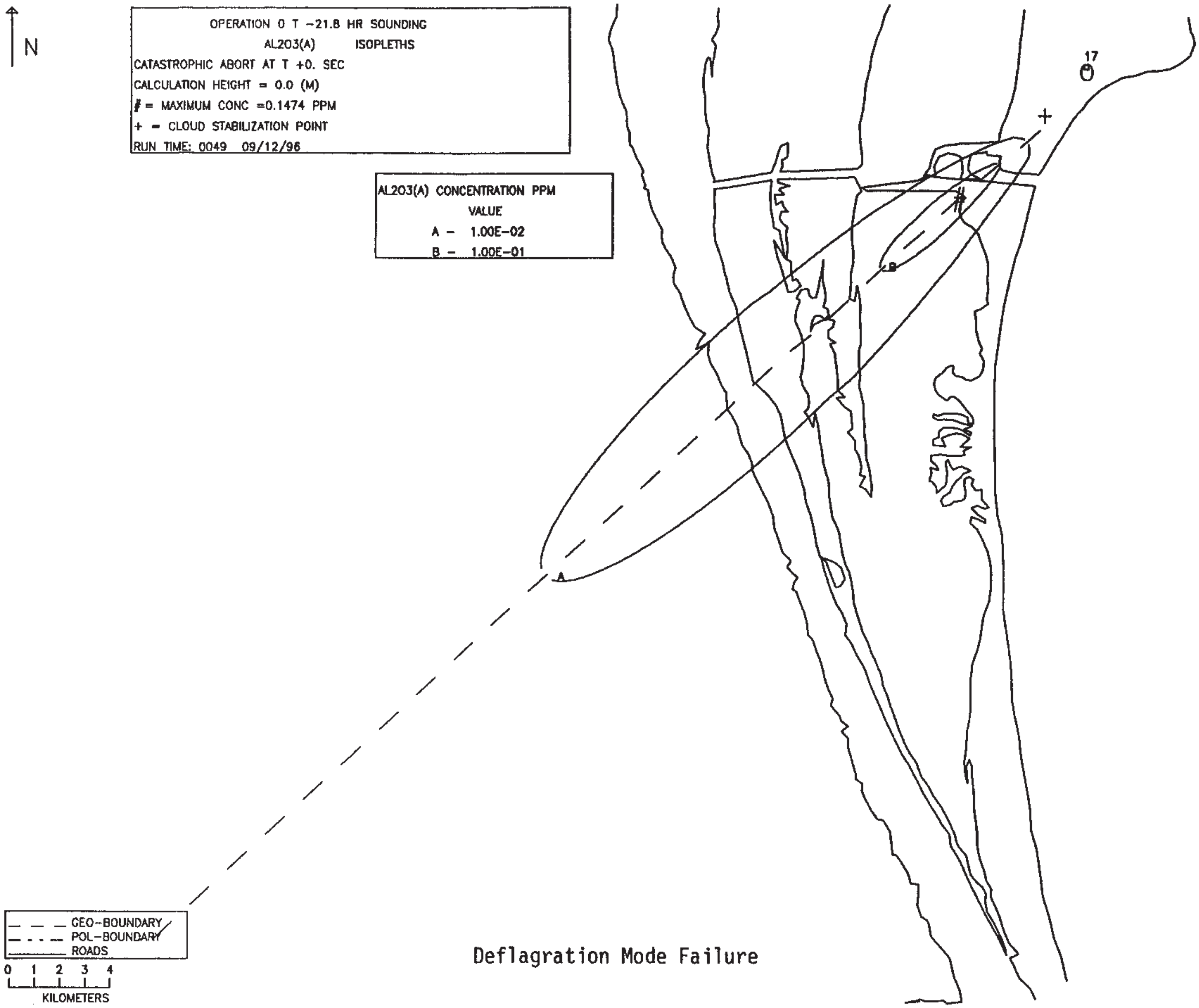

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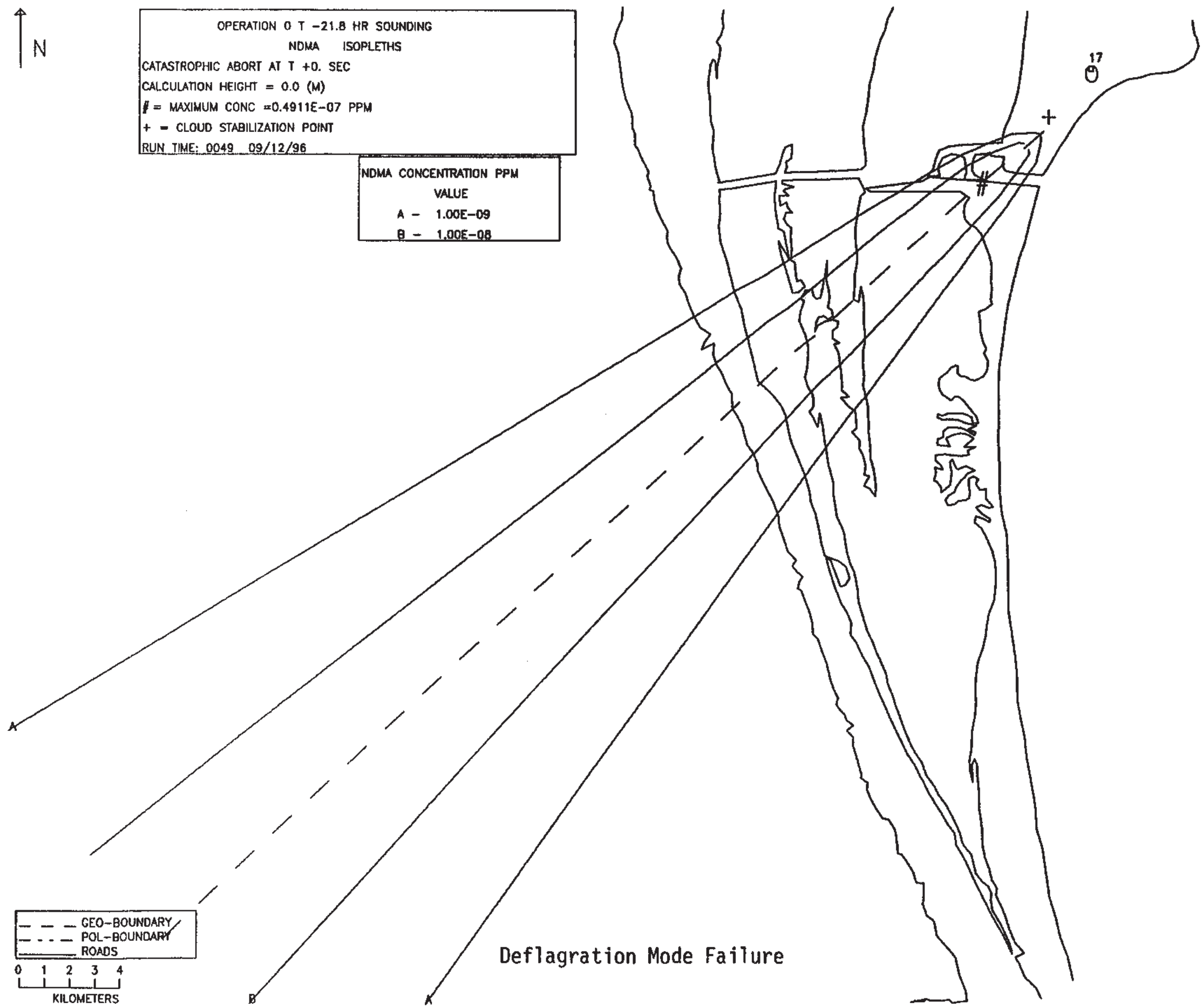

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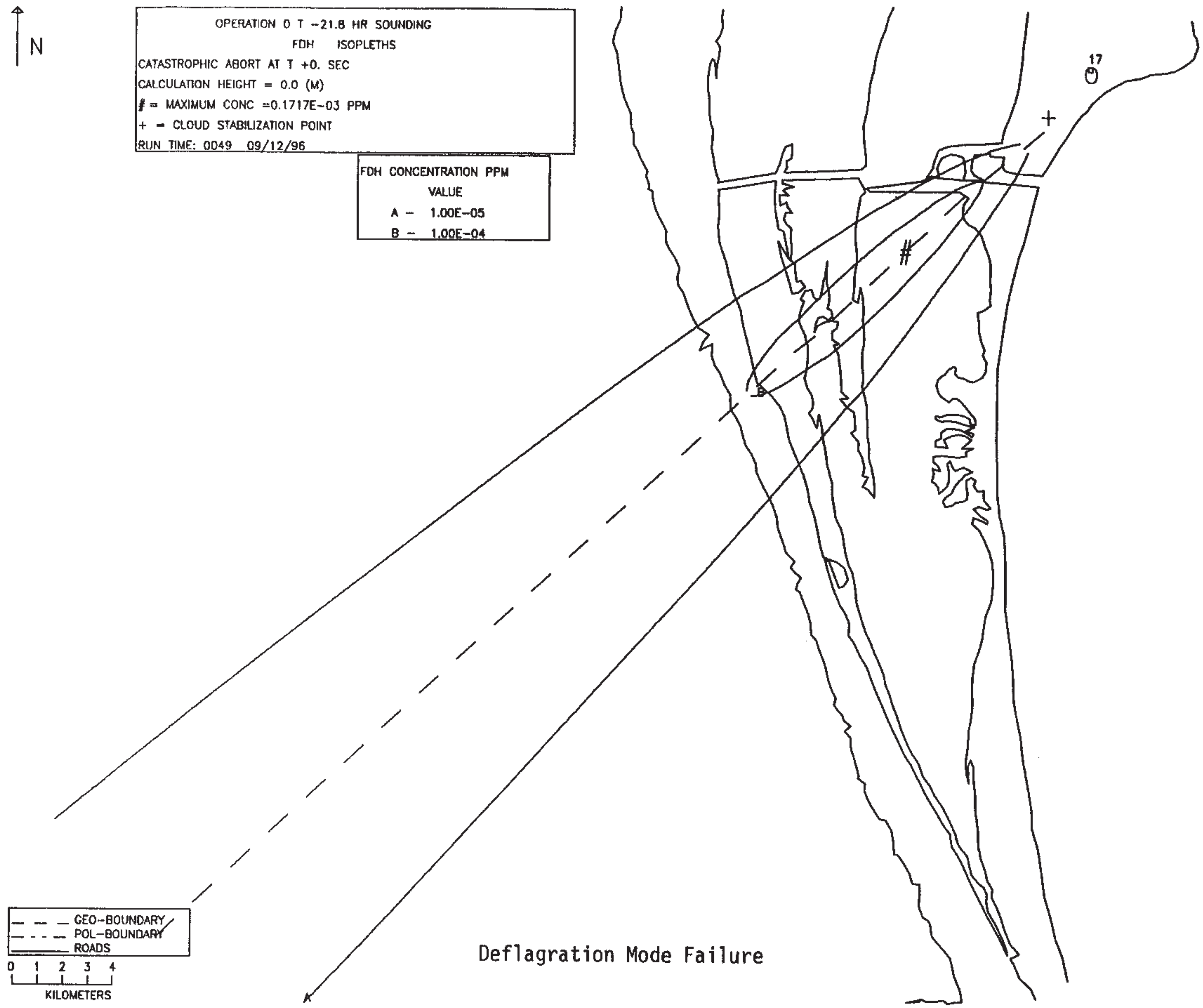

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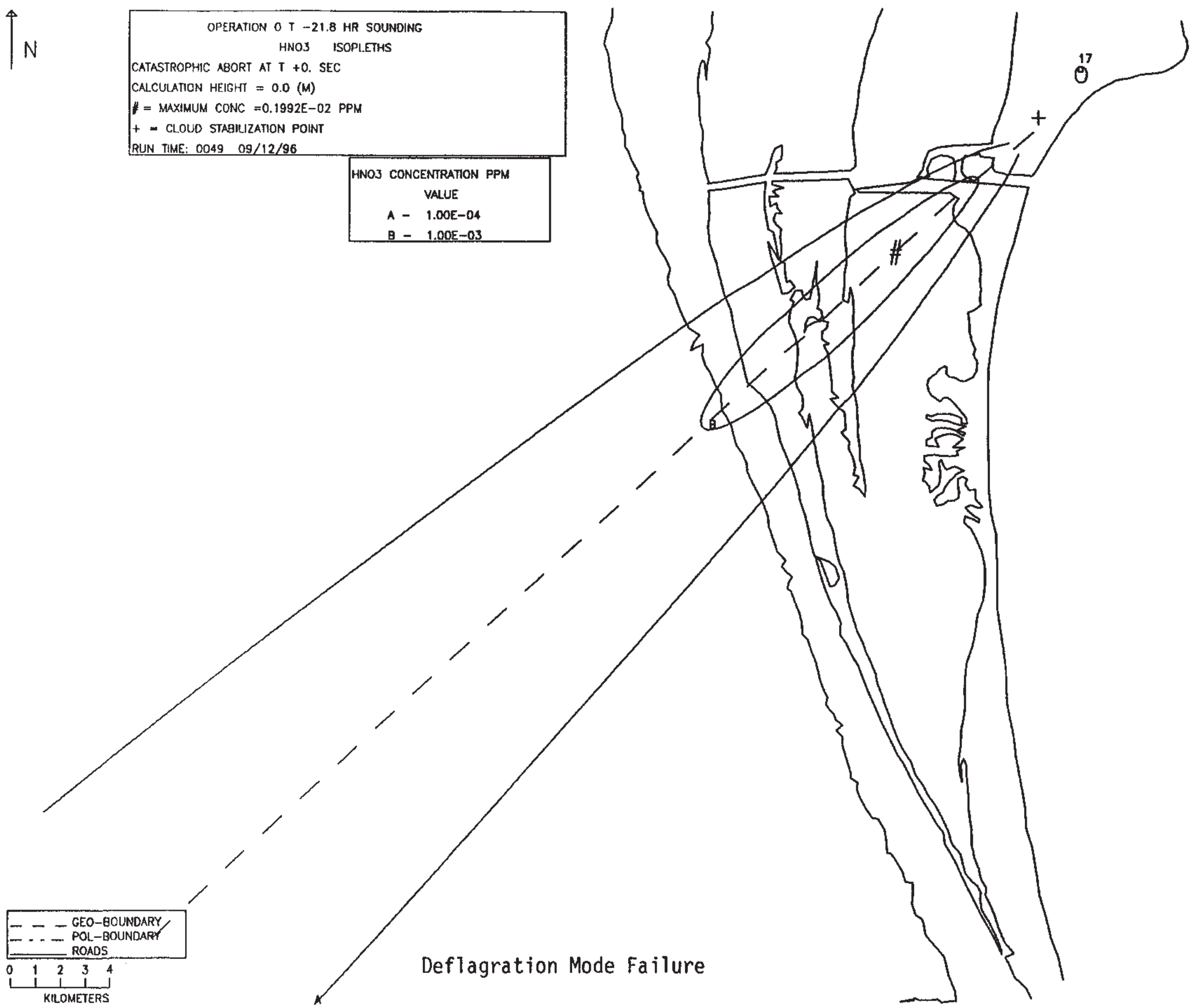

Deflagration Mode Failure