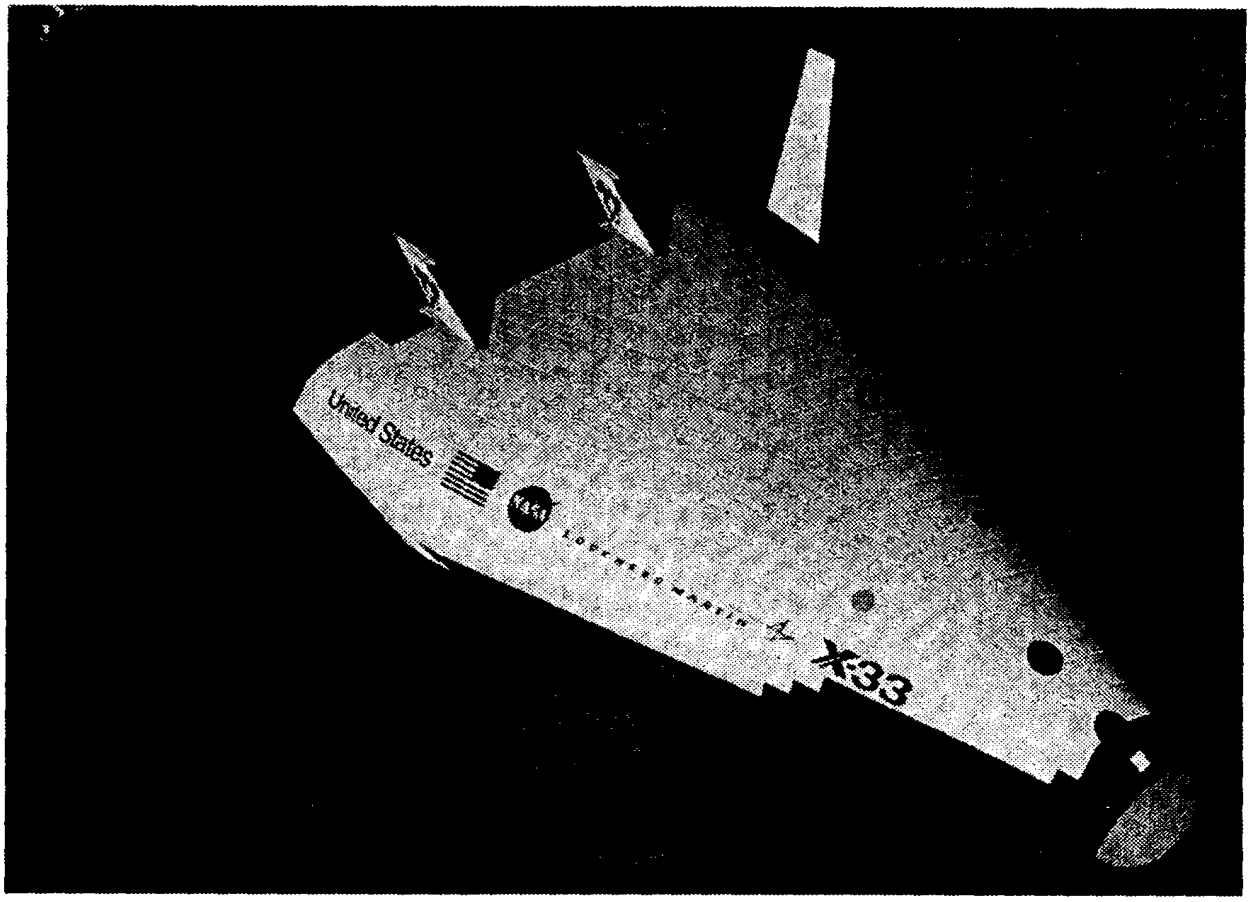
National Aeronautics and
Space Administration

X-33 Advanced Technology Demonstrator Vehicle Program

FINAL ENVIRONMENTAL IMPACT STATEMENT
Volume I



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National Aeronautics and
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AE01/184-97

Reply to Attn of:

TO: Distribution

FROM: AE01/Rebecca C. McCaleb

SUBJECT: "X-33 Advanced Technology Demonstrator Vehicle Program Final Environmental Impact Statement"

By separate shipping means, a copy of the above referenced Final Environmental Impact Statement (EIS) has been sent to you. Included with this correspondence are two errata sheets: (1) Table 3-8 due to some of the data being inadvertently left off the table; and (2) a list of small typos and grammatical errors that were found after the document was printed.

We sincerely appreciate your participation in preparation, review, and comment during scoping and review of the Draft EIS. The Record of Decision containing NASA's final selection of alternatives will be issued no sooner than 30 days after the Notice of Availability (NOA) of the Final EIS. At this time, we anticipate that the NOA will appear in the Federal Register on October 3, 1997.

If you have any questions concerning this document or final actions required by the agency to conclude the environmental process, please contact me by any of the following means:

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Thank you for your participation in the EIS process for NASA's X-33 Program.

Rebecca C. McCaleb, Ph.D.
Director, Environmental Engineering
and Management Office

Enclosures

X-33 Final Environmental Impact Statement

Errata Sheet

1. Replace Table 3-8 (which is incomplete) with the attached Table 3-8.
2. Page 4-63, line 12: Insert "be" between "to" and "minimal."
3. Page 4-74, line 21: Replace "site" with "sites."
4. Page B-109: Replace "Tim Dead" with "Tim Read."
5. Page B-130, response 9-2, line 8: Replace "Unites" with "United."
6. Page B-187, Note, Line 3: Replace "consistantly" with "consistently."
7. Page B-232, response 40-19, line 1: Delete "benefit."
8. Page B-295, response 52-6, line 3: Replace "maintianing" with "maintaining."

Table 3-8. Areas of Potential Environmental Concern in the Silurian Valley Area.

Quadrangle Name	Nature of Area Studied and/or Potential Environmental Problems
Owl Lake	Owl Hole Springs - Manganese ore mill site, small oil spills in proximity to spring, distressed vegetation.
East of Owl Lake	No environmental concerns noted in area.
Old Ibex Pass	Large metal box located near prospect holes, unknown nature of materials (if any) in box.
	Boston Valley Claims - Rock salt deposits, no environmental hazards noted.
	King Claims - Rock salt deposits, no environmental hazards noted.
	Salt Basin Claims - Rock salt and gypsum deposits, no environmental hazards noted.
Saddle Peak Hills	Prospect holes, no environmental hazards noted.
	Ruins of old structure, no environmental hazards noted.
	Salt Spring Hills - Poisonous gases, potential cyanide or mercury contamination from gold separation techniques.
Dumont Dunes	No environmental concerns noted in area.
Valjean Hills	No environmental concerns noted in area.
Avawatz Pass	Denning Springs - Potential cyanide wash tank and smaller vessels containing white powder near old gold mine.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Salt Basin Mines - Mineshafts, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Cottonwood Spring - Old structure and mineshaft, no environmental hazards noted.
Sheep Creek Spring	Sheep Creek Mine - Talc deposits, no environmental hazards noted.
	Sheep Creek Spring - University of California research station, scattered refuse, no environmental hazards noted.
	Large Ore Stockpile - Uncharacterized stockpile, probably containing ore from Sheep Creek Mine.
	Prospect holes, no environmental hazards noted.
	Avawatz Crown Mine - Large operation, potential for leachates from lead, zinc, and silver ore.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Old Mormon Springs Ruins - No environmental hazards noted.
Silurian Lake	Ruins of Renoville - No environmental hazards noted.
	Williams Well - Dry well and possible ore leaching/wash reservoir.
	Mineshaft, prospects, and old ruins - No environmental hazards noted.

Table 3-8. Areas of Potential Environmental Concern in the Silurian Valley Area. (Continued).

Quadrangle Name	Nature of Area Studied and/or Potential Environmental Problems
Silurian Hills	Mineshaft, prospects - Moderate amount of partially buried refuse in wash near mine.
	Mineshafts - Large amount of household refuse thrown down vertical shaft, not fully characterized.
	Mineshaft and prospect holes - No environmental hazards noted.
	Former Riggs Tonopah and Tidewater railroad siding - underground cistern or tank and possible well.
	Former Valjean settlement - No environmental hazards noted.
	Annex and Berryhill talc and silver mines and residence - uncharacterized tailings potentially containing zinc, lead, and silver, aboveground storage tank at residence.
	Prospect holes, no environmental hazards noted.
	Mineshafts, prospects, and processing site - Very large reservoir may have been leach tank, 55-gallon drum containing whitish powder.
	Riggs Mine - Large operation, tailings may contain leachable lead and silver, abandoned well, former processing area.
	Silver Hills Mine #1 - No environmental hazards noted.
	Prospect holes, no environmental hazards noted.
Red Pass Lake, NE	Small structure near unnamed spring in Avawatz Mountains - No environmental hazards noted.
	Mineshafts and prospects - No environmental hazards noted.
Silurian Valley	Caltrans road maintenance area - No environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Borrow pit - No environmental hazards noted.
	Borrow pit - No longer locatable, no environmental hazards noted.
North of Baker	Former Tonopah and Tidewater railroad talc siding - No environmental hazards noted.
	Mineshaft and prospects - No environmental hazards noted.
	Extensive mineshafts and prospect holes - No environmental hazards noted.
	Moderate size gravel pit - Road grader and water truck, no environmental hazards noted.

X-33 ADVANCED TECHNOLOGY DEMONSTRATOR VEHICLE PROGRAM

FINAL ENVIRONMENTAL IMPACT STATEMENT

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Date: September 1997

ABSTRACT

The Final Environmental Impact Statement (EIS) addresses environmental impacts associated with implementing the proposed action of: (1) preparation of flight operations facilities, including launch infrastructure; and (2) ground and flight test of a "lifting body" concept of a fully reusable spaceplane, dubbed the eXperimental-33 (X-33). The flight test program would have a common flight operations and launch site within Edwards Air Force Base (EAFB) near Lancaster, California. The X-33 would be tested using a flight envelope expansion plan of progressively increasing altitude, speed and distance until full vehicle performance is verified at a speed of 18,000 km/hr (11,000 mph). Optimally, the flight test plan to meet Program objectives would involve flights of downrange distances of approximately 160 km (100 mi) (short-range), 720 km (450 mi) (mid-range), and 1,530 km (950 mi) (long-range). Reasonable alternatives identified to satisfy Program flight test objectives are: (1) for the launch site–Haystack Butte and Space Port 2000 sites within Edwards Air Force Base; and (2) for the landing sites–short-range landing–Armitage Airfield within China Lake Naval Air Warfare Center near Ridgecrest, California, and Silurian Lake near Baker, California; mid-range landing–Michael Army Air Field within Dugway Proving Ground near Tooele, Utah; and long-range landing–Malmstrom Air Force Base near Great Falls, Montana, and Grant County Airport near Moses Lake, Washington. Issues of potential primary concern are noise and sonic boom; flight safety; transportation effects; and airspace and air traffic impacts.

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ABBREVIATIONS AND ACRONYMS

341 MW	341st Missile Wing
ac	acre(s)
ac-ft	acre-feet
ACEC	area of critical environmental concern
ACM	asbestos-containing material
AF	Air Force
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFFTC/EM	Air Force Flight Test Center/Environmental Management
AFI	Air Force Instruction
AFOSH	Air Force Occupational Safety and Health
AFR	Air Force Regulation
AFSPC	Air Force Space Command
AGL	above ground level
AICUZ	Air Installation Compatible Use Zone
APCD	Air Pollution Control District
APZ	Accident Potential Zone
AQCR	Air Quality Control Region
AQMD	Air Quality Management District
ARG	Air Refueling Group
ARTCC	Air Route Traffic Control Center
ATV	all terrain vehicle
AUTODIN	Automatic Digital Network
AUTOVON	Automatic Voice Network
AVAPCD	Antelope Valley Air Pollution Control District
AVEK	Antelope Valley East Kern (Water District)
bgs	below ground surface
BHPO	Base Historic Preservation Officer
BLM	Bureau of Land Management
°C	degrees Celsius
CA	California
CAAA	Clean Air Act Amendment
CAAQS	California Ambient Air Quality Standard
CAN	Cooperative Agreement Notice
CCR	California Code of Regulations
CDCA	California Desert Conservation Area

CDOT	California Department of Transportation
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	centimeter(s)
CNEL	Community Noise Equivalent Levels
CNPS	California Native Plant Society
CO	carbon monoxide
COE	Corps of Engineers
CONUS	Continental U.S.
CSEL	C-weighted sound exposure level
CTS	Center Telecommunications System
CZ	Clear Zone
dB	decibel(s)
dBA	decibel, weighted to the A-scale
DNL	Day/Night Level
DOD	Department of Defense
DODD	Department of Defense Directive
DSN	Defense Switch Network
EA	Environmental Assessment
EAFB	Edwards Air Force Base
EDNA	Environmental Designation for Noise Abatement
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ES/QD	explosive safety/quantity distance
ET	external tank
^{o}F	degrees Fahrenheit
FAA	Federal Aviation Administration
FDEP	Federal Directorate of Environmental Programs
FLPMA	Federal Land Policy and Management Act
FRF	flight readiness firings
FSOC	Federal Species of Concern
ft^2	square feet
ft/day	feet per day
ft/sec	feet per second
FTS	Flight Termination System
gal	gallon(s)
GH_2	gaseous hydrogen

GHe	gaseous helium
GLOW	gross liftoff weight
GOX	gaseous oxygen
GN_2	gaseous nitrogen
GPD	gallons per day
gpm	gallons per minute
H_2	hydrogen
ha	hectare(s)
HAP	hazardous air pollutant
HQ	Headquarters
HUD	Housing and Urban Development
HWSTF	Hazardous Waste Storage and Transfer Facility
Hz	hertz
IC	internal combustion
in	inch(es)
IFR	instrumental flight rules
INEEL	Idaho National Engineering and Environmental Laboratory
IRP	Installation Restoration Program
ISDNO	Integrated Switched Digital Network
JPL	Jet Propulsion Laboratory
kbps	kilobytes per second
KCAPCD	Kern County Air Pollution Control District
kg	kilogram(s)
kg/mo	kilograms per month
kg/yr	kilograms per year
kgd	kilograms per day
km	kilometer(s)
km/hr	kilometers per hour
kPa	kilopascal(s)
kV	kilovolt(s)
L	liter(s)
L_{dn}	day-night average sound level
LAFB	Larson Air Force Base
LAN	local area network
LF	linear feet
lb	pound(s)
lb/mo	pounds per month
lb/yr	pounds per year

LH_2	liquid hydrogen
LN_2	liquid nitrogen
LOX	liquid oxygen
LPD	liters per day
m	meter(s)
m^3	cubic meter(s)
m/day	meters per day
MAFB	Malmstrom Air Force Base
MBL	Main Base Landfill
MCG	Mojave Coordinating Group
MDAQMD	Mojave Desert Air Quality Management District
MECO	main engine cut off
$\mu g/cm^3$	micrograms per cubic centimeter
mg/kg	milligrams per kilogram
mgd	million gallons per day
mi	mile(s)
mi^2	square miles
mLd	million liters per day
MOA	military operating areas
mph	miles per hour
MSFC	George C. Marshall Space Flight Center
MSL	mean sea level
MT	Montana
mT/yr	metric tons per year
MVA	megavolt-ampere
MW	megawatts
N/A	not applicable
LN_2	liquid nitrogen
N	Newton
N_2	nitrogen
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NASP	National Aero-Space Plane
NAWS	Naval Air Weapons Station
NAWC	Naval Air Warfare Center
NAWCWPNS	Naval Air Warfare Center Weapons Division
NEPA	National Environmental Policy Act
NHB	NASA Handbook

NIPDWR	National Interim Primary Drinking Water Regulation
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOI	Notice of Intent
NOTAM	Notice to Airmen
NPL	National Priorities List
NRHP	National Register of Historic Places
NSDWR	National Secondary Drinking Water Regulation
NTC	National Training Center
NWR	National Wildlife Refuge
O_3	ozone
OCC	Operations Control Center
OCONUS	Outside Continental U.S.
ODC	ozone depleting chemical
OLF	Orbitor Lifting Fixture
OPSEC	Operations Security
OSHA	Occupational Safety and Health Administration
OU	Operable Units
pH	unit of expressing the degree of acidity or basicity
PB	precision bombing
PCB	polychlorinated biphenyls
PG	proving ground
PHS	Priority Habitats and Species
PIRA	Precision Impact Range Area
PL	Public Law
PM_{10}	particulates less than 10 microns in size
$PM_{2.5}$	particulates less than 2.5 microns in size
ppb	parts per billion
ppm	parts per million
PRI	Primary Rate Interface
psf	pounds per square foot
PST	Pacific Standard Time
PUD	Public Utility District
QD	quantity-distance
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RCS	Reaction Control System
RLV	Reusable Launch Vehicle

ROI	region of influence
RP	rocket propellant
RTLS	return-to-launch site
SAP	satellite accumulation point
SCA	Shuttle Carrier Aircraft
SCE	Southern California Edison
SEA	Sensitive Ecological Area
SIP	State Implementation Plan
sq ft	square feet
sq km	square kilograms
sq m	square meter
sq mi	square mile
SSTO	single-stage-to-orbit
SWPPP	Stormwater Pollution Prevention Plan
SVPA	Searles Valley Planning Area
t/day	tons per day
t/yr	tons per year
TNT	trinitrotoluene
TPS	thermal protection system
TRI	Toxic Release Inventory
UAV	unmanned aerospace vehicle
U.S.	United States
U.S.C.	United States Code
USAF	United States Air Force
USACOE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UTTR	Utah Test and Training Range
VAFB	Vandenburg Air Force Base
VFR	visual flight rules
VOC	volatile organic compound
VOR	Very High Frequency Omni Range
WDW	Washington Department of Wildlife
WSA	Wilderness Study Area
WSMR	White Sands Missile Range
WWTP	wastewater treatment plant
X	eXperimental vehicle
X-33	eXperimental-33

UNIT CONVERSION FACTORS

Area

1 square meter	=	10.7639 square feet	1 square foot	=	0.0929 square meter
1 square kilometer	=	0.3861 square mile	1 square mile	=	2.5900 square kilometers
1 hectare	=	2.4711 acres	1 acre	=	0.4047 hectare

Force

1 Newton	=	0.2248 pound force	1 pound force	=	4.4482 Newtons

Length

1 meter	=	3.2808 feet	1 foot	=	0.3048 meter
1 meter	=	1.0936 yards	1 yard	=	0.9144 meter
1 kilometer	=	0.6214 statute mile	1 statute mile	=	1.6093 kilometer
1 centimeter	=	0.3937 inch	1 inch	=	2.54 centimeters

Mass

1 kilogram	=	2.2046 pounds	1 pound	=	0.4536 kilogram
1 metric ton	=	1.1023 tons	1 ton	=	0.9072 metric ton

Pressure

1 kilo Pascal	=	20.88543 pounds per square foot	1 pound per square foot	=	0.0479 kilo Pascal

Speed

1 kilometer per hour	=	0.6214 mile per hour	1 mile per hour	=	1.6093 kilometers per hour
1 meter per second	=	2.2369 miles per hour	1 mile per hour	=	0.4470 meters per second
1 kilometer per hour	=	0.54 knots (nautical miles per hour)	1 knot	=	1.85 kilometers per hour

Temperature

0° Celsius	=	32° Fahrenheit	°C	=	5/9×(°F-32)
100° Celsius	=	212° Fahrenheit	°F	=	(9/5×°C) + 32

Volume

1 liter	=	0.2642 gallon	1 gallon	=	3.7854 liters
1 cubic centimeter	=	0.0610 cubic inch	1 cubic inch	=	16.3871 cubic centimeters
1 cubic meter	=	35.3147 standard cubic feet	1 cubic foot	=	0.0283 cubic meter
1 cubic meter	=	8.1071×10^{-4} acre-feet	1 acre foot	=	1,233 cubic meters

Abbreviations

ac	acre	L	liter
C	Celsius	lb	pound
cm	centimeter	m	meter
F	Fahrenheit	mi	statute mile
ft	foot	mi/hr	miles per hour
gal	gallon	psf	pounds per square foot
ha	hectare	scf	standard cubic feet
in	inch	sq ft	square foot
kg	kilogram	sq in	square inch
km	kilometer	sq km	square kilometer
km/hr	kilometers per hour	sq m	square meter
kPa	kilopascal	sq mi	square mile
		yd	yard

EXECUTIVE SUMMARY

This Final Environmental Impact Statement (EIS) has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 *et seq.*), as amended; the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508); and the National Aeronautics and Space Administration's (NASA) policy and procedures (14 CFR Subpart 1216.3). This EIS supports the decision-making process concerning the Proposed Action and alternatives for the Experimental Thirty-Three Advanced Technology Demonstrator Vehicle (X-33), a major component of NASA's Reusable Launch Vehicle (RLV) research program.

ES.1 Background/ Purpose and Need for Action

For many years, the United States has recognized that space transportation costs must be significantly reduced in order for the Nation to afford continued exploration, development, and use of space. In NASA's *Access to Space Advanced Technology Team Final Report,* a single-stage-to-orbit (SSTO) transportation architecture was recommended as a prime candidate for the next generation of reusable space transportation systems which could meet future requirements with significant reductions in annual operating costs.

On August 5, 1994, President Clinton issued the National Space Transportation Policy and designated NASA as the Lead Agency for advanced technology development and demonstration of the next generation of RLVs. Section III, paragraph 2(a) of the policy, reads "The objective of NASA's technology development and demonstration effort is to support Government and private sector decisions by the end of this decade on development of an operational next-generation reusable launch system."

In order to meet the objective of President Clinton's policy in a timely and cost-efficient manner, NASA developed the X-33 Program based on the following internal Agency guidelines:

- reduce the technical and business risks which are currently barriers to privately financed space transportation system(s) (current and future) through the use of sub-scale, state-of-the-art technology demonstrator vehicle(s)
- design and test (both ground and flight) a technology demonstrator vehicle's major components, subsystems, and full system in a manner that ensures traceability (technology and general design similarity) and scaleability (directly scaleable weights, margins, loads, design, fabrication methods, and testing approaches) to a full-scale system
- verify full-scale systems operability and performance in "real world" environments.

To fulfill the purpose of the National Space Transportation Policy using the Agency's internally developed guidelines, a sub-scale, state-of-the-art space vehicle concept, dubbed the X-33, was

developed to meet technology and test flight objectives developed through a rigorous trade study of space transportation architectures and refined through additional inputs from private industry.

Proposed implementation of the X-33 Program has been divided into three phases. During Phase I, a cooperative agreement notice, CAN 8-1, was issued by NASA for concept definition and preliminary design of the reusable advanced technology demonstrator system, X-33. Three concepts and preliminary designs were prepared independently by: (1) Lockheed Martin Skunk Works, Palmdale, California; (2) McDonnell-Douglas Aerospace, Huntington Beach, California; and (3) Rockwell International Corporation, Space Systems Division, Downey, California. During this phase, NASA prepared the *Final X-33 Programmatic Environmental Assessment: Vehicle and Technology Demonstration Concepts*. Based on results of Phase I, evaluation of proposals received in response to the second cooperative agreement announcement, CAN 8-3, Lockheed Martin Skunk Works was selected as the Industry Partner to continue working with NASA during Phase II and, based on the EA, a determination was made to prepare an EIS for the X-33 Program.

Phase II involves preparation of final design, fabrication of the X-33, assembly, and ground and flight testing of the Lockheed Martin Skunk Works concept which is a "lifting body" design propelled by unique aerospike engines. The design concept is depicted in Figure ES-1. Specific Program objectives for Phase II are to:

- conduct flight and ground tests necessary to reduce business and technical risks which are currently barriers to privately financed development and operation of a next-generation space transportation system
- design and test the X-33 spaceplane, subsystems, and major components, and ensure traceability (technology and general design similarity) and scaleability (directly scaleable weights, margins, loads, design, fabrication methods, and testing approaches) to a full-scale SSTO system
- verify full-scale systems operability and performance in "real world" environments.

Phase III would involve design, manufacturing, and operation of the RLV system, based on SSTO architecture. Execution of Phase III is solely an industry decision. An SSTO system would operate in an "aircraft-like" mode (i.e., the entire space vehicle with all fuel tanks and engines would be launched and returned to Earth as one unit). No stages would be jettisoned with an SSTO system. In Phase III, the Government would potentially become the customer, not an owner or operator, of the launch system(s).

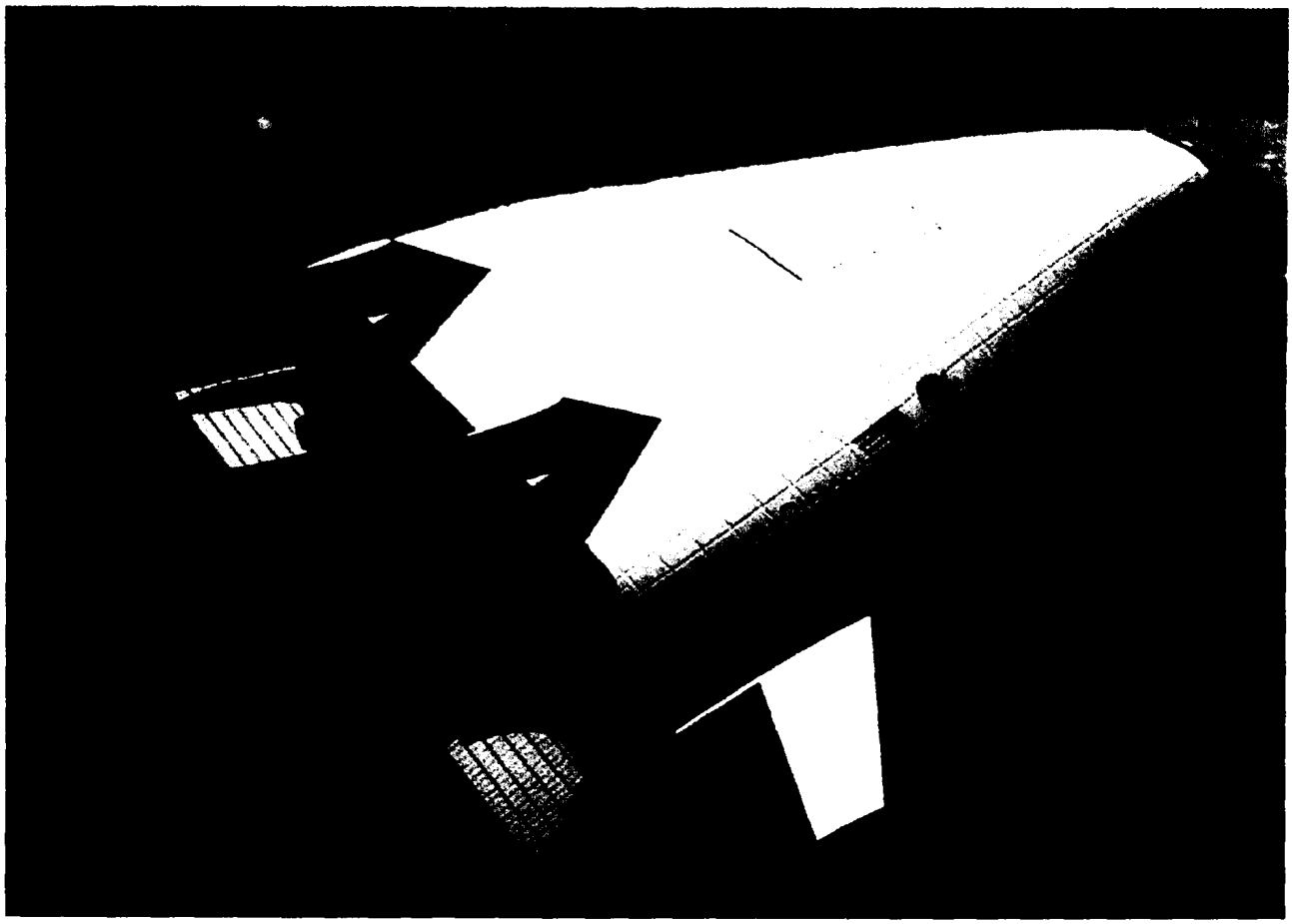


Figure ES-1. X-33 Spaceplane Concept.

ES.1.1 Program Objectives

The X-33 suborbital space vehicle is proposed to be flight tested in realistic operational environments and to demonstrate critical technologies needed for an orbital SSTO vehicle(s).
To the extent practical, the X-33 would be tested in ascent and reentry flight environments that would be experienced by a full-scale SSTO vehicle. In addition, the X-33 would focus on those operational issues which are critical to development of reliable, low-cost, reusable space transportation.

Specific technology objectives of the X-33 space vehicle include:

- demonstrate a reusable cryogenic tank system, including the tanks for liquid hydrogen (LH_2) and liquid oxygen (LOX), cryogenic insulation, and an integrated thermal protection system (TPS)
- verify TPS durability, low maintenance, and performance at both low and high temperatures

- demonstrate guidance, navigation, and control systems, including autonomous flight control of checkout, takeoff, ascent, flight, reentry, and landing for an autonomously controlled space vehicle
- achieve hypersonic flight speeds (speeds up to Mach 15 or 18,000 km/hr (11,000 mph))
- demonstrate composite primary space vehicle structures integrated with the TPS
- demonstrate ability to perform 7-day turnarounds between three consecutive flights (a turnaround is the amount of time required from a takeoff and flight until the vehicle is serviced, refueled, and ready to fly again)
- demonstrate ability to perform a 2-day turnaround between two consecutive flights
- demonstrate that a maximum of 50 personnel performing hands-on vehicle operations, maintenance, and refueling can successfully accomplish flight readiness for two flights.

Specific test flight objectives would include demonstration of:

- successful interaction of the engines, airframe, and launch (also referred to as takeoff) facility
- engine performance, thrust, and throttling capability meets specifications
- operability and control of the X-33's flight control surfaces (canted fins, flaps, ailerons, etc.)
- durability of the metallic thermal protection system during repeated flights
- performance of the guidance, navigation, and control system
- performance of primary operations facilities, including takeoff infrastructure
- automated landing at a designated point on the runway
- verification of tasks required to service the vehicle on landing and prepare it for next flight in minimal time.

ES.1.2 Phase II Decision (Proposed Action) and Alternatives

There are two major components which must be implemented to complete Phase II of the X-33 Program: ground support activities and flight testing. Ground activities would include final design and assembly of the X-33; ground testing of X-33 components leading to a full systems test; and a "flying wind tunnel" test accomplished by flying, but not releasing, the X-33 piggyback on the Shuttle Carrier Aircraft (SCA), which is a specially equipped Boeing 747 (see Figure ES-2). Flight testing would involve flying the X-33 under progressively more rigorous conditions in order for the vehicle's flight tests to meet the objectives stated in Section ES.1.1 above.

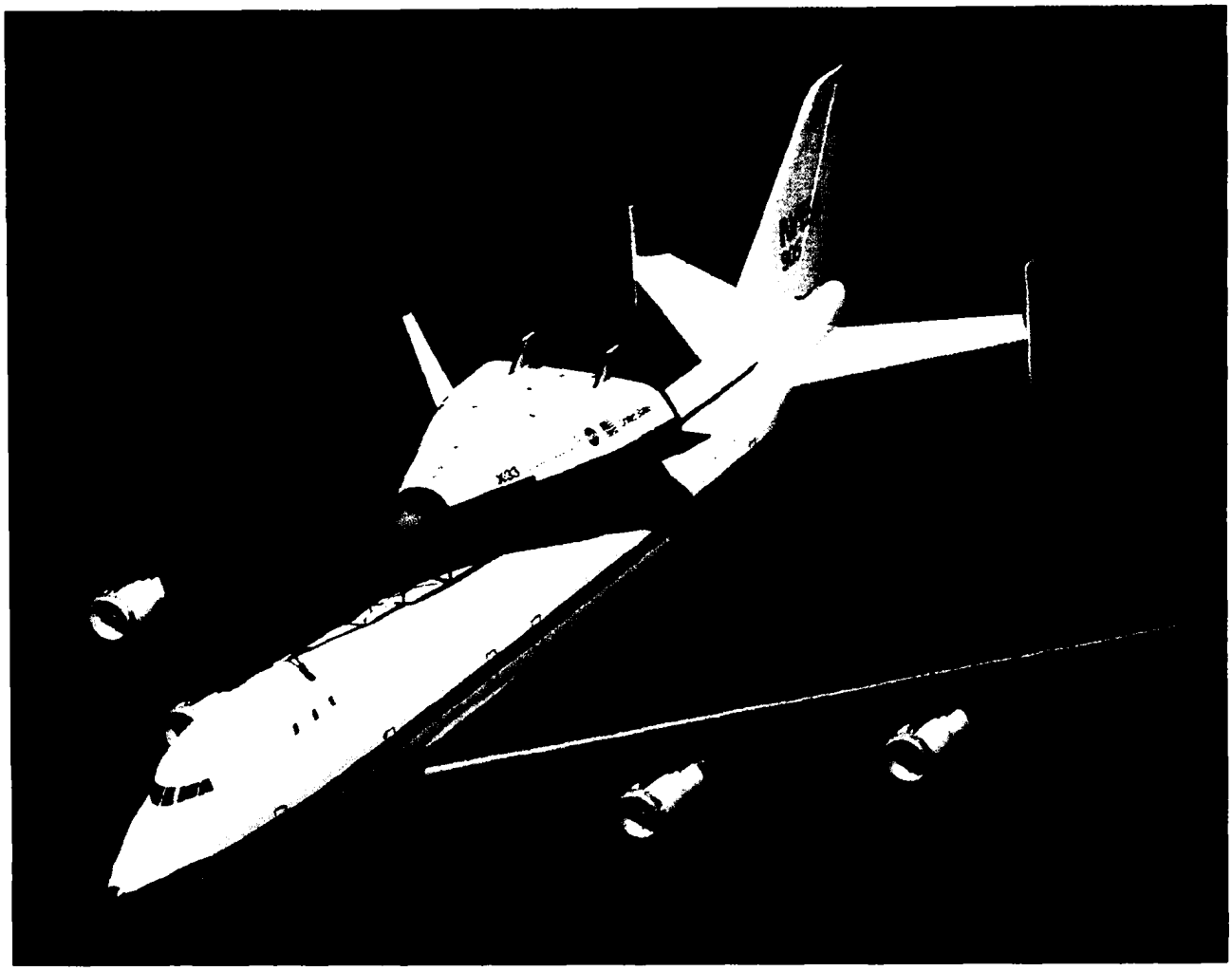


Figure ES-2. X-33 on the Shuttle Carrier Aircraft.

The first level decision is whether to continue with Phase II and design, build, and flight test the X-33. The Proposed Action and NASA's preferred alternative is to conduct the flight test activities, using a launch and flight operations site at Edwards Air Force Base, California, with landing sites which would accommodate incremental advances to Mach 4, 9, and 15 for the baseline vehicle, as shown in Figure ES-3. As required by NEPA regulations, potential environmental impacts of implementing the X-33 Program must be compared to the current baseline conditions, called the "No Action." In this case, the No Action alternative would be to not implement the X-33 Program and, consequently, to not demonstrate the potential ability to significantly reduce the cost of development, production, and operation of future reusable spaceplane systems based on this design and technology which could be commercially implemented.

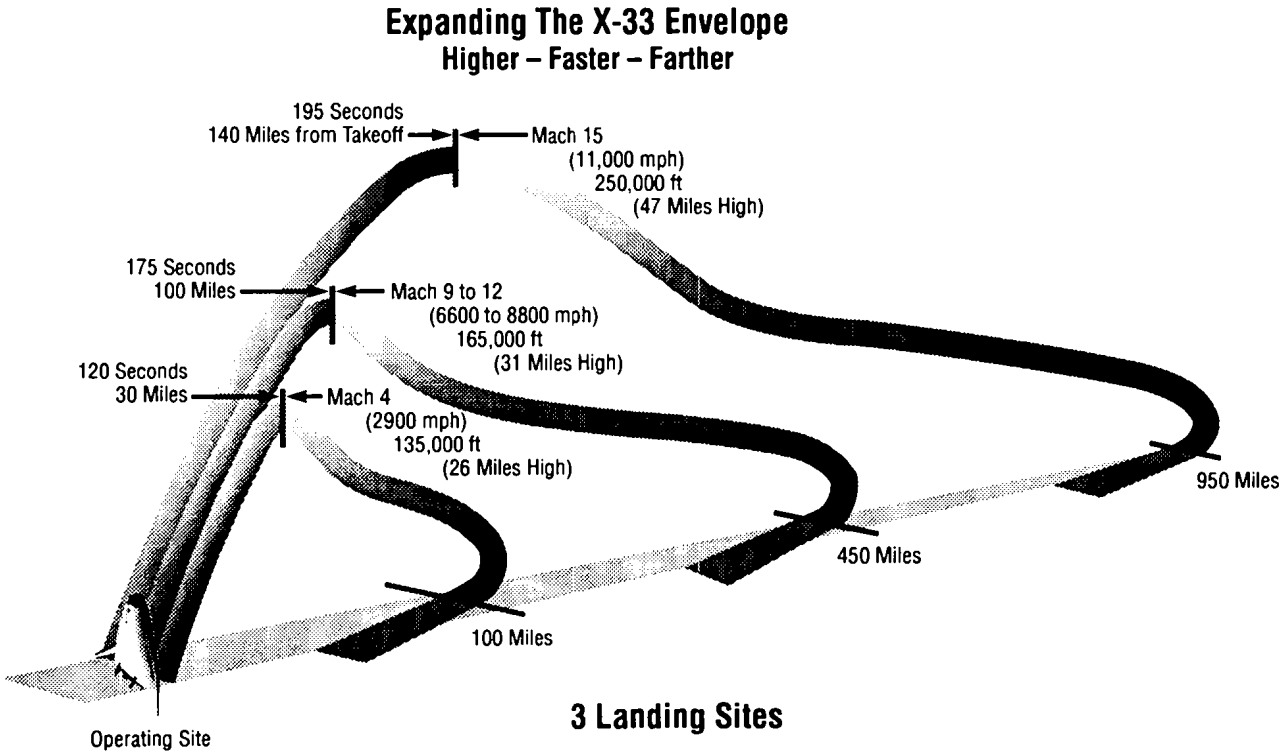


Figure ES-3. Baseline Flight Envelope Expansion Concept.

If the decision were made to proceed with the flight test program, then a series of second level decisions for implementation of support operations would be required as shown in Figure ES-4. A site within Edwards Air Force Base must be identified to support launch of the X-33. Two reasonable alternatives have been identified: (1) Haystack Butte; and (2) Space Port 2000. Three landing sites are preferred to conduct the flight test program in a manner that fully meets Program objectives and generates the entire array of data necessary to fully understand the performance of all technologies and systems integrated into the X-33. The flight testing would use an envelope expansion process in which speed, distance, and maximum altitude of ascent are increased in incremental steps. Alternative landing sites, shown in Figure ES-5, are: (1) Silurian Lake near Baker, California; (2) Armitage Airfield within the China Lake Naval Air Weapons Station near Ridgecrest, California; (3) Michael Army Airfield within Dugway Proving Ground, Utah; (4) Malmstrom Air Force Base near Great Falls, Montana; and (5) Grant County Airport near Moses Lake, Washington.

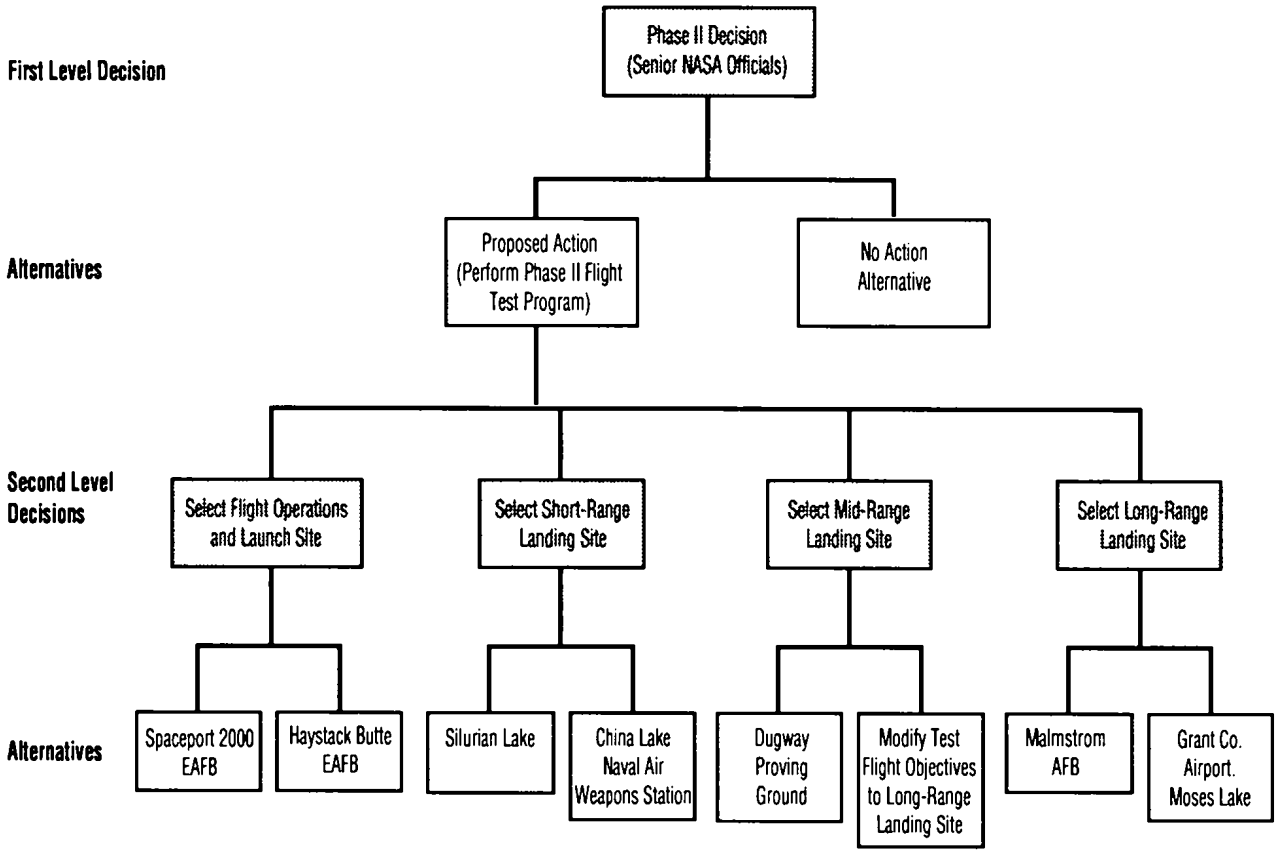


Figure ES-4. Phase II Decision Process.

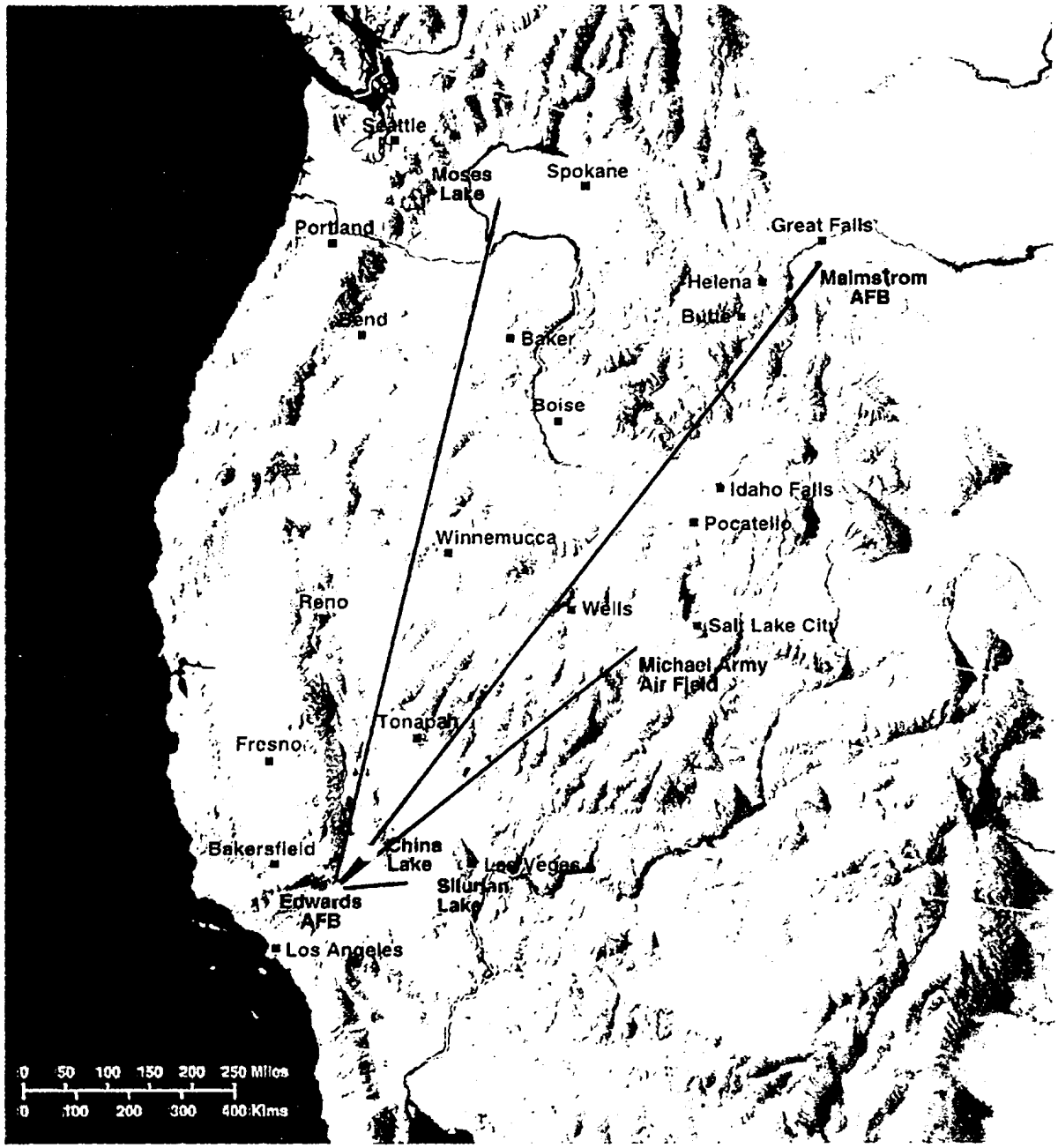


Figure ES-5. Alternative X-33 Flight Paths and Landing Sites.

ES.1.3 Cooperating Agencies

In accordance with Council on Environmental Quality regulations, 40 CFR 1501.6, three Federal Agencies, listed in the Table ES-1, have acted as cooperating agencies during the NEPA process in the preparation, review, and comment on this EIS.

Table ES-1. Cooperating Agencies.

Cooperating Agency	Sub-element	Site	Purpose
Department of Defense	U.S. Air Force	Edwards Air Force Base	flight operations and launch (takeoff) site
		Utah Test and Training Range	trajectory(ies) to Dugway Proving Ground
		Malmstrom Air Force Base	long-range landing site
	U.S. Army	Dugway Proving Ground	mid-range landing site
		Ft. Irwin[1] (Silurian Lake)	short-range landing site
	U.S. Navy	China Lake Naval Air Weapons Station	short-range landing site
Deapartment of the Interior, Bureau of Land Management	California Desert District, Barstow Resources Area	Silurian Lake	short-range landing site
Department of Transportation	Federal Aviation Administration	National Air Space	trajectories or portions thereof under 18,000 m (60,000 ft) and not within established controlled air space

[1] Potential future Federal manager of Silurian Lake

ES.1.4 Public Involvement

ES.1.4.1 Scoping

The Notice of Intent to prepare the EIS was pubished in the *Federal Register* on October 7, 1996, (i.e., 61 FR 52467) with details of how to submit scoping issues to NASA and where meetings would be conducted to inform the public of the Proposed Action. Advertisements for comment and public meetings were placed in local and regional papers. Informal consultation and coordination of Program activities were initiated in the states of California, Idaho, Oregon, Montana, Nevada, Utah, and Washington. Twelve public scoping meetings were also conducted between October 1996 and January 1997 to identify significant issues of the public and local authorities to be addressed in the EIS. Native American Indian tribal leaders were contacted directly to arrange meetings and solicit comments.

Some of the issues and concerns collected during the scoping process involved the following areas:

- public safety/risk

- hazardous materials
- exact flight path(s)
- avalanche potential from sonic booms
- sonic booms/noise impacts on wildlife and endangered/threatened species
- disruption or suspension of airport services
- diminishment or disruption of flight corridors for private aircraft
- concern over crowds of spectators in neighborhoods in proximity to landing site
- benefit
- accessibility and visibility to launch and landing
- impact on "Wilderness" areas
- reliability without a pilot on board
- avoidance of sensitive military operations
- abort scenarios, consequences, and procedures
- schedule

ES.1.4.2 Public Participation Meetings

The Notice of Availability of the Draft EIS was published in the *Federal Register* on July 3, 1997, (i.e., 62 FR 128:36081-36083) with details of the Draft EIS; where meetings would be conducted; where the Draft EIS could be reviewed or obtained; to how to submit comments; and the closing date of the comment period. A second series of meetings was held after the Draft EIS was released to the public. The purpose of the meetings was to provide the public and local authorities with answers to issues that were raised during the scoping period and to update the public on the progress of the program. Advertisements for comment and public meetings were placed in local and regional papers. Eleven public participation meetings were conducted in California, Idaho, Montana, and Utah between July 7, 1997 and July 24, 1997. Additional meetings were held with Native American Tribal leaders, political officials, and Bureau of Land Management agencies as requested.

Some of the issues and concerns collected during the public participation process involved the following areas:

- Environmental Impact Statement
- Benefits of the X-33 Program
- Costs
- Damage Claims
- Economic Impacts/Employment Opportunities
- Flight and Landing Operations, and Vehicle Design
- Follow-On RLV Program
- Missions/Goals/Future Plans
- Public Safety and Risk/Flight Termination and Vehicle Failures/Contingency Planning

- Missions/Goals/Future Plans
- Public Safety and Risk/Flight Termination and Vehicle Failures/Contingency Planning
- Public Viewing
- Road Closures
- Site Selection
- Sonic Booms
- Stratospheric Ozone
- Wildlife/Vegetation Impacts
- Other

ES.2 Proposed Action and Alternatives

ES.2.1 Proposed Action

The Proposed Action evaluated in the EIS includes: (1) preparation of flight operations facilities (takeoff site and launch support infrastructure) and landing sites; and (2) ground and flight testing the X-33. A functional flow chart of proposed activities is provided in Figure ES-6.

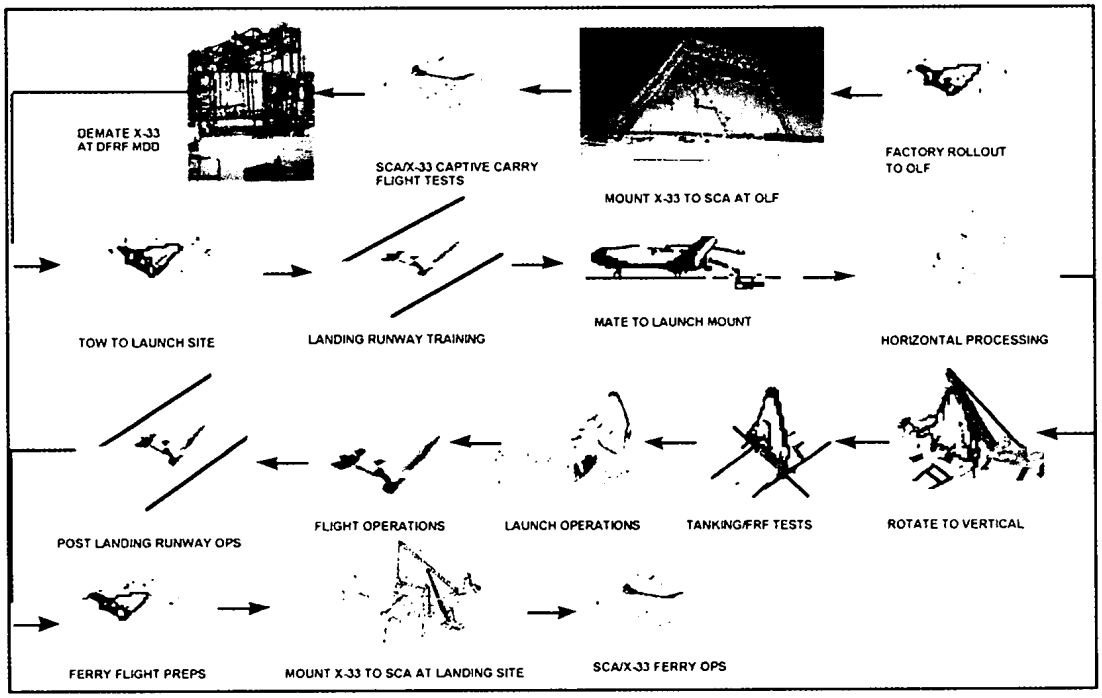
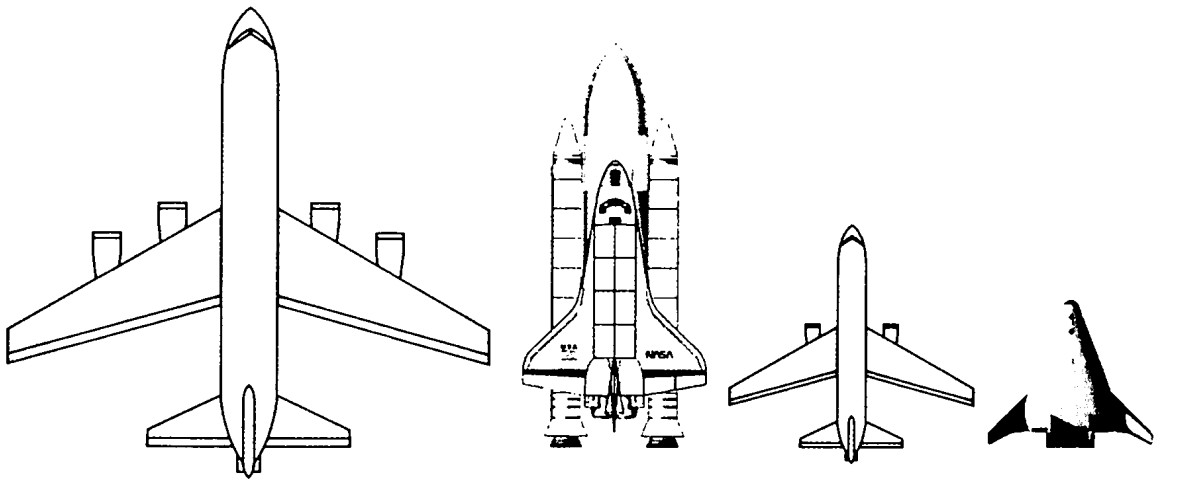


Figure ES-6. Functional Operational Flow.

ES.2.1.1 Vehicle Description

The X-33 vehicle as shown in Figure ES-1, is planned to be approximately one-half geometric scale of its planned successor reusable space vehicle. A comparison of the X-33 with existing systems is shown in Figure ES-7. Table ES-2 contains a list of new technologies that would be utilized on the X-33 and improvements over existing technologies, which are key to the successful development of spaceplanes based on this design that are highly reliable and far less expensive to operate than today's launch vehicles.



System	*Boeing 747*	*Space Transportation System*	*Boeing 737*	*X-33*
Length	232 Ft	184 Ft	109 Ft	67Ft
Width	196 Ft	78 Ft	94 Ft	68 Ft
Gross Lift Off Weight	710,000 Lb	4,500,000 Lb	135,000 Lb	273,000 Lb
Fuel	Commercial Aviation	LH_2/LOX + Solid	Commercial Aviation	LH_2/LOX
Fuel Weight	316,000 Lb	3,803,000 Lb	24,000 Lb	211,000 Lb
Empty Weight	320,000 Lb	594,000 Lb	62,000 Lb	65,000 Lb
Main Propulsion	4 Turbines	2 Solids + 3 SSME Bells	2 Turbofans	2 J-2S Linear Aerospikes
Take Off Thrust	200,000 Lb	6,400,000 Lb	40,000 Lb	410,000 Lb
Maximum Speed	Mach 0.6	Mach 25	Mach 0.84	Mach 15
Payload to 100 NMI/28.5 deg. orbit	N/A	51,000 Lb	NA	NA
Payload Bay Size	N/A	15×60 Ft	77 Ft	5×10 Ft

Figure ES-7. Comparison of the X-33 With a Conventional Aircraft and the Space Transportation System (Space Shuttle).

Table ES-2. New Technologies Required for Successful Development of Operationally Simple, Cost-Effective, and Reliable Spaceplanes.

Required Improvement	Technology
75% fuel packing efficiency	Multilobe tanks; full length orbital maneuvering tanks
Decrease main propulsion system weight	Composite LH_2 tanks; composite LOX tanks; pressure stabilized tanks; composite feed lines; jet boost pumps
Improved engine performance	Aerospike engine
Improved fuel bulk density	Densified propellants
Improved operations	"Aircraft-like" operations
Eliminate separate orbital maneuvering system engine	Restartable main engine
Reduce control surface	System refinement

The X-33 design would have a lifting body airframe. This design enables the vehicle to obtain aero-lift from its body shape and not wings like conventional airplanes. The primary composite structure would provide support for the vehicle, internal tanks, flight control surfaces, and thermal protection system (TPS). The TPS would be attached to the aeroshell and is a metallic material made from a combination of inconel (an alloy of iron, nickel, and cobalt) or titanium panels and carbon epoxy panels. The internal configuration is shown in Figure ES-8.

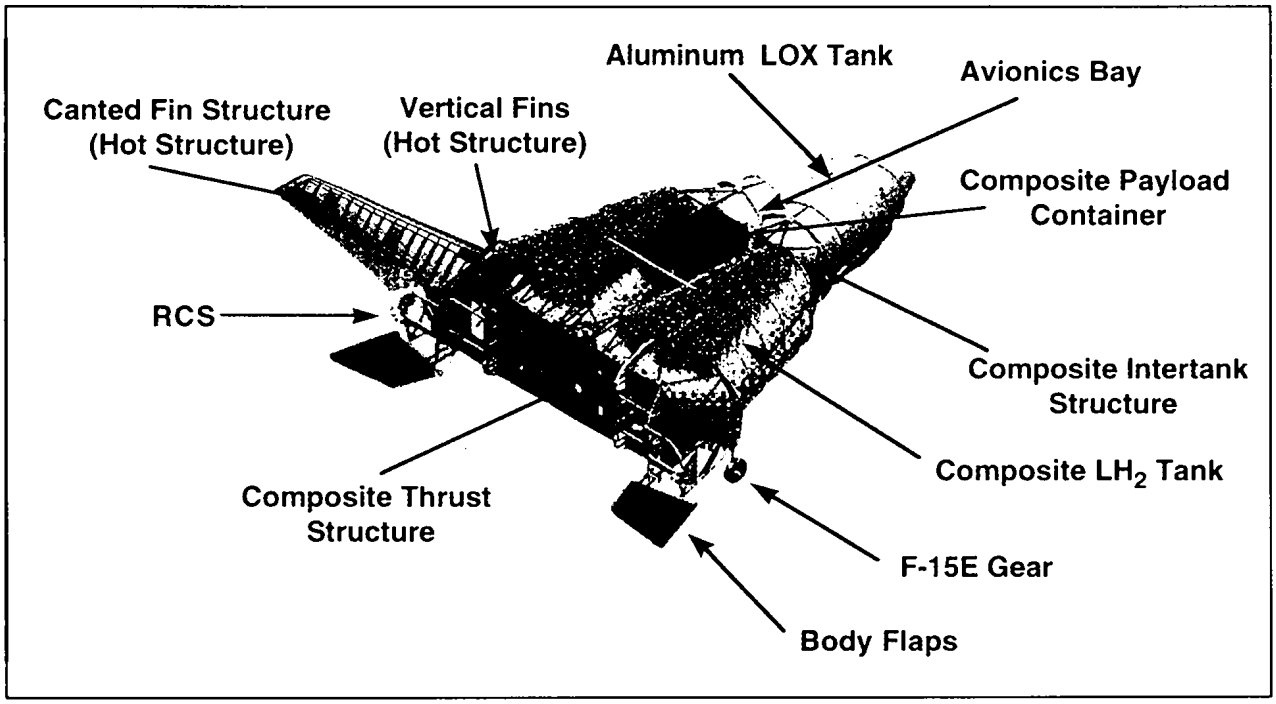


Figure ES-8. Internal Configuration of the X-33.

The X-33 would use two linear J-2S aerospike engines made by Boeing Rocketdyne Division, shown in Figure ES-9. The engine burns liquid hydrogen (LH_2) and liquid oxygen (LOX), releasing only water vapor into the atmosphere. All other fuel sources required to provide energy for onboard computers, the reaction control system, etc., depend on LH_2 and LOX, thereby greatly reducing the toxicity of fuel gases to those of normal, nontoxic constituents of the atmosphere. The engine does not require a "bell nozzle" to channel the hot gases of combustion for directional control of the vehicle. The hot gases expelled by the J-2S engine from the thrust cells would be directed in such a way that the atmosphere provides a natural channeling effect. Elimination of the bell nozzle provides significant weight and size reductions of the overall engine.

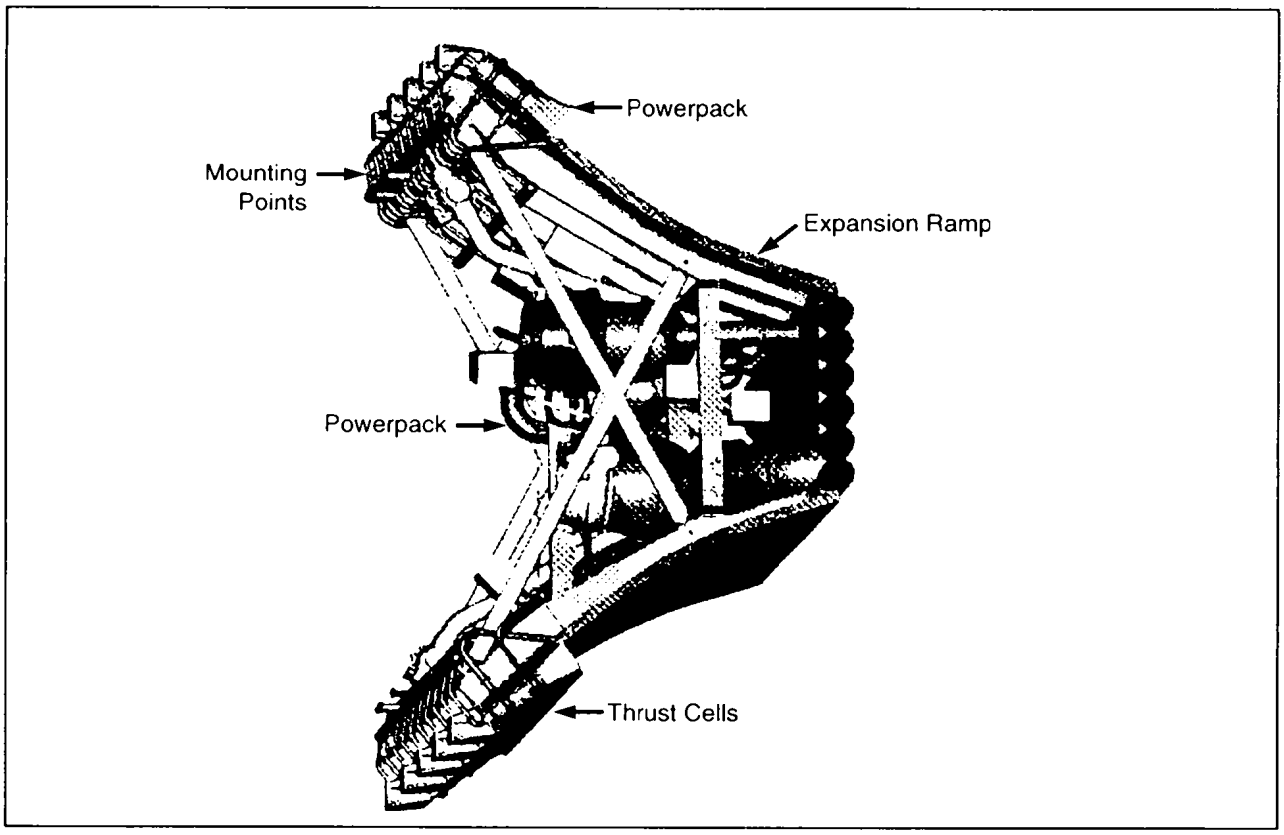


Figure ES-9. Linear J-2S aerospike engine.

ES.2.1.2 Final Design, Fabrication, and Assembly of the X-33

Final design, main fabrication, and assembly of the X-33 would be performed at the Lockheed Martin Skunk Works facilities in Palmdale, California, approximately 70 km (45 mi) southwest of Edwards Air Force Base. These facilities have been used for aerospace manufacturing for many years and, as such, are covered by existing environmental permits which would require little or no modification. Final design would correct deficiencies in the preliminary design and address any significant environmental issues arising out of the EIS process that NASA determines to require mitigation. Manufacture and testing of numerous X-33 components and wind tunnel models would be accomplished at several existing facilities around the United States shown in Figure

ES-10. Components would be shipped to Palmdale, California, via air, truck, and rail. All components would be inert and nontoxic.

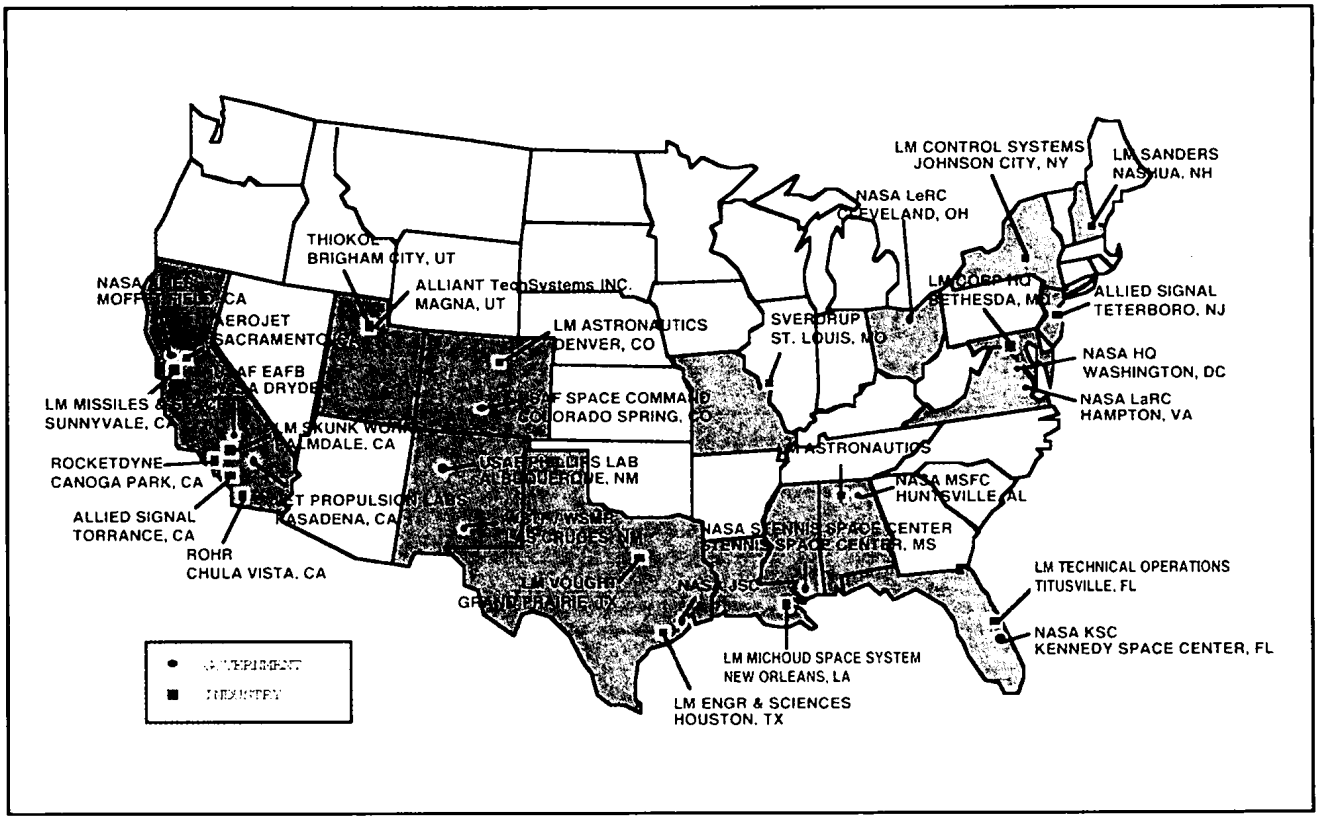


Figure ES-10. X-33 Vender and Component Test Laboratories.

ES.2.1.3 Flight Operations and Launch Support

Basic components of the launch complex would include:

- launch mount structure mates for the aft end of the X-33
- exhaust trench for channeling and deflecting engine hot exhaust flows
- bulk storage and delivery systems for LH_2 and LOX
- bulk storage and delivery systems for gaseous nitrogen and gaseous helium
- a system for providing conditioned air and gaseous nitrogen for vehicle cooling and purging
- shelter for protection of the X-33
- translating system to move the X-33 from a horizontal to vertical position
- water system for suppression of launch ignition overpressure loads on the vehicle and cooling of the exhaust trench.

An Operations Control Center (OCC) with launch and mission command and monitoring systems would be located near the launch site within Edwards. The OCC would house command and monitoring capabilities for ground and flight tests. A schematic of the launch complex is provided in Figure ES-11.

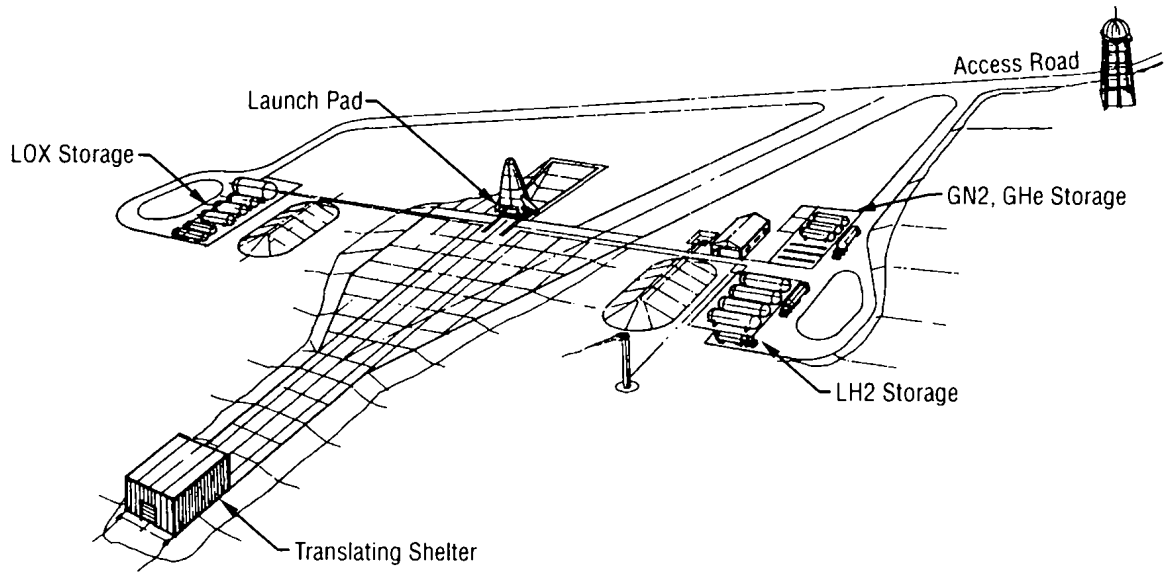


Figure ES-11. Launch Complex Schematic.

Other flight operations support requirements would be provided by existing facilities within Edwards established for support of military and NASA flight programs. These facilities would include the Main Base runway for takeoff and return of the Boeing 747 used to air ferry the X-33, the Space Shuttle mate/demate facility for decoupling the X-33 from its piggyback configuration on the Boeing 747, and towing equipment to move the X-33 to the launch site. The Air Force Flight Test Center (AFFTC) within Edwards Air Force Base would be responsible for airspace control, tracking, and coordination with other users, ranges, FAA, and landing site owners. X-33 flight safety and emergency response plans would be prepared by Lockheed Martin with NASA participation and coordinated with and approved by the AFFTC and respective landing site authorities. In addition, coordination with and approval by landing site safety organizations and installation authorities would be required for use of their respective facilities.

ES.2.1.4 Ground Testing (Infrastructure and Vehicle)

Various vehicle components and systems would be tested prior to final commit to full flight tests of the X-33 to ensure proper working of critical elements. Ground tests of propellant storage and transfer systems, electronic controls, and communication systems will be conducted prior to the X-33's arrival at the launch site.

Flight readiness firings (FRF) of the engines would be conducted at the launch site. These engine test firings, while mounted on the vehicle in "launch mode," provide a full propulsion systems evaluation and determination of readiness for flight.

The X-33 vehicle captive carry tests (flying wind tunnel tests) would be conducted by flying the X-33 piggyback on the Boeing 747 and testing the X-33's aerodynamic systems. The X-33 would not be released from the Boeing 747 during these tests.

ES.2.1.5 Flight Tests

Test flights involve: (1) launching the X-33 from a vertical position like a conventional space launch vehicle—this reduces the weight of the landing gear and wheels to only that required to support an unfueled vehicle (baseline dry weight of vehicle is approximately 29,500 kg (65,000 lb) and fueled weight of X-33 is approximately 123,800 kg (273,000 lb)); (2) accelerating the vehicle to top speeds of Mach 15 (15 times the speed of sound or approximately 18,000 km/hr (11,000 mph) and reaching high altitudes up to approximately 75,800 m (250,000 ft); (3) shutting down the engines; gliding over long distances up to 1,530 km (950 mi) downrange of the launch site followed by conducting terminal area energy maneuvers to reduce speed and altitude; and (4) landing like a conventional airplane.

Optimally, the flight test plan to meet Program objectives would involve flights of approximately 160, 720, or 1,530 km (100, 450, and 950 mi). Landing sites meeting the above criteria and providing 3,050 m (10,000 ft) of hard surface are referred to as short-, mid-, and long-range landing sites, respectively. The X-33 Program prefers to land the vehicle on a dry lake bed at least for its first flight in order to have a wider and slightly safer landing area than conventional runways offer. The same philosophy was used for the Orbiter's and most X-planes' first landings. The baseline test program would include a combined total of approximately 15 flights beginning in July 1999 and concluding in December 1999. The baseline test flight plan includes three short-range, seven mid-range, and five long-range test flights. Actual numbers of test flights to any range may vary due to changing plans and/or actual test flight data evaluation.

After landing, the X-33 would be "safed" (purged of residual propellant by venting to atmosphere and displacement with an inert gas such as helium or nitrogen), field inspected for major structural problems which might preclude immediate return to the flight operations site, hoisted by two mobile cranes and mated to the back of the Boeing 747, and air ferried back to the flight operations site for checkout, servicing, and re-flight.

Minor facilities, such as mobile tracking stations, would be required along the flight paths. Contingency plans for abort would be developed and be in place before flight.

ES.2.1.6 Engine Test Firings

In order to safely fly the X-33 with two J-2S aerospike engines, the engines must be test fired in accordance with standard test procedures for other space engines, such as the Space Shuttle Main Engines mounted on the Space Shuttle's Orbiter. Two installations have been identified with existing facilities requiring very minor modifications to conduct this work. These installations are the John C. Stennis Space Center in Hancock County, Mississippi, and the George C. Marshall Space Center in Huntsville, Alabama. Environmental impacts of a wide variety of engines including ones similar to the J-2S are covered in a recent Draft EIS for long-range planning of engine testing at these facilities. No substantive environmental comments were raised by the public and federal, state, or local entities.

ES.2.1.7 Program Management and Miscellaneous Activities

The Office of Aeronautics and Space Transportation Technology at NASA Headquarters in Washington, DC, manages the Reusable Launch Vehicle (RLV) Technology Program. Marshall Space Flight Center (MSFC), Huntsville, Alabama, is Lead Center for the X-33 Program. Various government laboratories and installations are participating in this effort under task agreements to Lockheed Martin to develop technologies and data necessary for the success of the X-33 Program. The following government-owned facilities have X-33 task agreements: NASA/MSFC; NASA/MSFC/Michoud Assembly Facility, New Orleans, Louisiana; NASA/Dryden Flight Research Center (DFRC) on Edwards Air Force Base, California; NASA/Ames Research Center in Santa Clara County, California; NASA/Lewis Research Center in Cleveland, Ohio; NASA/Langley Research Center in Hampton, Virginia; NASA/Johnson Space Center in Houston, Texas; Jet Propulsion Laboratory, contractor operated, in Pasadena, California; NASA/Kennedy Space Center (KSC) in Brevard County, Florida; NASA/Stennis Space Center in Hancock County, Mississippi; U.S. Air Force Phillips Laboratory at Edwards Air Force Base, California near Lancaster, California; and U.S. Air Force Wright Patterson Laboratories in Dayton, Ohio.

ES.2.2 Alternatives

A careful study of existing test ranges and launch complexes and potential test flight corridors and landing sites at the necessary downrange distances was done. Two reasonable alternative sites for proposed flight operations and launch were identified within Edwards Air Force Base: (1) Space Port 2000 and (2) Haystack Butte. Reasonable short-range landing sites being considered are Silurian Lake, a dry lake bed, California; and Armitage Airfield on China Lake Naval Weapons Station, near Ridgecrest, California. Alternatives for the mid-range landing site are Michael Army Air Field at Dugway Proving Ground, Utah; and modifying flight objectives to the long-range landing site and deleting the mid-range site. Reasonable long-range landing site alternatives being considered are the Grant County Airport near Moses Lake, Washington; and Malmstrom Air Force Base near Great Falls, Montana. Table ES-3 outlines the X-33 site alternatives.

Table ES-3. X-33 Site Alternatives

Purpose	Installation	Site/Facility
Flight operations and launch	Edwards Air Force Base, CA	Haystack Butte
		Space Port 2000
Landing	Silurian Lake, CA	dry lake bed
	China Lake Naval Air Weapons Station, CA	Armitage Airfield
	Dugway Proving Ground, UT	Michael Army Airfield
	Malmstrom Air Force Base, MT	Base airport
	Moses Lake, WA	Grant County Airport

Defining the No Action alternative and comparing its environmental impact with those of the Proposed Action is a requirement of the regulations implementing the National Environmental Policy Act (40 CFR 1502.14(d)). The No Action alternative defines the baseline conditions which would prevail in the absence of the proposed program. For this Program, the No Action alternative would mean that the X-33 Program would not be implemented, resulting in the lack of development and verification of key technologies needed for a successful Phase III as envisioned with development and implementation of an operational single-stage-to-orbit RLV solely by private industry.

ES.2.3 Alternatives Considered But Not Carried Forward

White Sands Missile Range (WSMR), New Mexico, was considered for both flight operations and landing. The installation was not pursued because of difficulty in planning flight trajectories to minimize public exposure and meeting baseline Program plans to choose landing sites along a common corridor.

East and West coast flight operations and landing sites were also investigated. Potential coastal operations sites were the John F. Kennedy Space Center (KSC), Florida, and Vandenberg Air Force Base (VAFB), California. For both of these sites, landing the X-33 would require flying over extensive U.S. territories with dense populations. Trajectories entirely over water would require landing the X-33 at non-U.S. territories, which was highly undesirable due to protection requirements for unique U.S. technologies and the need for international negotiations. For VAFB, the longest over water flight corridor that could be accommodated within U.S. territories was approximately 320 km (200 mi).

In southern California, Bicycle Lake on Ft. Irwin, Three Sisters Lake, and Cuddeback Lake were considered for short-range landing sites. Bicycle Lake was eliminated due to significant surface preparation required to render the lake bed suitable for landing, and the latter two lake beds were too close to Edwards. Silver Lake southwest of Silurian Lake was considered, but eliminated because most of it has been Congressionally designated as a Wilderness Study Area. The Bonneville Salt Flats near Wendover, Nevada, was considered as a mid-range landing site, but was eliminated because of its reduced distance to airspace boundaries as compared to the Michael

Army Air Field. Glasgow, Montana, was considered as a long-range landing site, but eliminated because the X-33 could not reach Glasgow on a flight from Edwards. On Edwards AFB, South Base launch site was not considered further due to adverse safety and operations impacts.

ES.2.4. Preferred Alternatives

The preferred launch site is Haystack Butte due to lower risks to personnel and the public than Space Port 2000. The preferred landing site alternatives are Silurian Lake for short-range flights; Dugway Proving Ground for mid-range flights; and Malmstrom Air Force Base for long-range flights. These alternatives are preferred because technical and safety analyses indicate that these areas and airfields are within optimal ranges, afford incremental test flight capability along a common corridor, and are expected to meet risk guidelines. Silurian Lake and Malmstrom's risk assessments project lower risk to base personnel and the public than respective alternatives. The current X-33 design lacks performance capability to overcome required maneuvering and maintain sufficient energy to achieve safe landing at Moses Lake. Dugway affords flight testing of the X-33 at lower minimum speeds than would be required for the X-33 to achieve landing at a long range site. The X-33 Program prefers mid-range flights to Dugway to minimize initial stress on the X-33 while obtaining valuable flight test data. Neither the preferred launch site nor preferred landing sites exhibit major environmental or socioeconomic drawbacks when compared to the other reasonable alternatives.

ES.2.5 Preferred Flight Test Plan

The X-33 Program is considering three flight test plan options based on the use of the preferred alternatives: (!) baseline plan of 3 test flight to Silurian lake, 7 to Dugway, and 5 to Malmstrom: (1) 3 test flights to Silurian Lake and 12 to Malmstrom: and 10 test flights to Dugway and 5 to Malmstrom. The environmental analyses and impact projections, including safety analyses, would remain unchanged regardless of which flight test plan option is used. Launch, landing and safety approval authorities as indicated in Section 4.3 must be satisfied through sufficient ground testing of the vehicle's critical components and systems that the vehicle and its flight termination system would perform within design specifications. Flight test plan options include a baseline total of 15 flights. Actual flights to each landing site may vary from those indicated below depending on data evaluation following each flight.

The preferred flight test plan is the one with 10 test flights to Dugway and 5 to Malmstrom. For short range flights, current analyses indicate that modifications to the vehicle would be required due to the low weight of the propellants of lift off. These modifications would lower the maximum performance capability of the X-33, precluding Mach 15 flights and causing the Program to not meet ultimate test objectives. If approving authorities impose requirements of the X-33 Program that are not addressed in this EIS as a result of selecting a flight test plan option other the baseline test plan, environmental impacts would be reevaluated and environmental documentation prepared, as appropriate.

ES.3 Affected Environment

The launch and landing sites would be potentially affected by preparation and implementation of launch and landing operations of the X-33 space vehicle. Existing environments for the Proposed Action and alternatives are summarized below.

ES.3.1 Edwards Air Force Base: Haystack Butte and Space Port 2000

Edwards Air Force Base is a large, diverse U.S. Air Force installation covering approximately 121,500 hectares (ha) (300,000 acres (ac)) in southern California near Lancaster. Two reasonable alternative launch sites within the Air Force base have been identified: Haystack Butte and Space Port 2000. These sites are very similar in character. They are essentially undeveloped, typical southern California desert terrain. The only wildlife species of particular concern for these two sites is the federal- and state-threatened desert tortoise *(Gopherus agasizii)*. Tortoise density is likely to be higher at Haystack Butte. Site preparation activities are not expected to affect more than 19 ha (43 ac), which is far less than 0.5 percent of current operational areas. With respect to air quality, the Haystack Butte site is located within an area designated as severe federal non-attainment for ozone and moderate federal non-attainment for particulate matter less than 10 microns in size, PM_{10} (dust, soot, and miscellaneous particles in the air that are small enough to be inhaled into the lungs). Space Port 2000 is located in an area designated as a federal "serious" non-attainment for ozone, but PM_{10} levels in the air are considered to be in attainment of federal air quality standards. Baseline noise levels at both sites are within ranges to be expected around an active military airfield supporting both conventional as well as supersonic aircraft operations. The Haystack Butte site is uniquely distinguished from Space Port 2000 by the potential presence of unexploded ordnance due to past weapons testing in the vicinity of the site.

Primary missions of Edwards are to conduct and support tests of aircraft systems; conduct flight evaluation and recovery of aerospace research vehicles, and development and testing of aerodynamic decelerators; operate the Air Force Test Pilot School; and support and participate in Air Force, Department of Defense, other Governmental agency, foreign, and contractor test and evaluation programs. Rocket engines and motors using a variety of propellants are currently tested at Phillips Laboratory within Edwards. The base also provides an alternative landing site for NASA's Space Shuttle. Proposed X-33 Program activities are compatible with the missions and capabilities of the base. Due to the extensive existing infrastructure, necessary services for communications, power, water, wastewater treatment, solid and hazardous waste management, and fire protection can be utilized with little to no extensions of lines or roads or significant augmentation of the existing systems.
Edwards airspace is designated as R-2515 military restricted airspace. R-2515 is included in the R-2508 Complex airspace, the military restricted airspace of Edwards, China Lake Naval Air Weapons Station, and Ft. Irwin as well as the airspace in 14 military operating areas.

ES.3.2. Silurian Lake

Silurian Lake, shown in Figure ES-12, is a dry lake bed the majority of each year and is located approximately 30 km (18 mi) north of Baker, California, and immediately east of California State Highway 127. The lake bed is approximately 3,840 m (12,600 ft) long by 640 m (2,100 ft) wide with a surface similar to the Roger's Dry Lake Bed on Edwards Air Force Base used for landing of the Space Shuttle Orbiter.

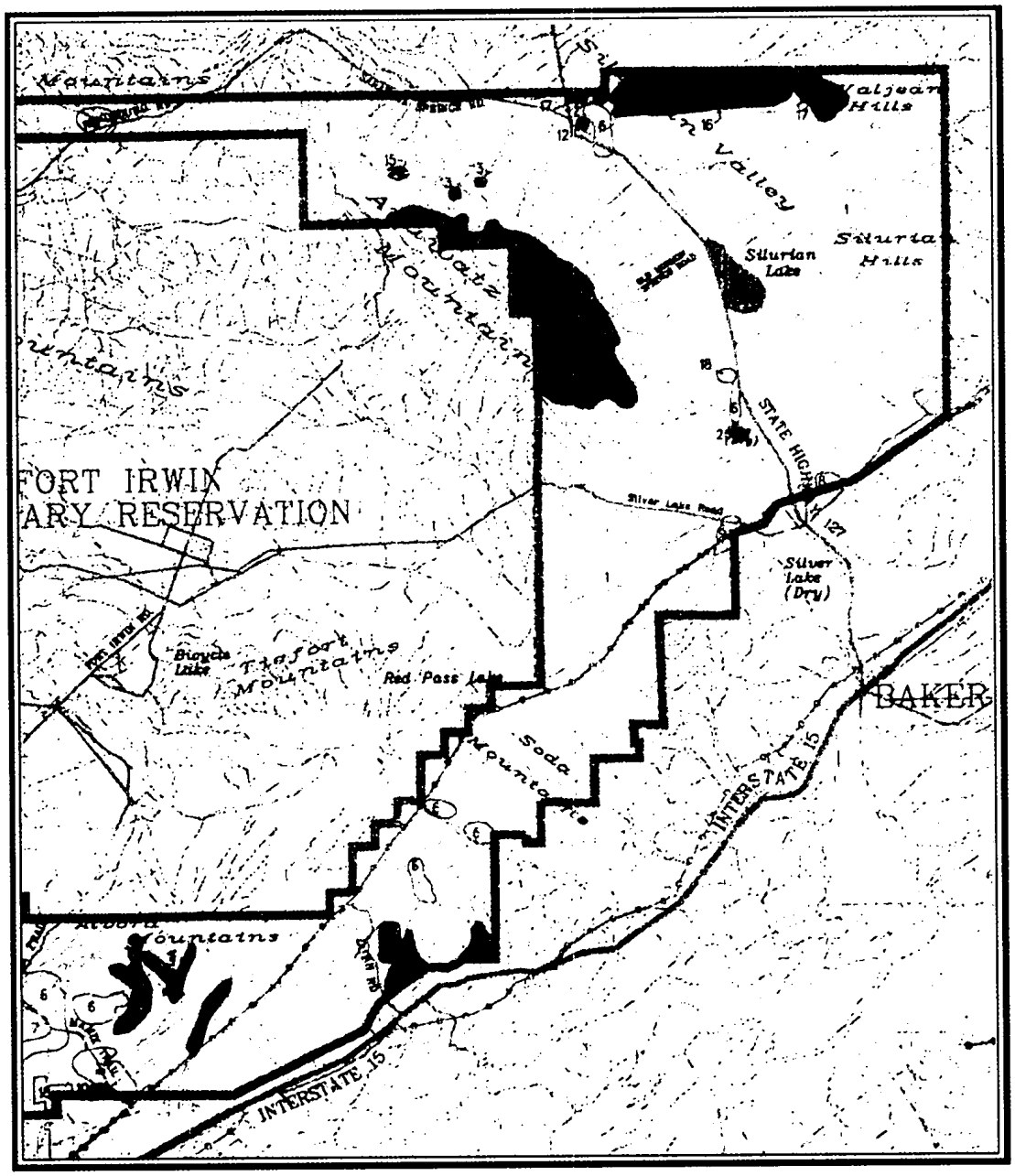


Figure ES-12. Silurian Lake, California.

The U.S. Department of the Interior, Bureau of Land Management (BLM) is the federal government manager of the property as well as much of the surrounding area. A pending future action involves transferring this property to the U.S. Army, Ft. Irwin, California, for expansion

of their boundaries and capabilities in desert warfare training (BLM 1996). Silurian Lake is classified by BLM as a Multiple-Use I (intensive use) area and such activities as commercial filming have been permitted at the site.

The surrounding terrain is relatively flat. It is within the Mojave Desert scrub biome (region) of California. Due to the known ponding of water in the lake bed each year, general characteristics of Silurian Lake and the time required to collect data for an official determination of wetlands' status through the U.S. Army Corps of Engineers, NASA has taken a conservative view of the lake bed, and it is assumed that Silurian Lake would meet the definition of a jurisdictional wetlands or floodplains and require a Section 404 permit under the Clean Water Act for any disturbance of the lake bed. The lake is essentially devoid of vegetation and does not provide wildlife habitat when dry, although some species migrate across the lake bed. The Silurian Valley (which includes Silurian Lake) is in attainment of all federal quality standards, except PM_{10} for which it is classified as non-attainment of both state and federal air quality standards. The valley area is also non-attainment for state ozone standards. Use of Silurian Lake as a landing site might require some smoothing of the lake bed.

The ambient noise environment is influenced by military operations at nearby Ft. Irwin. Routine military aircraft operations in established airspace corridors also contribute to the existing noise environment. Silurian Lake's airspace is included in the Shoshone Military Operating Area (MOA) of the R-2508 Complex whose use would be coordinated by the AFFTC. Civilian aircraft can operate within the MOA under visual flight rules.

ES.3.3 Armitage Airfield on China Lake Naval Air Weapons Station, California

China Lake Naval Air Weapons Station is located in the high desert adjacent to the community of Ridgecrest, California. Home to the Naval Air Warfare Center Weapons Division, the Naval Air Weapons Station, and the Naval Weapons Test Squadron, the installation covers approximately 485,800 ha (1.2 million ac). The airfield is located within the military restricted airspace of R-2505 which is part of the R-2508 Complex, and also incorporates the airspace above and around Edwards Air Force Base and Ft. Irwin near Barstow, California.

China Lake Naval Air Weapons Station's mission is to be the principal Navy research, development, testing, and evaluation center for air warfare and missile weapons systems; and the national range/facility for parachute test and evaluation. Capabilities include testing of tactical aircraft systems, including flight tests of aircraft avionics and defense suppression systems; propulsion testing for the development of solid, air-breathing, and liquid propulsion units, including static tests of rocket motors; and special purpose testing for warhead, fuze, motor, airframe, and other components.
The Naval Air Weapons Station operates and maintains base facilities, including the airfield which would be used for landing the X-33 and landing and takeoff of the Boeing 747. The airfield is located at the southern edge of the base and has been used for several decades as a supersonic

aircraft training facility. Runway 3-21 on Armitage Airfield is an alternative for X-33 landings. It is a paved runway, 3,050 m by 61 m (10,000 ft by 200 ft). China Lake's airspace is part of the R-2508 restricted military airspace. Noise levels are typical of those associated with conventional and supersonic aircraft. Procedures have been established to minimize noise disturbances to the nearby residents of Ridgecrest, California. The airfield is located in an area considered to be in serious non-attainment for the federal ozone air quality standard.

ES.3.4 Michael Army Airfield on Dugway Proving Ground, Utah

Dugway Proving Ground is located approximately 130 km (80 mi) southwest of Salt Lake City, Utah, near the town of Tooele. Dugway Proving Ground encompasses approximately 324,000 ha (800,000 ac) of the Great Salt Lake Desert. Dugway is part of the U.S. Army Test and Evaluation Command, headquartered at Aberdeen Proving Ground, Maryland.

The airfield within Dugway Proving Ground proposed for landing the X-33 is called Michael Army Airfield. This airfield is located on the eastern boundary of Dugway. The airfield has a 3,960 m (13,000 ft) long by 61 m (200 ft) wide hard surfaced runway. Immediate surrounding terrain is relatively flat. It is a secure facility with a long history of flight operations. The airspace above Dugway Proving Ground is restricted military airspace controlled by Hill Air Force Base which manages and approves use of the Utah Test and Training Range (UTTR).

Dugway is primarily responsible for planning, conducting, and analyzing tests involving chemical warfare and biological defense systems; flame, incendiary, and smoke obscurant systems; and artillery systems to determine their applicability to military defense programs. The Air Force manages the UTTR at Michael Army Airfield on Dugway. Their primary mission is testing and evaluating unpiloted aerospace vehicles (UAV's) and UAV launch and recovery systems. They support testing of weapons systems; training for operational aircrews and other combat units; maintaining and operating a variety of aircraft; scheduling and monitoring flight activities; and providing range support and air traffic control. UTTR operations are compatible with the mission of the X-33 Program, and no new site preparation would be required.

Dugway Proving Ground's air quality is in attainment for all criteria pollutants under the federal Clean Air Act. Noise levels are representative of an active airfield used by both conventional and military supersonic aircraft. No new areas would be disturbed, thereby precluding direct impact to vegetation and wildlife. The installation has standard procedures to prevent unnecessary disturbance of the desert terrain.

If use of Dugway is determined to not meet environmental and/or Program needs or suitability, test objectives for flying the X-33 to the long-range landing site will be modified, and all test flights except those to Silurian Lake or China Lake Naval Air Weapons Station will be conducted to the selected long-range landing site.

ES.3.5 Malmstrom Air Force Base, Montana

Malmstrom Air Force Base is located 12 km (7 mi) east of downtown Great Falls, Montana. The installation occupies approximately 1,279 ha (3,159 ac). It is home to the 341st Missile Wing (341 MW), which is responsible for operation, maintenance, and security of assigned intercontinental ballistic missile systems. Since the late 1980's, Malmstrom Air Force Base has been home to the 43rd Air Refueling Group. As a result of the Department of Defense's Base Realignment and Closure Plan, the 43rd Air Refueling Group was transferred to MacDill Air Force Base, Florida. After the move, the airfield was closed on Decmeber 31, 1996, except for the area used by helicopters of the Malmstrom's Air Rescue Flight. The airfield has a hard surface runway approximately 3,500 m (11,500 ft) long and 61 m (200 ft) wide with a 305 m (1,000 ft) overrun at each end. Since closure of the airfield, the USAF has no plans or budget to operate the runway. There is no control tower, no instrument landing system, no visual aids for visual approach, no slope indicator lights, no airfield weather support, and no on-going maintenance of the runway. The terrain surrounding the airfield is relatively flat At the time of the proposed X-33 flights, the airspace will be under Federal Aviation Administration (FAA) control. Reopening of the airfield through permission of the USAF and/or Congressional authorization would be required in order for NASA to land the X-33 at this facility, even on a limited, temporary basis.

Malmstrom Air Force Base is located in a semi-arid region, moderated by the presence of the Rocky Mountains to the west and Big and Little Belt ranges to the south. Most indigenous vegetation within the Malmstrom boundaries was removed by developmental activities and introduction of exotic grasses. Bald eagles have been observed in the area surrounding the base. The base is potential habitat for candidate species of ferruginous hawk and loggerhead shrike. However, threatened and endangered species do not currently impose any constraints to development and use of the base. Air quality is in attainment for all federal criteria pollutants under the Clean Air Act. Noise levels at the time of proposed X-33 landings and support activities will be much lower than those experienced when the base maintained an active, operational airfield operation. However, the immediate vicinity of the airfield, established as acoustical compatibly zones with surrounding activities and facilities, will not be encroached as a result of proposed X-33 and Boeing 747 landings and takeoff of the Boeing 747 with the X-33 piggyback for return to Edwards.

ES.3.6 Grant County Airport Near Moses Lake, Washington

The Port of Moses Lake, Washington, owns and operates the Grant County Airport. The airport is a former part of the Strategic Air Command known as Larson Field Air Force Base which was decommissioned in 1965 and became part of the Port of Moses Lake in 1966. The Port of Moses Lake is adjacent to the community of Moses Lake, Washington. Today, Grant County Airport is a regional aviation, industrial, and educational facility. This facility conducts significant flight testing and training of Boeing 747 and other commercial flight crews.

Runway 14L-32R is 46 m (150 ft) in width and 4,115 m (13,500 ft) in length and would be used for landing the X-33 and takeoff and landing of the Boeing 747 carrier aircraft.

The facility is located in the arid eastern half of the state of Washington. It is predominantly surrounded by shrub-steppe vegetation, supporting few wetland areas. Birds and animals use the shrub-steppe vegetation for food, nesting and denning sites, escape cover, and protection from adverse weather. Little wildlife and vegetation concerns would be incurred by use of the existing facilities for proposed landing of the X-33 and other support activities. Noise levels are those normally associated with a conventional airport supporting aircraft as large as jumbo jets such as the Boeing 747. No supersonic aircraft routinely uses the airspace. The airspace in the vicinity of the airport is part of the National Airspace managed by the FAA and is not covered by any existing military operating restrictions. Air quality meets all requirements for attainment under National Ambient Air Quality Standards of the Clean Air Act.

McChord Air Force Base near Tacoma, Washington, plans to utilize the Grant County Airport as the location of the C-17 (a military cargo plane) shortfield. The USAF has included $2.4 million in its fiscal year 1999 military construction budget to fund infrastructure work at the Grant County Airport to support the C-17.

ES.4 Environmental Consequences

Criteria for determination of significance are provided in Table ES-4. All projected environmental impacts would be moderate or less. No direct or immediate environmental impacts would result from implementation of the No Action alternative. Environmental impacts most relevant to the Proposed Action were attributed to noise and sonic boom; flight safety; transportation effects; and airspace and air traffic impacts. The California sites were the only ones under consideration requiring air conformity analyses to determine whether or not proposed activities would exceed air emissions thresholds and require a conformity determination for consistency with the State Implementation Plan. The Silurian Lake alternative was the only one involving potential disruption to ground transportation. Projected impacts to threatened and endangered species have been covered in a Biological Assessment provided to the U.S. Fish and Wildlife Service. Environmental justice analyses of flight corridors indicated that no highly disproportionate and adverse impacts to minority or low income populations would be expected from flight operations or testing of the X-33.

Table ES-4. Significance Criteria.

Significance	Criteria
N/A	Issue has no relevance to the site or global environs.
None	No impacts expected.
Minimal	Impacts are not expected to be measurable, or are measurable but are too small to cause any change in the environment.
Minor	Impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with little effort and resources so that the impact is not substantial.
Moderate	Impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with effort and resources so that the impact is not substantial.
Major	Environmental impacts which individually or cumulatively could be substantial.

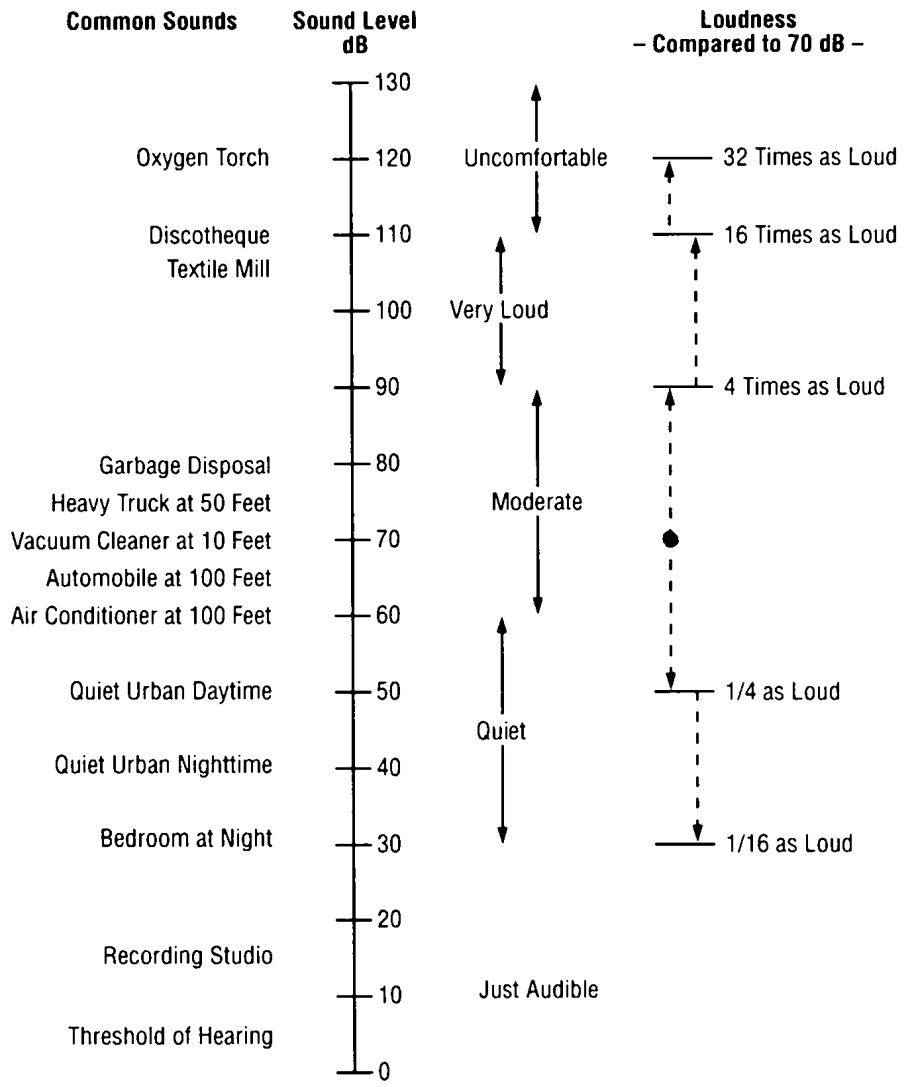
ES.4.1 Noise/Sonic Booms

Noise is generally defined as an unwanted sound. It is measured in several ways and definitions of those units of noise necessary to the understanding of the impacts from the X-33 are provided in Table ES-5 with typical sound levels provided in Figure ES-13. Noise generated by X-33 flight testing was analyzed for three distinct conditions:

- liftoff and flight readiness firing (FRF) (noise)
- ascent (noise and sonic boom)
- descent (sonic boom only).

Table ES-5. Noise Level Units and Definitions or Explanations.

Symbol/Unit	Term	Definition
dB	decibel	Unit of measurement of sound amplitude; logarithmic scale.
dBA	A-weighted sound level	Sound level filtered to the approximate response of the human ear.
dBC	C-weighted sound level	Sound level filtered to the range from approximately 20 Hz to 20,000 Hz.
Hz	frequency	Number of times per second air vibrates or oscillates as sound travels through it.
OASPL	Overall Sound Pressure Level	Total sound pressure level using all frequencies.
L_{dn}	Day-Night average sound level	The 24-hour energy average A-weighted sound level with a 10 dB weighting added to those levels occurring between 10 p.m. and 7 a.m. the following morning.
p (psf or Pa) psf = pounds per square foot Pa = Pascal = N/m^2	Peak Overpressure	Maximum pressure which the sonic boom produces above existing atmospheric pressure.



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979

Figure ES-13. Typical A-Weighted Sound Levels of Common Sounds.

Noise would be generated by the engines. Sonic booms would be generated by the vehicle moving through the atmosphere faster than the speed of sound (Mach 1 or 1,200 km/hr (730 mph)). A sonic boom is a transient or impulsive event lasting only about 1/4 of a second. A sonic boom is comparable to thunder from a nearby storm lightning strike.

At either Haystack Butte or Space Port 2000, liftoff noise levels would be at or below 110 dB and 90 dBA at approximately 6 km (3.7 mi) from the launch site. Workers would hear noticeable noise at distances up to 10 km (6.2 mi). The longest interval of time to hear engine noise at these levels would be approximately 20 seconds during an FRF. Maximum noise levels outside Edwards' boundaries would be expected to be 100 dB and 80 dBA, resulting in minimal impact.

The day/night average sound level (L_{dn}) projected level of 45 dBA would be well below the minimum federal guidelines for land use compatibility.

Sonic booms would be produced by the vehicle's movement through the atmosphere at speeds greater than Mach 1. Due to atmospheric conditions and maneuvers of the vehicle, two or more sonic booms can converge at ground level to produce a louder boom, called a focus boom. Most of the area under the flight track would experience low level sonic booms below 0.1 kilopascal (kPa) (2 pounds per square foot (psf)) with small probability of damage to structures, usually a cracked window. These overpressure levels due to sonic booms would be similar to the levels produced by a Space Shuttle Orbiter descending over the Antelope Valley when landing at Edwards. A very small area outside Edwards, approximately 32 to 40 km (20 to 25 mi) downrange, would experience a focus boom of approximately 0.17 to 0.34 kPa (3.5 to 7 psf). Maximum focus overpressure from the X-33 would be somewhat lower than the 0.48 to 0.53 kPa (10 to 11 psf) associated with the initial acceleration focus of the SR-71 (supersonic military plane) during its routine training missions.

Descent and landing at Silurian Lake would produce sonic booms of approximately 0.01 to 0.06 kPa (0.2 to 1.2 psf) through the ground track. There would be little probability of damage to structures from these low overpressures. Some focus overpressures would be as high as 0.5 kPa (10 psf). Focusing would occur within small regions of BLM-administered lands.

Descent and landing at China Lake would produce similar sonic booms levels as those projected for Silurian Lake. The focus boom would be approximately 91 m (100 yd) wide reaching levels as high as 0.53 kPa (11 psf), and would be expected to impact land within China Lake's boundaries.

Descent and landing at Dugway Proving Ground, Utah, would produce very low sonic boom footprints with overpressures of 0.05 kPa (1 psf) or less along the flight track for up to 240 km (150 mi) prior to landing. A focus boom, typically less than 91 m (100 yd) wide would occur on BLM lands approximately 32 to 40 km (20 to 25 mi) with a maximum overpressure of 0.53 kPa (11 psf). Similar sonic boom footprints at comparable distances from the runway would be expected at Malmstrom Air Force Base and Moses Lake.

A specific issue was submitted during scoping of the EIS concerning potential of sonic boom to influence snow avalanche. Developed areas located near avalanche-prone snow slopes (e.g., mountain passes and alpine and cross-country ski areas) generally employ methods to artificially trigger snow avalanches, thus avoiding the possibility of human injury or damage to structures. Due to the very low overpressures from sonic booms in the vicinity of mountain passes and skiing areas (approximately 0.05 kPa (1psf) or less), impact from X-33 sonic booms is expected to be minimal.

ES.4.2 Flight Safety

The national range system, established by Public Law (PL) 81-60, was originally sited based on two primary concerns: location and public safety. Thus, Range Safety in the context of national range activities, is rooted in PL 81-60 and the Department of Defense Directive 3200.11 "Use, Management and Operation of Department of Defense Major Range and Test Facilities," that provides the framework under which the national ranges operate and provide services to range users. To provide for public safety, the ranges, using a Range Safety Program, shall ensure that the launch and flight of launch vehicles present no greater risk to the general public than that imposed by overflight of conventional aircraft.

The range users (NASA and Lockheed Martin Skunk Works) would be required by Edwards Range Safety to endeavor and demonstrate through risk modeling that the lowest risk possible, meeting mission requirements, is consistent with launch risk guidance. This guidance is based on a standard of a collective per-flight risk level of not more than 30 casualties (harm) in 1 million (30×10^{-6}) for the general public and not more than 300 casualties in 1 million (300×10^{-6}) for essential launch area personnel. The basic standard for the general public is not more than the risk voluntarily accepted in normal day-to-day activities.

Another way of interpreting risk is to convert each risk estimate into a probability of occurrence simply by dividing each estimate into 1. A risk of 30×10^{-6} equates to a probability of 1 in 33,000 that an injury would occur. This probability does not mean that 1 out of every 33,000 people would be injured, but that for every 33,000 flights of the X-33, one injury to the public would be expected. A risk of 300×10^{-6} equates to a probability of 1 in 3,300. Flight paths have been analyzed to determine proposed trajectories (launch to landing) with lowest risk possible, consistent with mission requirements, and in consonance with AFFTC launch risk guidance. The risk analysis used debris patterns resulting from inflight breakup or explosion during powered mode and population databases for Edwards and the general public along proposed flight tracks. Using historical failure rates for powered flight mode and engineering reliability factors for main engine cut off through landing, the maximum downrange risk value and probability of occurrence for launches from Haystack Butte range from 19×10^{-6} (1 in 53,000) to 5.0×0^{-6} (1 in 200,000) on a collective (total) per flight risk basis over the entire trajectories. The maximum values of launch through main engine cut off (MECO) for launches from Space Port 2000 would be 21×10^{-6} and 1 in 48,000, respectively. The historical failure rate, used for risks from launch through MECO, was derived from launch failure rates of expendable launch vehicles (Atlas, Delta, and Titan II) and the Space Shuttle's LH_2/LOX engines. Engineering reliability factors were used for MECO through landing.The flight test safety record for X-planes is a reflection of the intensive and effective risk management procedures developed and practiced by the ranges over the last 50 years.

Hazards resulting from an uncontrolled situation would include: (1) on or near launch pad explosion; (2) high-altitude explosion downrange of the launch site while the vehicle is still in

powered flight; and (3) loss of vehicle control resulting in either vehicle breakup or a whole body impact. The debris zone in the vicinity of the launch pad due to an explosion at or immediately after liftoff would impact an area up to 640 m (2,100 ft) in radius or 126 ha (311 ac). Overpressures throughout this zone would pose some risk to light structures and windows. A high-altitude explosion on the trajectory to Silurian Lake or China Lake would produce a maximum debris zone of approximately 21 km (13 mi) in diameter and 32 km (20 mi) downrange.

If the vehicle undergoes a mid-air breakup and explosion during powered mode on flight to Dugway, debris would continue to move forward as it falls. If vehicle failure occurred close to its maximum speed at MEO, the leading edge of the debris patternwould be approzimately 400 km (250 mi) from Dugway. Debris would potentially fall along the flight track for up to 160 km (100 mi) long and 32 km (25 mi) wide due to the high energy achieved upon accelerating from Mach 9 to 12. At the maximum speed of Mach 15 which is needed to reach Malmstrom or Moses Lake, the elliptical debris pattern from a break up of the vehicle could fall along the flight track for up to 250 km (160 mi) long and 64 km (40 mi) wide. The leading edge of the debris field could be as far as approximately 1100 km (700 mi) downrange of Edwards or 400 km (250 mi) from Malmstrom. For all landings, potential debris zones would decrease in size as the vehicle loses speed and altitude, eventually converging on landing to the smallest potential debris field of approximately 4 ha (10 ac) if the vehicle crashes nose down short of the runway. Risk factors were based on debris projections and footprints to determine trajectories meeting range safety criteria for powered flight mode. Trajectory risk analyses would continue to be performed based on final design and risk projections specific to landing determined in order to refine energy management maneuvers and final approaches to landing sites.

After main engine cutoff and depletion of fuels, the vehicle would glide in extremely thin atmosphere, similar to a satellite or a Space Shuttle Orbiter during its long descent from space. Atmospheric loads on the vehicle would be significantly less than the design capability of the vehicle until the vehicle reenters the denser atmosphere and begins landing maneuvers.

NASA sought an "X" (eXperimental) designation for the X-33 spaceplane and worked closely with range safety at several installations which have been base operations for preceding X-planes in order to benefit from the flight decision-making process of these established organizations. In addition, the flight test program would be structured as an incremental expansion of altitude, speed, and range in order to flight test the vehicle in a safe, step-wise manner, cautiously testing the vehicle's capability more rigorously with each step. Data will be analyzed flight to flight with successive launch decisions dependent on the cumulative data available. Short-range flights would provide flight test and performance data for the shortest range and slowest speed that the X-33 can safely fly. The mid-range flight tests will allow test and performance data acquisition for the vehicle at approximately one-half its design capability and well within the vehicle's maximum tolerance limits. All systems must be determined to be functioning within acceptable design specifications prior to flight testing the vehicle's full design performance capability.

ES.4.3 Airspace and Air Traffic

Airspace is defined dimensionally by limitations describing its height, depth, width, and period of use (time). Changes in airspace usage such as activity intensity (few flights versus numerous flights), altitudes (low-level versus high-level), and speeds (subsonic versus supersonic) can affect other resource areas (noise and/or health and safety) or limit airspace availability to other users. The Department of Transportation, Federal Aviation Administration (FAA), is charged with overall management of national airspace and has established certain criteria and limits for use of various sectors of the airspace. The National Airspace System within FAA's control is classified A through G. Class A airspace is the airspace within the altitude bands of 5500 m through 18,300 m (18,000 ft through 60,000 ft) and is under positive control due to the large number of commercial air flights. Above Class A airspace resides Class E airspace which has a floor altitude of 18,300 m (60,000 ft) and is considered general control for unique aerospace activities such as those conducted by NASA.

Restricted areas are designed to confine or segregate activities considered to be hazardous. Specific permission is required from the controlling agency to penetrate active restricted areas. Military Operating Areas (MOAs) are established outside Class A area (below 5,500 m (18,000 ft)) to separate and segregate certain nonhazardous military activities from instrument flight rules (IFR) traffic. MOAs are identified by marking on appropriate aeronautical charts and are open to aircraft operating visual flight rules (VFR). They are used to conduct training activities such as air combat maneuvers, air intercept, aerobatics, low-altitude tactics, and other military-specific activities.

All X-33 flight paths would originate in the military restricted area airspace of R-2515 within R-2508 Complex which includes both military restricted airspace and MOAs over 51,800 sq km (20,000 sq mi) in land area and reaches from the Western Mojave Desert to the Southern Sierra Nevada Desert. The R-2508 Complex is a tri-service complex of restricted airspaces established in 1955 to protect military flight activities. The airspace complex includes all the land and airspace managed by three major military installations: (1) Air Force Flight Test Center (AFFTC) on Edwards Air Force Base; (2) China Lake Naval Air Weapons Station; and (3) Ft. Irwin. The AFFTC would coordinate X-33 use of range space within R-2508 as well as all other intervening airspace under the authority of other ranges or the FAA that the X-33 would fly within or over during flight tests.

Flight tests to Silurian Lake would use the Shoshone MOA to decend in a pattern to reduce energy and speed until the X-33 safely lands on the dry lake bed. The airspace within the Shoshone MOA, extending 14.4. km (9 mi) west of the restricted airspace of R-2502N encompassing the lake bed, and 4.8 km (3 mi) east of the lake bed with a total corridor width of 36.2 km (22.6 mi), would need to be cleared of all aircraft by a request for sterilization of the MOA and all other areas outside restricted area airspace pursuant to 14 CFR 91.143 or 19.137, or an altitude reservation, as appropriate, for up to 4 hours per landing as approved by the FAA.

The clear zone corridor for landing would also extend 12.8 km (8 mi) into the R-2502N restricted military airspace with the same width of 36.2 km (22.6 mi).

Flight tests to China Lake would remain entirely within restricted military airspace of the R-2508 Complex, thereby precluding any interaction with non-military aircraft. Military aircraft operations would be coordinated with all flight tests of the X-33 in order to ensure air safety.

Significant portions of proposed flights of the X-33 from Edwards to Michael Army Airfield on Dugway Proving Ground would involve overflight of or flight through the restricted military airspaces of the R-2508 Complex, Nellis Air Range under the authority of the Nellis Air Force Base near Las Vegas, Nevada, and the Utah Test and Training Range (UTTR) under control and management of Hill Air Force Base near Ogden, Utah. The X-33 would also overfly a total of four high altitude (5,500 to 18,300 m (18,000 to 60,000 ft)) and low altitude (surface to 5,500 m (18,000 ft) flight sectors under FAA control. Since the X-33's altitude would exceed 18,300 m (60,000 ft) when over FAA Class A airspace, Notices to Airmen (NOTAMs) would be required containing essential data concerning the X-33 flight track and emergency procedures in accordance with FAA Advisory Circular No. 150/5200-28B, "Notices to Airmen (NOTAMs) for Airport Operators." Descent of the X-33 would occur within the military restricted airspace of UTTR. AFFTC would coordinate flight approvals and plans with Hill Air Force Base and Dugway Proving Ground in advance of flight.

The X-33's flight track to Malmstrom Air Force Base would require similar coordination with R-2508 Complex users and the Nellis Air Range as described above. This flight path would potentially overfly a total of 16 high and low altitude flight sectors under positive control of the FAA. NOTAMs would be required. In addition, a sterile airspace void of all aircraft would be required for landing at the base. A corridor, 33.6 km (21 mi) long and 19.2 km (12 mi) in width, encompassing the runway, would be cleared of all aircraft for 1.5 to 4 hours per landing. A temporary restriction for all aircraft would be imposed by NOTAM on this airspace with minor disruption of general aviation due to avoiding the airspace. The NOTAM would include details on the flight track and emergency instructions. Since the base airfield would be closed to both commercial and military flight operations except for small aircraft such as helicopters, moderate disruption of aviation is expected.

The same procedures for sterile airspace, void of aircraft, would be required for landings at Moses Lake, Washington. The X-33 would fly through the Nellis Air Range and overfly a total of 16 high- and low-altitude flight sectors during a flight test terminating at Moses Lake. Since the Grant County Airport at Moses Lake is a significant aviation training center and provides commercial air service to the region, disruption of airport services during a 4-hour time period for each landing would generate moderate disturbances in air service.

ES.4.4 Air Quality

Under the general conformity regulations issued by the U.S. Environmental Protection Agency to comply with the Clean Air Act Amendments of 1990, federal agencies are required to ensure that any proposed action(s) that may affect a nonattainment or maintenance area must conform to the State Implementation Plan (SIP). The air quality status of the alternative sites is provided in Table ES-6. Air quality was in attainment for all air quality standards for criteria pollutants under the Clean Air Act except for the southern California alternative sites which were designated from severe to moderate non-attainment for ozone and/or particulate matter less than 10 microns in size (i.e., soot, particulate, dust, etc., small enough to be inhaled into the lungs). Air emissions for activities at all locations were determined to range from 4% to 64 % of the *de minimis* thresholds. Since no activities over any 1 year exceeded *de minimis* thresholds, no more detailed analysis and demonstration of compliance with the SIP is required under the conformity regulations. Air permits for construction, use of certain equipment such as generators, and some processes such as cleaning with solvents considered as volatile organic compunds (VOCs) would require permitting through respective state or district regulatory authorities.

Table ES-6. FederalAttainment Status and Conformity *de minimis* Levels for X-33 Proposed.

Site	Ozone		PM_{10}		Other Criteria Pollutants
	Classification	Conformity *de minimis* Level (NO_X & VOC's)	Classification	Conformity *de minimis* Level	Classification
Haystack Butte on Edwards	severe non-attainment	22.8 mtpy (25 tpy)	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Space Port 2000 on Edwards	serious non-attainment	45.5 mtpy (50 tpy)	attainment	N/A	attainment
China Lake Naval Air Weapons Station	serious non-attainment	45.5 mtpy (50 tpy)	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Silurian Lake	attainment	N/A	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Dugway	attainment	N/A	attainment	N/A	attainment
Malmstrom	attainment	N/A	attainment	N/A	attainment
Moses Lake	attainment	N/A	attainment	N/A	attainment

40 CFR Part 51, Subpart W, δ51.853(b).
mtpy = metric tons per year
tpy = tons per year
N/A = Not applicable; location is in attainment with NAAQS for that pollutant.

ES.4.5 Transportation

The only alternative which is expected to require disruption of transportation is the Silurian Lake alternative. Due to the close proximity of Highway 127 (see Figure ES-12) on the approach of the X-33 and Boeing 747 for landings, and takeoff of the Boeing 747 with the X-33 piggyback for return to Edwards, the state highway would require closing from a place approximately 16 km (10 mi) north of the lake bed to a location approximately 24 km (15 mi) south of the lake bed at Baker, California. State Highway 127 is the primary access road to Death Valley National Park. These locations were selected because the intervening length of highway does not contain any commercial services or intersections with detour roads. Road closure would be coordinated with and at the approval of the California Highway Department. The road would require closure for up to 4 consecutive hours during each flight test into the lake bed. A smaller section of the road (approximately 1.6 km (1 mi)) in the immediate vicinity of the lake bed would be closed for 15 to

30 minutes in order to land and takeoff the Boeing 747. Escorts for critical needs such as medical emergencies and perishable commodities would be available at both the north and south roadblocks. The X-33 Program projects 1 to 3 flights to land on the lake bed.

ES.4.6 Threatened and Endangered Species

A "Biological Assessment for Proposed Takeoff and Landing Sites for the X-33 Advanced Technology Demonstrator Program," was submitted to the U.S. Fish and Wildlife Service (USFWS) in April 1997. The biological assessment is required under Section 7 of the Endangered Species Act if any federal agency's action(s) may affect federally protected plant or wildlife species.

The X-33 Advanced Technology Demonstrator Program is expected to have no or minimal effects on federally protected species. The most significant impact would be the loss of desert tortoise Critical Habitat from launch facilities preparation at Haystack Butte within Edwards Air Force Base. The area is designated as Desert Tortoise Management Zone 1 by the USFWS due to the low tortoise density and high incidence of human disturbance already occurring. The loss of a maximum of 19 ha (47 ac) of habitat that supports so few tortoises is not likely to greatly influence desert tortoise populations or increase the species' extinction risk.

Preparation of the Silurian Lake bed and surrounding area for X-33 landings is not expected to have any impact on desert tortoise populations. No tortoises, tortoise burrows, or other evidence of tortoises have ever been documented from the lake bed or immediately adjacent habitat. Facilities brought to the site would be kept to the absolute minimum necessary to support landings and very little permanent habitat disturbance or destruction is anticipated.

Sonic booms that would be produced by X-33 are considered to be mildly annoying, but not dangerous for humans. Impacts to wildlife are difficult to predict because there are few studies addressing these effects. Good data exist for desert tortoises showing that sonic booms much greater than those expected from X-33 were necessary to induce even temporary hearing loss. The noise attenuation capacity of water is expected to protect the Mojave tui chub population at China Lake. Nesting birds may be startled off their nests, potentially doing harm to young or nestlings, or giving predators an opportunity to raid the nest while the adults are gone. Peregrine falcons are not easily startled from their nests, and when they do leave, return within a few minutes. Peregrines defend such a large nesting territory from other peregrines that very few birds are likely to be exposed to the booms. It is also improbable that the Inyo California towhees would damage or desert their nests because of sonic booms. However, if some mortality or nest abandonment occurs, there should be adequate time remaining in the season for the birds to renest, as they routinely do after nesting failures.

Based on available data and the opinions of species experts, it is expected that only a small number of individual desert tortoises may be adversely affected by the X-33 project. Effects

would be minimized by implementing, as planned, the measures to reduce or eliminate impacts discussed above.

ES.4.7 Global Environment

The major combustion product of X-33 flight tests is water. In the lower atmosphere or troposphere (surface to 13 km (8 mi)), water vapor contributions from the X-33 would be minute and not contribute any quantifiable greenhouse gas or impact to global warming. In addition, the stratospheric ozone impacts of a theoretical vehicle using X-33 type propulsion was compared to one using a combination of LH_2 and LOX engines and solid rocket motors which release chlorine-containing combustion products. The stratosphere extends from approximately 10 km (6 mi) of altitude to 50 km (31 mi). Current launch vehicles using solid rocket motors effect a relatively small reduction in stratospheric ozone. A potential successor spaceplane based on the X-33 design would reduce ozone impacts on launch by approximately 1,000 times.

ES.4.8 Cumulative Impacts

The X-33 program plans would require approximately 1 1/2 years to prepare the launch and landing sites for Program activities. Flight tests are expected to be accomplished in a 10 month consecutive time period and then cease. Approximately 19 ha (47 ac) of desert tortoise critical habitat, consisting of creosote bush scrub and Joshua tree woodland habitats, within Edwards would be disturbed with permanent structures, adding a small increment to the desert habitat changed from its pristine state. Long-term impacts would include potential desert tortoise mortalities. Due to the minimal nature and level of expected impacts, the short time frame of the entire project, and commitment to protection of natural resources, cumulative impacts are expected to be minimal.

ES.4.9 Incomplete or Unavailable Information

Due to this project being planned as an X-plane project, information through evaluation of similar X-plane, Space Shuttle, or supersonic aircraft using known data and proven theoretical modeling was available to determine most environmental impacts. In addition, proposed alternatives are well established installations, except Silurian Lake. A formal jurisdictional wetlands determination was not available for Silurian Lake. However, the X-33 Program assumes that it does meet criteria established by the U.S. Army Corps of Engineers and apply for a Section 404 permit for any disturbance and/or fill of the lake bed.

ES.5 Mitigation, Monitoring, and Permitting

Environmental impacts attributable to X-33 activities would be mitigated through pollution prevention programs, including reducing and/or eliminating the use of toxic substances from fabrication of the vehicle to flight test, replacement of ozone depleting substances with

substances that are benign to stratospheric ozone, reducing toxic emissions to the atmosphere, and recycling where practical and possible. Potential flight safety impacts would be mitigated by careful selection of flight corridors and cautious implementation of the flight test program through incremental expansion of the flight envelope (progressively increasing altitude, speed, and distance). Emergency response plans would be prepared and coordinated as described in section ES.2.1.3 in advance with emergency response agencies in affected states and localities.

Air quality impacts would be mitigated through established best management practices for dust control, and prudent use of internal combustion engines. Cultural resource impacts would be mitigated through ground surveys and avoidance of potential areas to the maximum extent possible. Transportation impacts for Highway 127 at Silurian Lake would require public notifications and alternative vehicle routing as approved by the California Department of Transportation. Escorts for critical needs such as ambulances, perishable commodities, etc., would be available. Impacts to desert tortoise Critical Habitat at Edwards would be mitigated through site surveillance by a biological monitor, placement of lines in accordance with desert tortoise requirements, relocation of desert tortoise(s) that are found within the launch site to a safe, prepared burrow. X-33 flights over mountain passes and alpine ski areas during winter months when snow avalanche potential exists would be coordinated with identified areas. The X-33 Program would obtain necessary air quality and other environmental permits for launch site preparation and use of equipment from appropriate state agencies and districts, Temporary Use Permit for use of Silurian Lake from BLM, Encroachment Permit from Caltrans for temporary closure of Highway 127 for landings at Silurian Lake and a request for appropriate airspace sterilization or an altitude reservation from FAA for potential landings at either Silurian Lake, Malmstrom Air Force Base and/or Moses Lake.

ES.6 Summary of Environmental Impacts

A summary of environmental impacts is provided in Tables ES-7, ES-8, and ES-9. No environmental impacts would result from implementation of the No Action alternative.

Table ES-7. Summary of Environmental Impacts: Launch Site Alternatives within Edwards Air Force Base.

Issues	Proposed Launch Site Alternatives	
	Haystack Butte	Space Port 2000
Utilities and Infrastructure	Increase in demands on utilities and services is minimal compared to existing capacities of these systems. Site preparation and placement of equipment of a wastewater treatment system is expected to produce only minimal impacts to the natural environment.	Increase in demands on utilities and services is minimal compared to existing capacities of these systems. Extensions of existing systems would be developed, however, no new systems would be needed to service this site.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. Minimal impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. Minimal impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Minimal impact to existing airspace due to its location within R-2508 Complex. Lowest risk to personnel and public from launch and powered flight.	Minimal impact to existing airspace due to its location within R-2508 Complex. Slightly higher risk to personnel and public in powered mode than Haystack Butte.
Biological Resources	Site preparation activities will impact 19 ha (47 ac) of Joshua tree woodland and creosote bush scrub. This area represents less than 0.1% of these habitats on Edwards. Impacts would be minimal.	Site preparation activities will impact 9.3 ha (23 ac) of halophytic phase saltbush scrub. This area represents less than 0.1% of this habitat on Edwards. Impacts would be minimal.
Threatened, Endangered and Sensitive Species	Part of launch site is within critical habitat for the desert tortoise. Approximately 15 to 20 individual tortoises could be affected. Mitigation measures would reduce impacts.	Launch site not within critical habitat. Impacts to desert tortoise are unlikely.
Cultural Resources	No eligible archeological sites located within project area. Several sites located within close proximity would be protected. No impacts expected.	One archeological site located within the project boundary would be mitigated by appropriate methods approved by the CA SHPO.
Water Resources	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.
Geology and Soils	Minimal impacts to soils from earth moving and related activities. No impacts to geological features expected.	Minimal impacts to soils from earth moving and related activities. No impacts to geological features expected.

Table ES-7. Summary of Environmental Impacts: Launch Site Alternatives (Continued).

	Proposed Launch Site Alternatives	
Issues	**Haystack Butte**	**Space Port 2000**
Health and Safety	Unexploded ordinance from previous activities must be removed. Base has appropriately trained personnel to perform this function; therefore, no impacts to safety are expected. Based on the relatively small amounts and proven track record for the industry, transportation of LH_2/LOX on public and Base transportation routes are not expected to impact transportation safety. This site poses minimal debris hazard due to early flight not being over facilities or populations.	This site has not been used as a test or training site for ordnance; therefore, no safety issues expected. Based on the relatively small amounts and proven track record for the industry, transportation of LH_2/LOX on public and Base transportation routes are not expected to impact transportation safety. Liftoff trajectories from this site may present debris hazards to some Edwards' facilities from potential breakup of the X-33 during launch and early flight. No personnel would be at risk due to clearing of all personnel to safe distances.
Operational Noise	Normal, non-flight operations would be similar to existing Base operations; therefore, no impacts are expected.	Normal, non-flight operations would be similar to existing Base operations; therefore, no impacts are expected.
Transportation	No off-site ground transportation corridors would be affected either through modification or increased usage or closure. On-site systems could be affected during road modifications or vehicle towing operations.	No off-site ground transportation corridors would be affected either through modification or increased usage or closure. On-site systems could be affected during vehicle towing operations.
Population and Employment	Short-term increase of relatively small number of workers would produce minimal positive impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal positive impacts on local economy.
Land Use	Land use change for this area from undisturbed to operational is considered within the overall mission of the Base.	Land use change for this area from undisturbed to operational is considered within the overall mission of the Base.
Snow Avalanche	No impacts expected.	No impacts expected.
Flight Noise and Sonic Booms	Operational and liftoff noise will be minimal. Minimal impacts from sonic booms may occur in the form of cracked windows.	Operational and liftoff noise will be minimal. Minimal impacts from sonic booms may occur in the form of cracked windows.
Flight Safety	Flight trajectories have been carefully selected, resulting in expected risk factors being well under Edwards' criteria established as safe. Therefore, safety impacts are expected to be minimal.	Flight trajectories have been carefully selected, resulting in expected risk factors being well under Edwards' criteria established as safe. Therefore, safety impacts are expected to be minimal.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

Table ES-8. Summary of Environmental Impacts: Short-Range Landing Site Alternatives.

Issues	Proposed Short-Range Landing Site Aternatives	
	Silurian Lake	China Lake
Infrastructure	There are no facilities at this site; therefore, all equipment will be temporary. No long-term impacts are expected.	No modifications to infrastructure required; existing systems can accommodate Program needs.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Airspace impacts are expected to be minimal since the majority of the trajectory is in R-2508 airspace. Sterile airspace, void of aircraft for 1.5 to 4 hours for area in the vicinity of Silurian Lake during reentry and landing would have minimal effect on general aviation.	Airspace impacts are expected to be minimal since the trajectory is in R-2508 airspace and ascent and descent would be in military restricted airspace. Impact on general aviation is expected to be minimal.
Biological Resources	All activities will occur on lake bed which is essentially devoid of vegetation and wildlife. Minimal impacts expected.	No impacts expected because no facility construction or modifications needed
Threatened, Endangered and Sensitive Species	Impacts to desert tortoise are expected to be minimal.	No species are expected to be adversely affected.
Cultural Resources	No properties are expected to be affected.	No properties are expected to be affected.
Water Resources	No impacts to water resources expected.	No impacts to water resources expected.
Geology and Soils	Minimal impacts to soils from staging area preparation and related activities. No impacts to geological features expected.	No impacts to geology or soils are expected because no construction is required.
Health and Safety	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.
Operational Noise	Non-flight operations are expected to produce minimal impacts due to the lack of noise receptors.	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.
Transportation	State Highway 127 would be closed for up to 4 hours, 1 to 3 times during the early portion of the flight program. Impacts would be mitigated through advance notices and coordination with appropriate state agencies and are therefore expected to be moderate.	No impacts to on-site or off-site transportation systems are expected.

Table ES-8. Summary of Environmental Impacts: Short-Range Landing Site Alternatives (Continued).

Issues	Proposed Short-Range Landing Site Aternatives	
	Silurian Lake	China Lake
Population and Employment	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.
Land Use	The lake bed is classified as a BLM Class I intensive use area. Therefore, the use of the lake bed as a landing area would represent minimal impact.	Base is considered to support similar activities; therefore, no impact
Snow Avalanche	No impacts expected.	No impacts expected.
Flight Noise and Sonic Booms	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.
Flight Safety	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

Table ES-9. Summary of Environmental Impacts: Mid- and Long-Range Landing Site Alternatives.

	Proposed Mid- and Long-Range Landing Site Alternatives		
Issues	**Dugway**	**Malmstrom**	**Moses Lake**
Infrastructure	No modifications to infrastructure required; existing systems can accommodate Program needs.	Runway maintenance and restoration of flight support or placement of mobile equipment would be required.	No modifications to infrastructure required; existing systems can accommodate Program needs.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Minimal impact to airspace is expected because descent and landing are all within restricted airspace.	Moderate impact to airspace and air traffic is expected due to temporary restriction of all aircraft from airspace within a 19.2km (12 mi) by 33.6 km (21 mi) area of the landing site for 1 to 2.5 hours.	Moderate impact to airspace and air traffic is expected due to temporary restriction of all aircraft from airspace within a 25.5 km (17 mi) by 32 km (20 mi) area of the landing site for 1 to 2.5 hours.
Biological Resources	No impacts expected because no facility construction or modifications needed.	No impacts expected because no facility construction or modifications needed.	No impacts expected because no facility construction or modifications needed.
Threatened, Endangered and Sensitive Species	No species are expected to be adversely affected.	No species are expected to be adversely affected.	No species are expected to be adversely affected.
Cultural Resources	No properties are expected to be affected.	No properties are expected to be affected.	No properties are expected to be affected.
Water Resources	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.
Geology and Soils	No impacts to geology or soils are expected because no construction is required.	No impacts to geology or soils are expected because no construction is required.	No impacts to geology or soils are expected because no construction is required.
Health and Safety	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.
Operational Noise	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.	Non-flight operations would be similar to existing operations; therefore, minimal impacts are expected.

Table ES-9. Summary of Environmental Impacts: Mid- and Long-Range Landing Site Alternatives (Continued).

	Proposed Mid- and Long-Range Landing Site Alternatives		
Issues	**Dugway**	**Malmstrom**	**Moses Lake**
Transportation	Minimal impacts to on-site or off-site transportation systems are expected.	Minimal impacts to on-site or off-site transportation systems are expected.	Minimal impacts to on-site or off-site transportation systems are expected.
Population and Employment	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.
Land Use	Base is considered to support similar activities; therefore no impact.	Base is considered to support similar activities; therefore no impact.	Site is considered to support similar activities; therefore no impact.
Snow Avalanche	No impacts expected.	No impacts expected. Launch time will be delayed if avalanche conditions exist under the flightline until standard avalanche control measures are conducted.	No impacts expected. Launch time will be delayed if avalanche conditions exist under the flightline until standard avalanche control measures are conducted.
Flight Noise and Sonic Booms	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.
Flight Safety	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

1.0 PURPOSE AND NEED FOR PROPOSED ACTION

This Environmental Impact Statement (EIS) was prepared in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 *et seq.),* the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508), and NASA policy and procedures (14 CFR Part 1216, Subpart 1216.3). NASA is the lead agency. The Department of Defense (DOD) (supported by the Air Force, Army, and Navy); U.S. Department of the Interior, Bureau of Land Management (BLM); and Department of Transportation are cooperating agencies to NASA in preparation of this EIS.

1.1 Purpose of the Proposed Action

For many years, the United States (U.S.) has recognized that space transportation costs must be significantly reduced in order for the Nation to afford continued exploration, development, and use of space. In NASA's *Access to Space—Advanced Technology Team Final Report*, a single-stage-to-orbit (SSTO) transportation architecture was recommended as a prime candidate for the next generation of reusable space transportation systems which could meet future requirements with significant reductions in annual operating costs (NASA 1993). On August 5, 1994, President Clinton's Space Transportation Policy designated NASA as lead agency for advanced technology development and demonstration of the next generation of reusable launch systems. Work involved to support this effort would focus on the Advanced Technology Demonstrator Vehicle Experimental Thirty-three (X-33).

To meet the objective of President Clinton's policy in a timely and cost efficient manner, NASA developed the X-33 Program based on the following internal agency guidelines:

- reduce the technical and business risks which are currently barriers to privately financed space transportation system(s) (current and future) through the use of sub-scale, state-of-the-art technology demonstrator vehicle(s)
- design and test (both ground and flight) the technology demonstrator vehicle's major components, subsystems, and full system in a manner that ensures traceability (technology and general design similarity) and scaleability (directly scaleable weights, margins, loads, design, fabrication methods, and testing approaches) to a full-scale system
- verify full-scale systems operability and performance in "real world" environments.

The purpose of NASA's Advanced Technology Demonstrator Vehicle X-33 Program, a major component of NASA's larger Reusable Launch Vehicle (RLV) Program, is to implement the National Space Transportation Policy, specifically Section III, paragraph 2(a): "The objective of NASA's technology development and demonstration effort is to support government and private sector decisions by the end of this decade on development of an operational next-generation reusable launch system."

1.2 Need for Proposed Action

To fulfill the purpose of the National Space Transportation Policy, NASA needs to develop and test a sub-scale, state-of-the-art space vehicle. This space vehicle must meet technology and test flight objectives that were developed through a rigorous trade study of space transportation architectures (NASA 1993) and refined through additional input from private industry.

The planned X-33 is a suborbital spaceplane that must be flight tested in realistic operational environments to demonstrate critical technologies needed for an orbital SSTO vehicle(s). Without compromising public safety or unduly interfering with commercial and private aircraft operations, the X-33 needs to be tested in ascent and reentry environments that would be experienced by a full-scale SSTO vehicle. In addition, the X-33 needs to focus on operational issues that are critical to development of reliable, low-cost, reusable space transportation. The X-33 would contain advanced materials which would reduce: (1) the vehicle's dry weight, and (2) the ratio of propellant weight to vehicle weight at liftoff to those required by an SSTO vehicle. X-33 supportability goals are key to lowering the number of ground service personnel, equipment, and materials necessary for supporting the X-33 and lowering operational costs. The performance demonstrated by the X-33 would provide data necessary to establish detailed requirements for future operational SSTO vehicles. The X-33 Program, as planned, has an unprecedented opportunity to systematically flight test a prototype spaceplane through a series of incrementally more rigorous flights.

1.3 X-33 Program Overview

NASA sought an "X" (eXperimental) designation for the X-33 spaceplane and worked closely with range safety organizations at several installations which have been base operations sites for the preceding X-planes in order to benefit from the flight decision-making process of these established organizations. A history of the X-Plane Program is provided in Appendix A. The range safety organizations have expertly and consistently assured safety and protection of personnel and private property during flight testing of the X-planes.

1.3.1 Phase I

The X-33 Program has been divided into three phases. During Phase I, a cooperative agreement notice, CAN 8-1, was issued by NASA for concept definition and preliminary design of the reusable advanced technology demonstrator system, X-33 (MSFC 1995A). Three concepts and preliminary designs were prepared independently by: (1) Lockheed Martin Skunk Works, Palmdale, California; (2) McDonnell-Douglas Aerospace, Huntington Beach, California; and (3) Rockwell International Corporation, Space Systems Division, Downey, California. During this phase, NASA prepared the *Final X-33 Programmatic Environmental Assessment: Vehicle and Technology Demonstration Concepts* (hereinafter, the "EA") (MSFC 1996A). Based on results of Phase I, evaluation of proposals received in response to a second cooperative agreement announcement, CAN 8-3 (MSFC 1996B), Lockheed Martin Skunk Works was

selected as the industry partner to continue working with NASA during Phase II and based on the EA, a determination was made to prepare an EIS for the X-33 Program. The EA supported the selection of one of the three concepts and proceeding with further preliminary work required to support the EIS and final Program decisions.

1.3.2 Phase II

The Lockheed-Martin Skunk Works concept is based on a "lifting body" design propelled by unique aerospike engines. This concept is depicted in Figure 1-1. Phase II involves preparation of final design, fabrication of the X-33, assembly, and ground and flight testing of the vehicle. Specific Program objectives for Phase II are to:

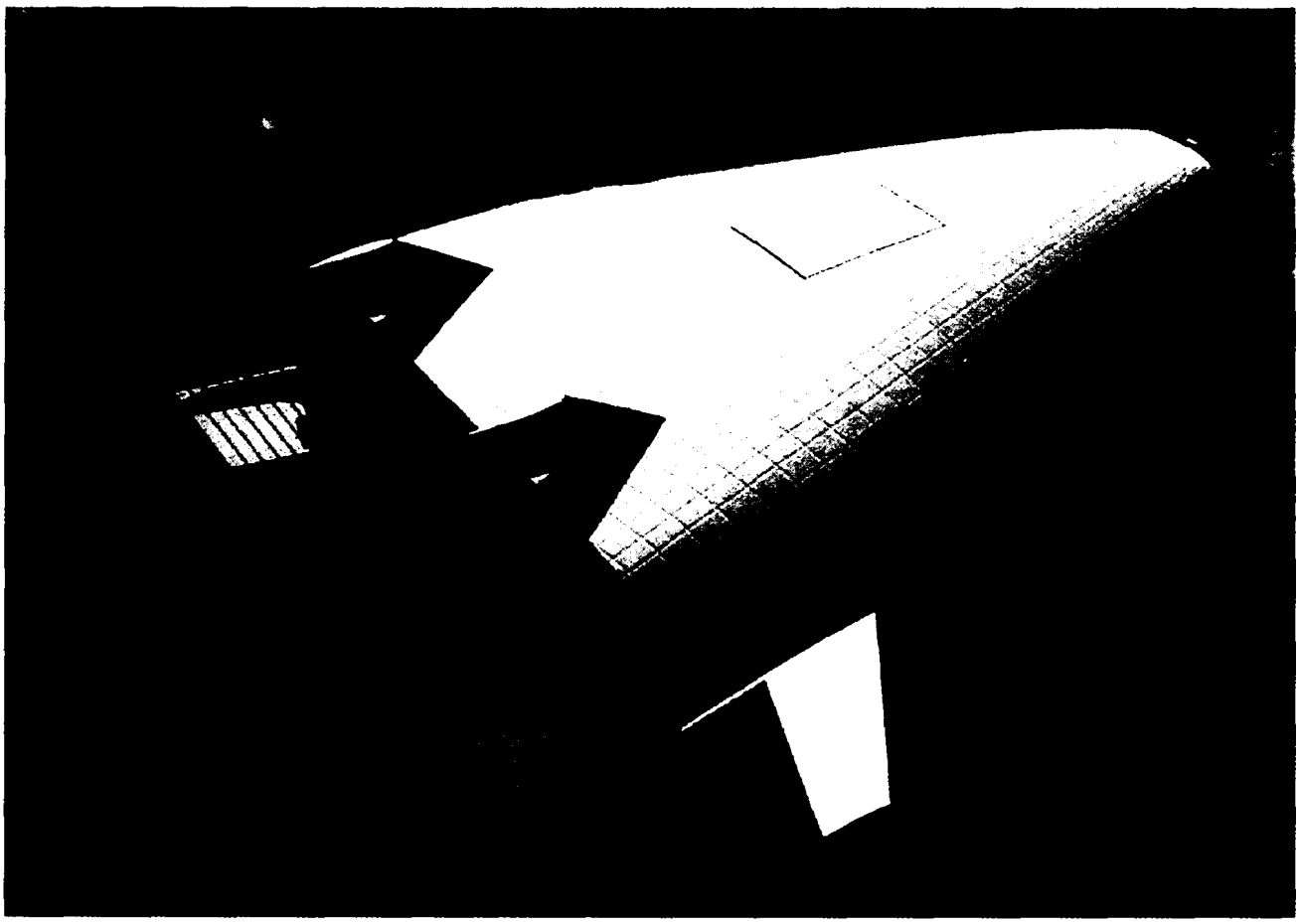


Figure 1-1. X-33 Spaceplane Concept.

- conduct flight and ground tests necessary to reduce business and technical risks which are currently barriers to privately financed development and operation of a next-generation space transportation system

- design and test the X-33 spaceplane, subsystems, and major components and ensure traceability (technology and general design similarity) and scaleability (directly scaleable

weights, margins, loads, design, fabrication methods, and testing approaches) to a full-scale SSTO system
- verify full-scale systems operability and performance in "real world" environments.

Management of the X-33 Program reflects the overall philosophy of the RLV Program in accomplishment of Program objectives with less resources and in less time than compared to past NASA programs. The management philosophy, Program schedule, and funding profile resulted in the following Program strategy drivers:

- maximize selection of advanced technologies necessary to design a vehicle light enough to be built and operated as one unit, i.e. an SSTO
- design an SSTO vehicle with significantly less operating expense than current vehicles require
- highlight the need for an intensive, detailed cost evaluation of conventional systems to determine where to emphasize design and technology changes on the X-33
- maximize use of existing facilities and infrastructure
- minimize affected national airspace, the airspace in which private and commercial aircraft fly and the Federal Aviation Administration (FAA) controls
- emphasize reliability and safety
- change government procurement strategy with private industry resulting in cooperative agreements committing both government and industry investment in the Program. Cost-sharing by NASA and the Industry Partners was part of the Phase I and II cooperative agreements.

It is anticipated that Phase II would be completed by the year 2000. Phase II would also develop necessary data to support an informed Program continuation decision at the completion of the phase. Data would include Program planning and a detailed business plan for Phase III and an operational RLV system designed to a level sufficient to provide a high confidence cost estimate and show that Program risks have been identified and are acceptable.

1.3.3 Phase III

Phase III would involve design, manufacturing, and operation of the operational RLV system based on SSTO architecture. Execution of Phase III is solely an industry decision. An SSTO system would operate in an "aircraft-like" mode (i.e., the entire spaceplane with all propellant tanks and engines would be launched and returned to earth as one unit). No stages would be dropped with an SSTO system. In Phase III, the government would potentially become a customer, not an owner or operator, of the launch system(s).

1.3.4 Phase II Decision (Proposed Action)

There are two major components which must be implemented to complete Phase II of the X-33 Program: ground support activities and flight testing. Ground activities would include preparation of flight operations facilities (take off site and launch support infrastructure) and landing sites; ground testing of X-33 components leading to a full systems test; and a "flying wind tunnel" test accomplished by flying, but not releasing, the X-33 piggyback on the Shuttle Carrier Aircraft (SCA), which is a specially equipped Boeing 747. Flight testing would involve flying the X-33 under progressively more rigorous conditions in order for the vehicle's flight test objectives to be met. The decisions that would be involved in fully implementing Phase II are discussed below and summarized in Figure 1-2.

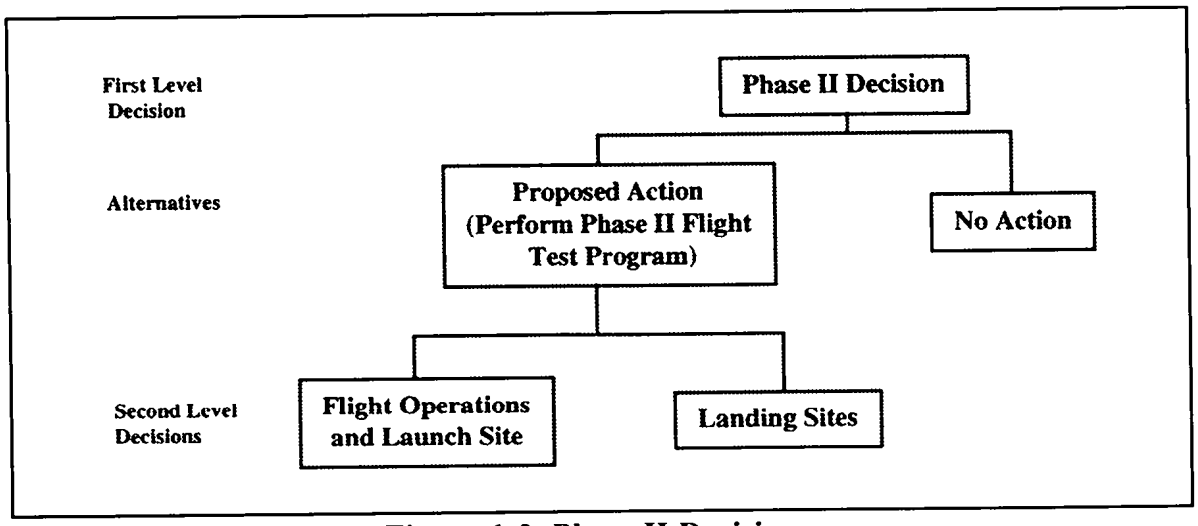


Figure 1-2. Phase II Decisions.

Final Phase II activities that would occur as a result of a positive decision, and the alternatives developed for each of the subdecisions are discussed in Section 2.

The first level decision is whether to continue with Phase II and design, build, and flight test the X-33. The Proposed Action, and NASA's preferred alternative, is to conduct the flight test activities using a launch and flight operations site at Edwards Air Force Base, California, with landing sites which would accommodate incremental advances to Mach 4, 9, and 15 for the baseline vehicle.

1.3.5 Second Level Decisions

If the decision were made to proceed with the flight test program, then a series of secondary decisions for implementation of support operations would be required. These decisions are summarized as follows.

Flight Operations and Launch Site Decision

Sites must be identified to support flight operations and launch of the X-33. Flight operations include air transport of the X-33 to a landing area within close proximity to the launch site, decoupling of the X-33 from the back of the carrier aircraft, towing to the site, propellant storage, weather protection, and a flight control center. An area large enough to safely accommodate launch and support infrastructure must also be identified.

Landing Sites

The X-33 would be flight tested using an envelope expansion process in which speed, distance, and maximum altitude of ascent are increased in incremental steps. Optimally, three landing sites meeting Program criteria discussed in depth in Section 2 are preferred to conduct the flight test program in a manner that fully meets Program objectives and generates the entire array of data necessary to fully understand the performance of all technologies and systems integrated into the X-33.

1.4 Programmatic Environmental Assessment

An EA entitled *Final X-33 Programmatic Environmental Assessment: Vehicle and Technology Demonstration Concepts* environmentally analyzed major elements of the Proposed Action (MSFC 1996A). The purpose of the EA was to support the Program continuation decision and Proposed Action to continue with the design/demonstration phase of the X33 Program as part of NASA's RLV Technology Program. Specific analyses of alternatives were prepared where the level of detail was sufficient to do so. Alternatives of potential landing sites and overland test flight corridors were not available for use in the EA since the Industry Partners reserved the right to maintain this information as proprietary during Phase I. Therefore, preliminary analyses of a generic landing site and overland test flight corridors were provided in order to ensure that relevant and potentially major environmental issues were recognized and appreciated early in the Program. Preliminary analyses also provided a perspective of impacts and issues that must be addressed prior to finalizing X-33 Program decisions on the flight operations site, landing sites, and overland test flight corridors. Additional issues were identified following publication of the EA as a result of the scoping process for preparation of the EIS.

The EA environmentally evaluated three concepts and flight operations sites within the John F. Kennedy Space Center located near Titusville, Florida; White Sands Missile Range located near Las Cruces, New Mexico; and Edwards Air Force Base (Edwards or EAFB) located near Lancaster, California. Generic analyses of a landing site and overland test flight corridors were provided. The No Action alternative in the EA was the same as the No Action alternative in the EIS.

Table 1-1 contains a summary of environmental impact projections from the EA. Primary environmental issues identified in the EA were projected to be noise, sonic booms, and safety. Preliminary analyses indicated that, with careful selection of flight trajectories, exposure of the public to safety risks and noise and sonic boom impacts could be minimized and would meet range safety criteria for launch approval.

Table 1-1. X-33 Impact Projections from the EA (MSFC 1996).

ISSUES	EAFB	WSMR	KSC (Eastern Range)	OFF-RANGE or GLOBAL
Facilities and Infrastructure (Combined)	Minimal	Minimal	Minimal	EIS
Wastewater Treatment	Minimal	Minimal	Minimal	EIS
Electricity	Minimal	Minimal	Minimal	EIS
Communications	Minimal	Minimal	Minimal	EIS
Natural Gas	Minimal	Minimal	Minimal	EIS
Fuel	Minimal	Minimal	Minimal	EIS
Hazardous Waste	Minimal	Minimal	Minimal	EIS
Nonhazardous Solid Waste	Minimal	Minimal	Minimal	EIS
Air Quality (Combined)	Minor	Minor	Minimal	EIS
Airspace				
On-Range Flights	None	None	None	N/A
Off-Range Flights in Range-Controlled Airspace	Minimal	Minimal	Minimal	Minimal
Off-Range Flights Outside of Range-Controlled Airspace	N/A	N/A	N/A	EIS
Biological Resources (Combined)	Minimal	Minimal	Minimal	EIS
Threatened, Endangered, and Sensitive Species	EIS	EIS	EIS	EIS
Cultural Resources	EIS	EIS	EIS	EIS
Water Resources				
Domestic/Industrial	Minimal	Minimal	Minimal	EIS
Launch Deluge	Minor	Minor	Minimal	EIS
Geology and Soils	Minimal	Minimal	Minimal	EIS
Hazardous Materials				
Contamination	Minor	None	Minor	EIS
Explosive Safety/Quantity Distance	None	None	None	EIS
Transportation	None	None	None	EIS
Health and Safety				
Flight Safety	Minimal	Minimal	Minimal	EIS
Non-Flight Safety	None	None	None	EIS
Land Use	None	None	None	EIS
Operational Noise	Minimal	Minimal	Minimal	EIS
Transportation	Minor	Minimal	None	EIS
Population and Employment	Minimal	Minimal	Minimal	EIS
Flight Noise and Sonic Booms	None	None	None	EIS
Off-Site Safety (Overflight)				
Flight Safety	EIS	EIS	EIS	EIS
Non-Flight Safety	EIS	EIS	EIS	EIS
Troposphere	None	None	None	None
Stratosphere (ozone)	None	None	None	Minimal

Key to the Categories:

N/A: The issue has no relevance to the site or global environs.

None: There are no impacts expected.

Minimal: The impacts are not expected to be measurable or are too small to cause any degradation to the environment.

Minor: Those impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with little effort and resources so that the impact is not substantial.

Moderate: Those impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with effort and resources so that the impact is not substantial.

Major: Those environmental impacts which individually or cumulatively could be substantial.

EIS: Those issues which, through lack of design data and/or proposed operational plans, could not be analyzed. Further discussion of these items was deferred to the EIS.

1.5 EIS Scoping

1.5.1 Scoping Meetings

Public scoping meetings were conducted early in the Program's development in an open process to identify significant issues of the public and local authorities that should be addressed in the EIS. The number of scoping meetings held in each state, as well as their locations, were coordinated between NASA and federal, state, and local agencies based upon each state's individual needs and policies. A total of 12 scoping meetings were held in the following states: California, Utah, Nevada, Montana, Washington, and Idaho. Times, dates, and locations of the scoping meetings appeared in the Notice of Intent (NOI) published in the Federal Register October 7, 1996, (i.e., 61 FR 195: 52467-52469) and/or in an information update published in state and local papers. A complete listing of scoping meeting dates and locations can be viewed in Table B-1-1of Appendix B-Section B-1.

1.5.2 Special Scoping Meetings during Scoping

In addition to scoping meetings, special scoping meetings were held at the request of state and local officials. These meetings included numerous Chamber of Commerce offices, mayors, and other political officials, Indian Tribal officials, and Port Authorities. No verbal concerns were offered as a result of these meetings. All parties involved in special meetings indicated a willingness to work with the X-33 Program, a desire to support the draft comment period, and requested to view the vehicle's landing in their specific area. A complete listing of these special meetings can be found in Table B-1-2 of Appendix B-Section B-1.

1.5.3 Advertisement and Comment Solicitation during Scoping

NASA placed announcements in local and state newspapers several times during the scoping process. Table B-1-3 is a listing of original advertisements placed to announce scoping meetings and solicit comments. Additional advertisements seeking input were placed in the overflight states as shown in Table B-1-4. Other advertisements included ads placed to announce the end of the public scoping comment period, as shown in Table B-1-5 and ads to announce the additional meeting in Idaho Falls, Idaho, as shown in Table B-1-6.

1.5.4 Issues/Questions/Concerns

Public issues and concerns collected during the scoping process involved the following areas:

- public safety/risk
- hazardous materials
- exact flight path(s)

- avalanche potential from sonic booms
- sonic booms/noise impacts on wildlife and endangered/threatened species
- disruption or suspension of airport services
- diminishment or disruption of flight corridors for private aircraft
- concern over crowds of spectators in neighborhoods in proximity to landing strip
- benefit
- accessibility and visibility to launch and landing
- impact on "Wilderness Areas"
- reliability without a crew on board
- avoidance of sensitive military operations
- abort scenarios and procedures
- schedule.

A number of comments were received that endorsed the X-33 Program.

1.6 EIS Public Participation

1.6.1 Public Participation Meetings

A second round of meetings, to facilitate public participation, was held after the Draft Environmental Impact Statement (DEIS) was released to the public. The purpose of the meetings was to provide the public and local authorities with answers to issues that were raised during the scoping period, to provide the public with knowledge of the issues addressed in the DEIS, and to update the public on the progress of the program. The number of meetings held in each state, as well as their locations, were coordinated between NASA and federal, state, and local agencies based upon each state's individual needs and policies. A total of 11 meetings were held in the following states: California, Utah, Montana, Washington, and Idaho. Times, dates, and locations of the meetings appeared in the Notice of Availability (NOA) of the draft EIS published in the Federal Register on July 3, 1997 (i.e., 62 FR 128: 36081-36083), and in an information advertisement placed in state and local papers. A complete listing of meeting dates and locations can be viewed in Table B-2-1 of Appendix B-Section B-2.1. Sign in sheets for each meeting can be viewed in Table B-2-2 of Appendix B-Section B-2.1 in chronological order.

1.6.2 Special Public Participation Meetings

Special meetings were held at the request of state and local officials. These included meetings with political officials, Indian Tribal Officials, and Bureau of Land Management Officials. A listing of these meetings is provided in Table B-2-3 of Appendix B-Section B-2.1. No verbal concerns were offered as a result of these meetings. All parties expressed appreciation for the information provided in the Draft EIS and a desire to continue working with the X-33

Program. In addition, all parties involved in special meetings indicated a desire to view the vehicle's landing

1.6.3 Comment Solicitations

Comments to the Draft Environmental Impact Statement were also solicited through advertisements in newspapers in California, Utah, Montana, Washington, and Idaho. A complete listing of these advertisements can be found in Table B-2-4 of Appendix B-Section B-2.1 Public comments were encouraged by offering a variety of media in which to submit, including written comments sent through the postal system, electronic mail, and facsimile, as well as verbal comments recorded on an answering machine receiving calls at NASA's X-33 "800" telephone number.

1.6.4 Issues/Questions/Concerns Raised at Public Participation Meetings

All public participation meetings were documented using a court reporter. Questions and issues brought out during the meetings are summarized in Table B-2-5 of Appendix B-Section B-2.2. The questions are organized in the following categories:

- Environmental Impact Statement
- Benefits of the X-33 Program
- Costs
- Damage Claims
- Economic Impacts/Employment Opportunities
- Flight and Landing Operations, and Vehicle Design
- Follow-On RLV Program
- Missions/Goals/Future Plans
- Public Safety and Risk/ Flight Termination and Vehicle Failures/ Contingency Planning
- Public Viewing
- Road Closures
- Site Selection
- Sonic Booms
- Stratospheric Ozone
- Wildlife/Vegetation Impacts
- Other

1.6.5 Written Comments and Responses

As stated above, public comments were encouraged by offering a variety of media in which to submit, including written comments sent through the postal system, electronic mail, and

facsimile. The public comment period was scheduled to run from July 3, 1997 through August 18, 1997. All comments were accepted, regardless of the date received. A complete collection of written comments received and the responses to them can be found in Appendix B-Section B-2.3.

1.6.6 Comments Received by Phone Message

A number of verbal comments were recorded on an answering machine receiving calls from NASA's X-33 "800" telephone number. A complete history of these calls and the responses can be found in Table B-2-6 of Appendix B-Section B-2.4.

1.7 Content of This EIS

This EIS addresses potential environmental consequences of implementing the Proposed Action at one of two alternative launch sites within Edwards AFB, overflying proposed flight corridors between the launch site and landing sites, and landing at each of the proposed alternative landing sites (see Figure 1-3) Implementation of the Proposed Action, described in this EIS, includes final design, fabrication, and assembly of the X-33 vehicle (hereinafter referred to simply as the "X-33"); preparation of the flight operations and launch site; preparation of landing sites; and flight testing of the X-33 at speeds up to Mach 15 (15 times the speed of sound) and over trajectories as long as 1,530 km (950 mi). Minor support facilities such as mobile tracking stations placed along flight corridors are described and addressed. Contingency planning for potential flight terminations is also addressed. As required by NEPA regulations, potential environmental impacts of implementing the X-33 Program are compared to the current baseline conditions, called the "No Action." In this case, the No Action alternative would be to not implement the X-33 Program and consequently, to not demonstrate the potential ability to significantly reduce the cost of development, production, and operation of future reusable spaceplane systems which could be commercially implemented.

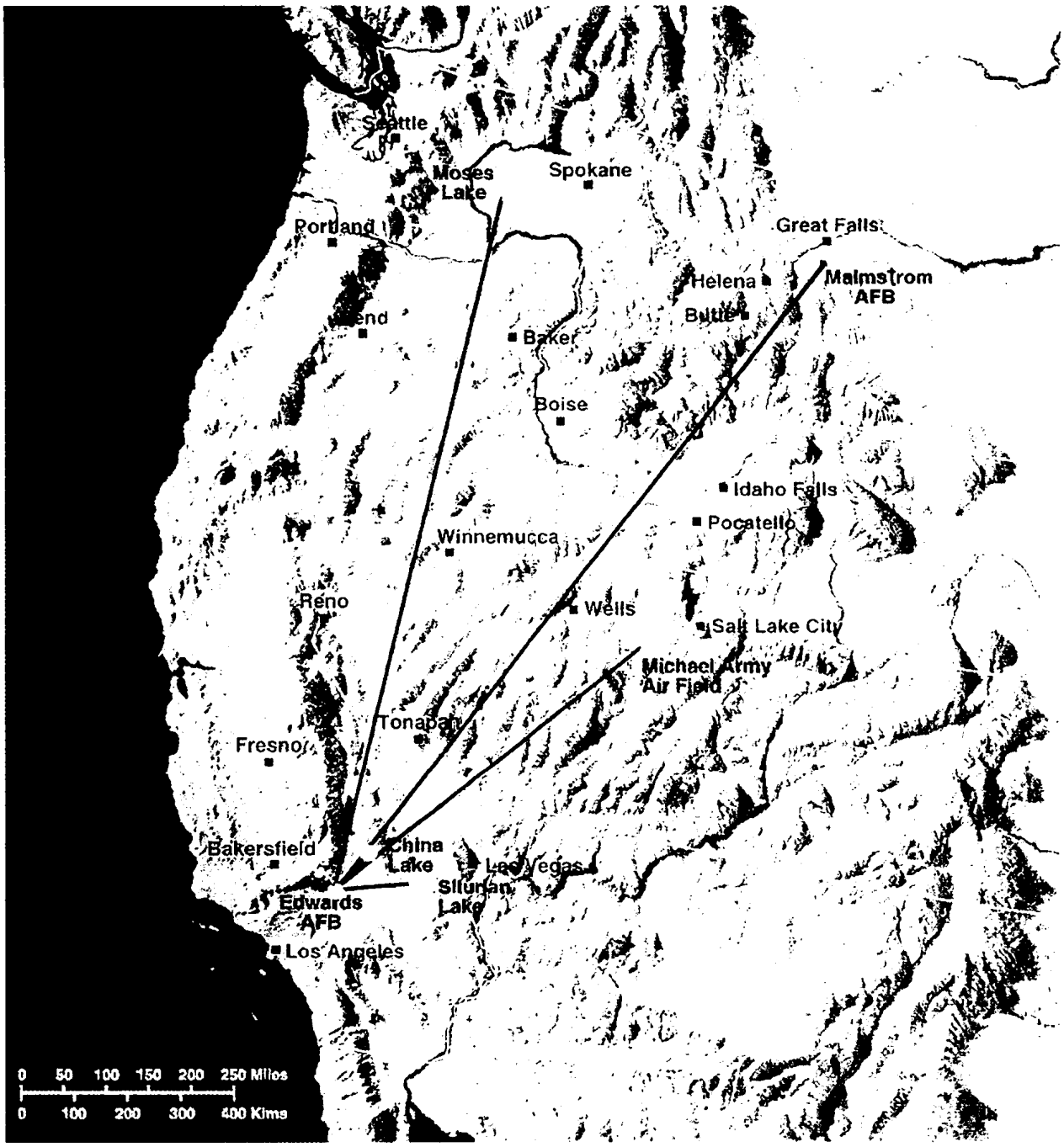


Figure 1-3. Alternative Flight Operations and Landing Sites.

1.8 Cooperating Agencies

1.8.1 Federal Agencies

In accordance with NEPA, 40 CFR 1501.6, an invitation for "cooperating agency" status was extended to three agencies for consultation, review, and comment on the draft and final EIS. Each agency accepted their respective invitation. The cooperating agencies are listed in Table 1-2.

Table 1-2. Cooperating Agencies, Sub-Elements, and Sites.

Cooperating Agency	Sub-Element	Site	Purpose
Department of Defense	U.S. Air Force	Edwards Air Force Base	Flight operations/launch site
		Utah Test and Training Range	trajectory(ies) to Dugway Proving Ground
		Malmstrom Air Force Base	long-range landing site
	U.S. Army	Dugway Proving Ground	mid-range landing site
		Ft. Irwin[1] (Silurian Lake)	short-range landing site
	U.S. Navy	China Lake Naval Air Weapons Station	short-range landing site
Department of the Interior, Bureau of Land Management	California Desert District, Barstow Resource Area	Silurian Lake	short-range landing site
Department of Transportation	Federal Aviation Administration	National Air Space	trajectories, or portions thereof, under 18,000 m (60,000 ft) and not within established controlled air space

[1] *Potential future federal manager of Silurian Lake.*

1.8.2 State Agencies

To ensure that the X-33 Program considers local issues from all involved states, informal consultation and coordination of Program activities was initiated through the following state and local agencies:

1. California
   - California State Clearinghouse, Governor's Office of Planning and Research
   - California Trade and Commerce Agency

2. Idaho
   - Idaho State Clearinghouse, NEPA Coordinator
   - Idaho National Engineering and Environmental Laboratory (INEEL) Oversight Program; Public Information Office
3. Montana
   - Montana State Clearinghouse, State Capitol
4. Nevada
   - Nevada State Clearinghouse; Department of Administration
5. Oregon
   - Office of Environmental Quality, State Capitol
6. Utah
   - Utah State Clearinghouse, Governor's Office of Planning and Budget
   - Bureau of Indian Affairs, Uintah and Ouray Agency
   - Constituent Bands of the Te-Moak Tribes of Western Shoshone Indians of Nevada
7. Washington
   - Washington State Clearinghouse, Environmental Review Section
   - Port of Moses Lake, Washington
   - Grant County Planning Department, Ephrata, Washington

2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The following sections describe the Proposed Action to conduct the X-33 Flight Test Program and alternative sites for conducting flight operations/launch and landing. Alternatives considered but eliminated from further investigation are presented, along with the reasons for their elimination. This Section closes with a summary comparison of environmental impacts related to each flight test Program alternative. Only one X-33 vehicle would be built if the Proposed Action is implemented.

The alternatives presented in this Section were developed from the Phase II decision process shown in Figure 2-1. The two alternatives, the Proposed Action and the No Action alternative, represent the main X-33 Program decision of whether to proceed with the Flight Test Program, requiring: (1) preparation of flight operations facilities (takeoff site and launch infrastructure) and landing sites; and (2) ground and flight testing the X-33. Within the Proposed Action, secondary alternatives are presented and analyzed; each of these secondary alternatives were developed to address the second level decisions of where to conduct flight operations/launch and landing.

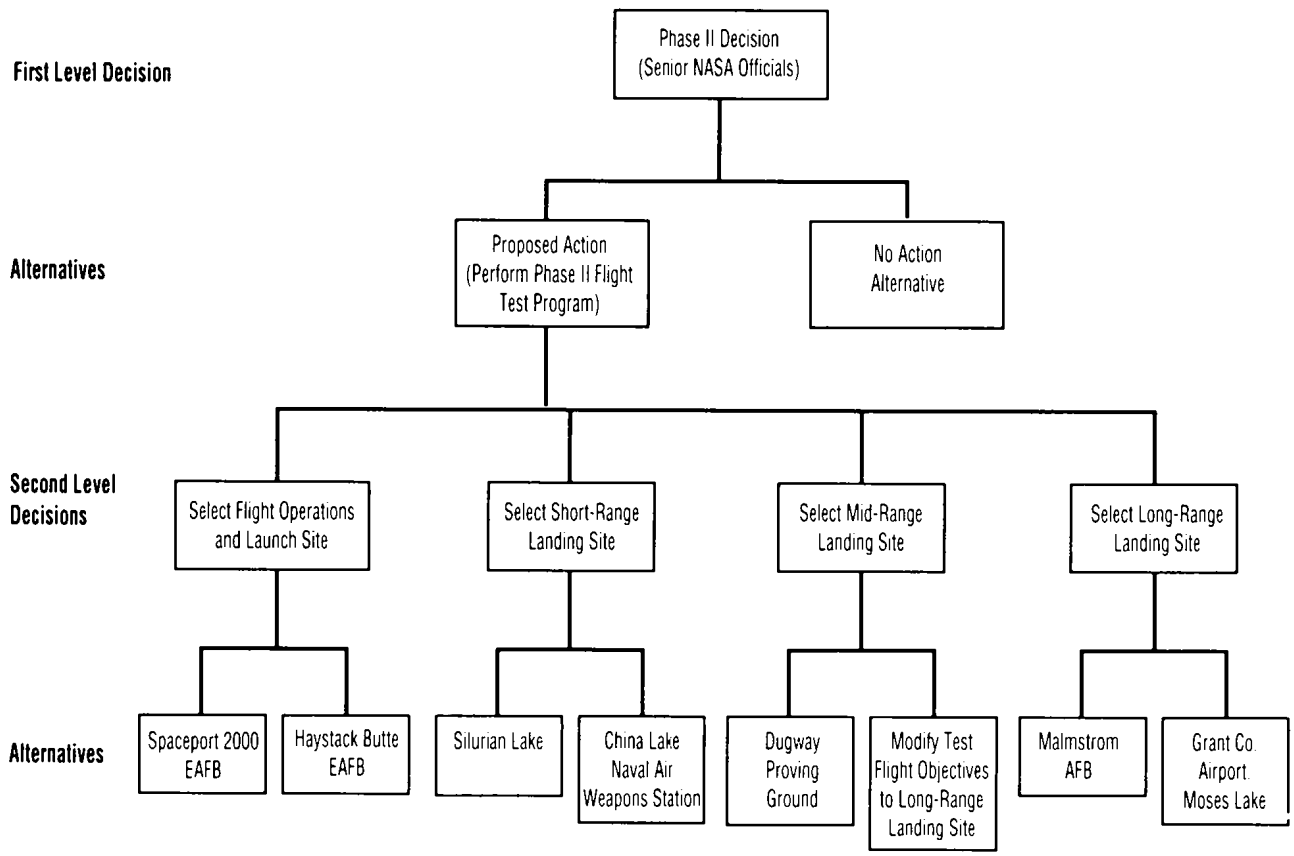


Figure 2-1. Phase II Decision Process

2.1 Description of Proposed Action

2.1.1 Objectives

Specific technology objectives of the X-33 are:

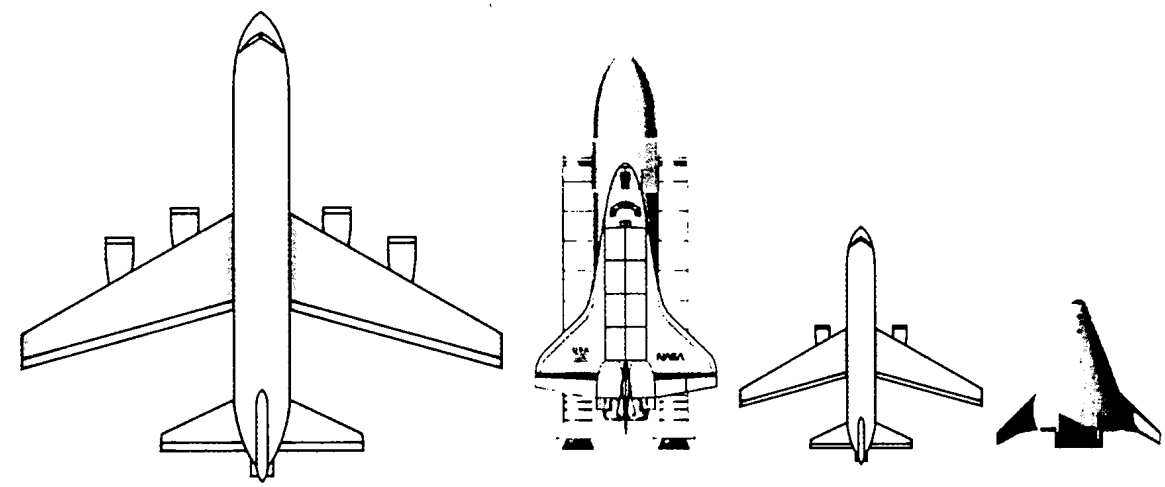
- demonstrate a reusable cryogenic tank system, including the tanks for liquid hydrogen (LH_2) and liquid oxygen (LOX), cryogenic insulation, and an integrated thermal protection system (TPS)
- verify TPS durability, low maintenance, and performance at both low and high temperatures
- demonstrate guidance, navigation, and control systems, including autonomous flight control of checkout, launch, ascent, flight, reentry, and landing for an autonomously controlled spaceplane
- achieve hypersonic flight speeds (speeds greater than Mach 5)
- demonstrate composite primary spaceplane structures integrated with the TPS
- demonstrate ability to perform 7-day turnarounds between three consecutive flights (a turnaround is the amount of time required from a launch and flight until the vehicle is serviced, refueled, and ready to fly again)
- demonstrate ability to perform a 2-day turnaround between two consecutive flights
- demonstrate that a maximum of 50 personnel performing hands-on vehicle operations, maintenance, and refueling can successfully accomplish flight readiness for two flights.

Specific test flight objectives are to demonstrate:

- successful interaction of the engines, airframe, and launch (also referred to as takeoff) facility
- engine performance, thrust, and throttling capability meets specifications
- operability and control of the X-33's flight control surfaces (canted fins, flaps, aileron, etc.)
- durability of the metallic TPS during repeated flights
- performance of the guidance, navigation, and control system
- performance of flight operations facilities, including launch infrastructure
- automated landing at a designated point on the runway
- verification of tasks required to service the vehicle on landing and prepare it for next flight in minimal time.

2.1.2 Vehicle Description

A comparison of the X-33 with two existing flight systems is shown in Figure 2-2. Table 2-1 contains a list of new technologies that would be utilized on the X-33 and improvements over existing technologies, which are key to the successful development of spaceplanes that are highly reliable and far less expensive to operate than today's space launch vehicles.



System	*Boeing 747*	*Space Transportation System*	*Boeing 737*	*X-33*
Length	232 Ft	184 Ft	109 Ft	67Ft
Width	196 Ft	78 Ft	94 Ft	68 Ft
Gross Lift Off Weight	710,000 Lb	4,500,000 Lb	135,000 Lb	273,000 Lb
Fuel	Commercial Aviation	LH_2/LOX + Solid	Commercial Aviation	LH_2/LOX
Fuel Weight	316,000 Lb	3,803,000 Lb	24,000 Lb	211,000 Lb
Empty Weight	320,000 Lb	594,000 Lb	62,000 Lb	65,000 Lb
Main Propulsion	4 Turbines	2 Solids + 3 SSME Bells	2 Turbofans	2 J-2S Linear Aerospikes
Take Off Thrust	200,000 Lb	6,400,000 Lb	40,000 Lb	410,000 Lb
Maximum Speed	Mach 0.6	Mach 25	Mach 0.84	Mach 15
Payload to 100 NMI/28.5 deg. orbit	N/A	51,000 Lb	NA	NA
Payload Bay Size	N/A	15×60 Ft	77 Ft	5×10 Ft

Figure 2-2. Comparison of the X-33 With a Conventional Aircraft and the Space Transportation System (Space Shuttle).

Table 2-1. New Technologies Required for Successful Development of Operationally Simple, Cost-Effective, and Reliable Spaceplanes.

Required Improvement	Technology
75% fuel packing efficiency	Multilobe tanks; full length orbital maneuvering tanks
Decrease main propulsion system weight	Composite LH_2 tanks; composite LOX tanks; pressure stabilized tanks; composite feed lines; jet boost pumps
Improved engine performance	Aerospike engine
Improved fuel bulk density	Densified propellants
Improved operations	"Aircraft-like" operations
Eliminate separate orbital maneuvering system engine	Restartable main engine
Reduce control surface	System refinement

The X-33 would have a lifting body airframe. This design enables the vehicle to obtain aero-lift from its body shape and not wings like conventional airplanes. The primary composite structure provides support for the vehicle, internal tanks, flight control surfaces, and TPS. The TPS is attached to the aeroshell and is a metallic material made from a combination of inconel (an alloy of iron, nickel and cobalt) or titanium panels and carbon epoxy panels. External and internal configurations are shown in Figures 2-3 and 2-4, respectively.

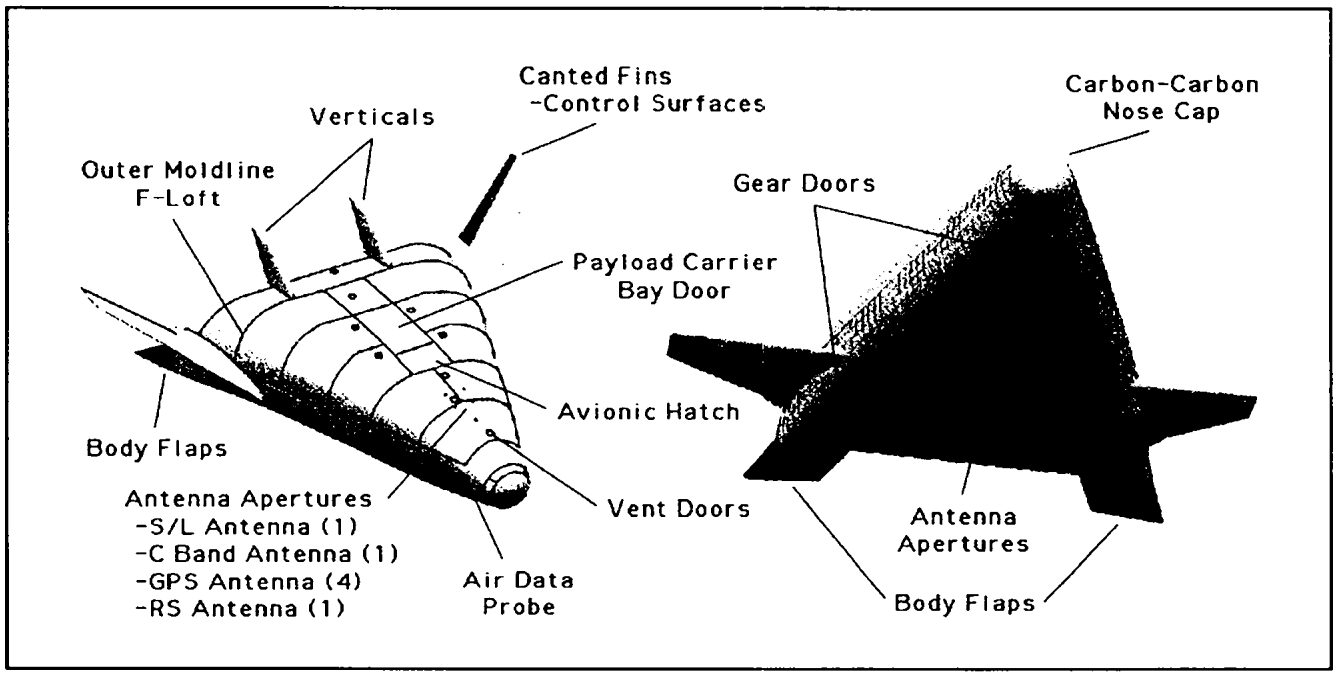


Figure 2-3. External Configuration of the X-33.

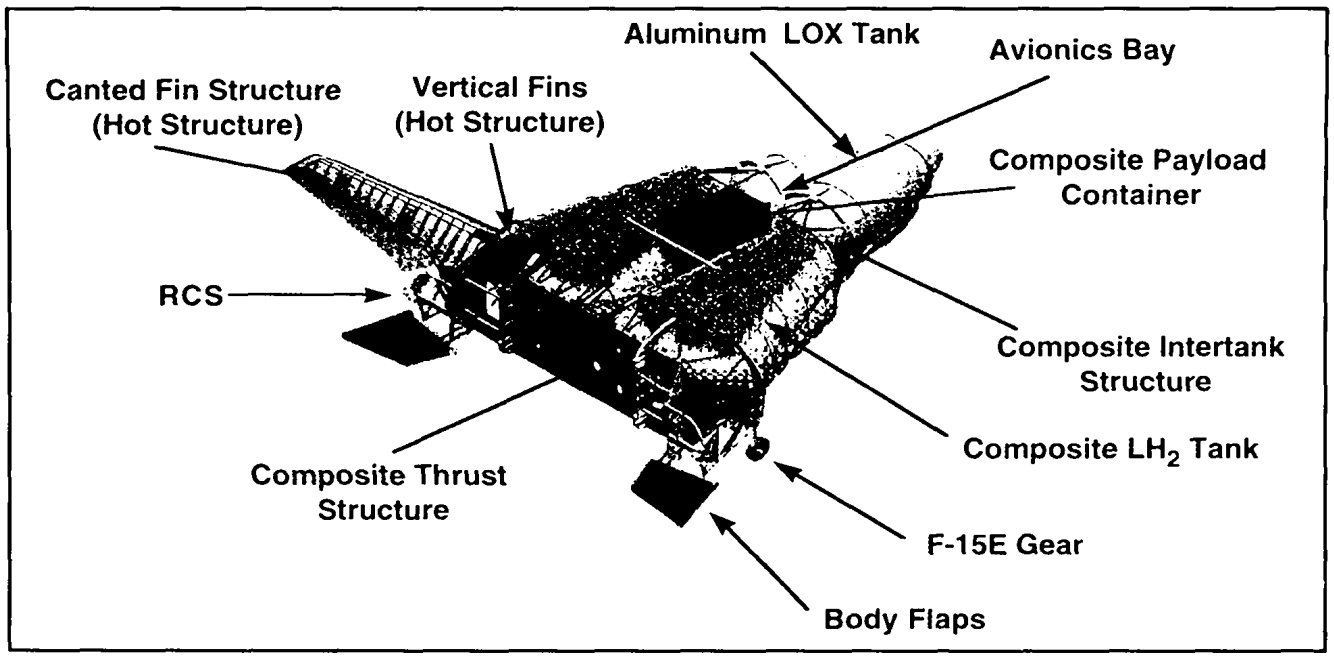


Figure 2-4. Internal Configuration of the X-33.

The spaceplane would use two linear J-2S aerospike engines made by Boeing North American Division and Rocketdyne, shown in Figure 2-5. Linear aerospike engines were developed in the 1970's and have been previously tested on the ground by firing them on engine test stands while secured to the stand and equipped with sensors to record performance and other vital data for the short- and mid-range flights. The main propulsion system (full system of engines and propellant tanks) consists of two J-2S aerospike engines, one aluminum LOX tank in the front, and two LH_2 tanks in the rear for short- and mid-range flights. The vehicle could sustain one engine out at liftoff and still have sufficient power from the remaining engine to continue acceleration and make a safe landing at the intended runway or an abort landing area depending on where the engine out occurred during flight. For the long- range flights an engine out situation could be tolerated approximately 30 seconds after liftoff.

The engine burns liquid hydrogen (LH_2) and liquid oxygen (LOX), releasing only water vapor into the atmosphere. All other fuel sources required to provide energy for onboard computers, the reaction control system, etc., depend on LH_2 and LOX, thereby greatly reducing the toxicity of fuel gases to those of normal, nontoxic constituents of the atmosphere. The engine does not require a "bell nozzle" to channel the hot gases of combustion for directional control of the vehicle. The hot gases expelled by the J-2S engine from the thrust cells would be directed in such a way that the atmosphere provides a natural channeling effect. Elimination of the bell nozzle provides significant weight and size reductions of the overall engine.

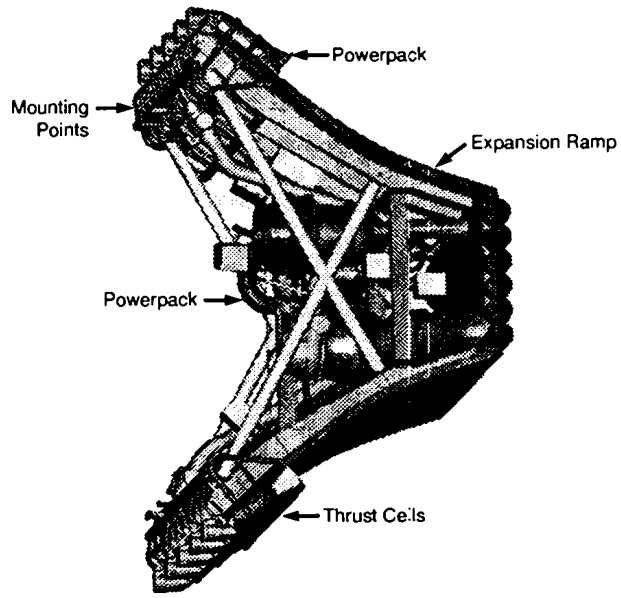


Figure 2-5. J-2S Linear Aerospike Engine.

The reaction control system for attitude (directional) control during portions of the flight plan and auxiliary power units also would use LOX and LH_2 as propellants. Propellants are supplied to these components from small auxiliary tanks located between the larger main propulsion system LH_2 tanks. The auxiliary power units generate power for the electromechanical actuators which move the flight control surfaces as directed by onboard computers or commanded from the ground control center. Flight control surfaces are used to steer the X-33 toward its intended destination. The X-33 would have double redundancy in these critical systems in order to maintain the overall reliability of the vehicle. The landing gear drive system would also be double redundant.

The X-33 would be controlled by an aviation electronics system referred to as the avionics system. Basic components of the avionics system include onboard computers, flight software, guidance/navigation/control systems, vehicle health monitoring systems, and systems that communicate from the vehicle to ground stations. Three avionics systems would be on board the X-33 to provide triple redundancy in these vital control functions.

2.1.3 Final Design, Fabrication, and Assembly of the X-33

Final design of the X-33 would be performed at the Lockheed-Martin Skunk Works facilities in Palmdale, California, approximately 72 km (45 mi) southwest of Edwards. Preliminary design and analysis of critical wind tunnel and component test data are underway to support final design. Component and wind tunnel tests with X-33 models are being conducted at established government installations listed in Section 2.1.9. Final design would correct deficiencies in the

preliminary design and address any significant environmental issues arising out of the Environmental Impact Statement (EIS) process that NASA determines require mitigation.

Manufacture of numerous X-33 components would be accomplished at several existing facilities around the U.S. (Figure 2-6). Components would be shipped to Palmdale, California, via air, truck, and rail. Following manufacturing and assembly, the X-33 without propellants would be inert, and its final components nontoxic.

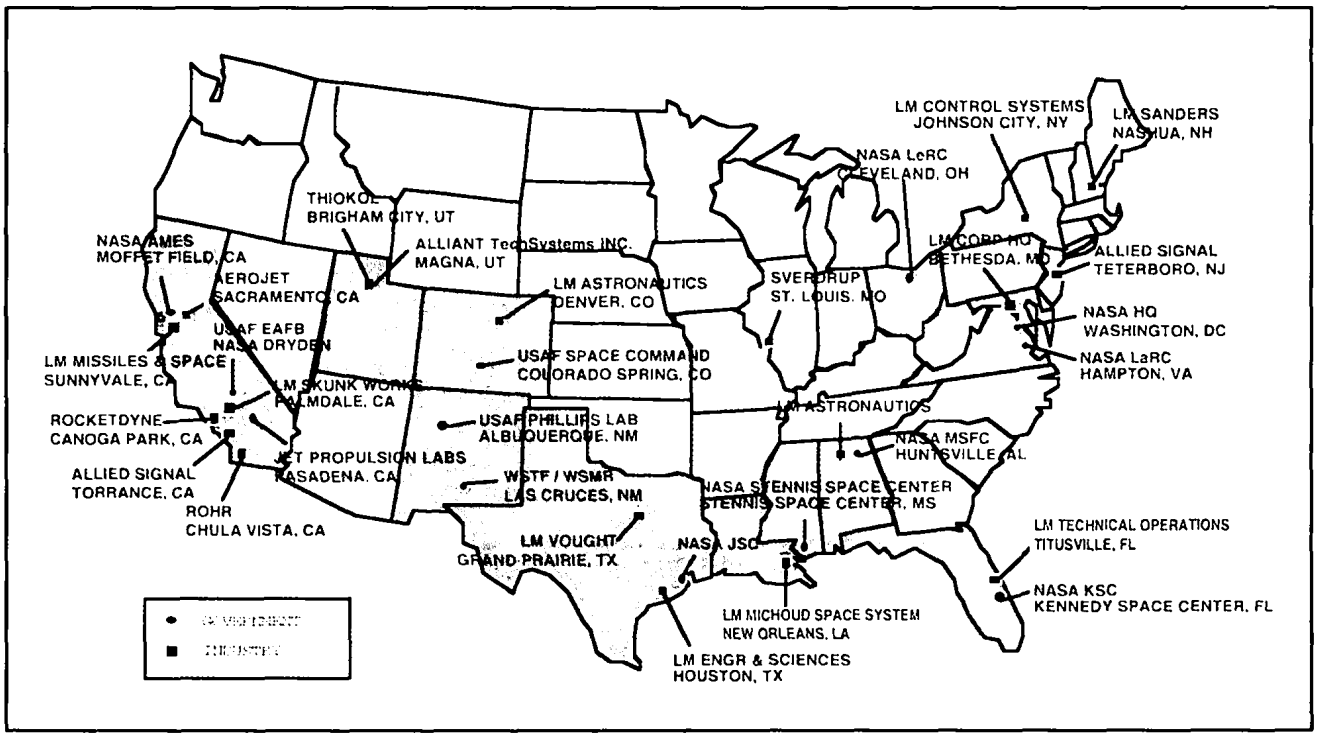


Figure 2-6. X-33 Vendor and Component Test Laboratories.

Manufacture and assembly of the X-33 would be conducted in one of Lockheed-Martin Skunk Works' facilities in Palmdale, California. These facilities have been used for aerospace manufacturing for many years and, as such, are covered by existing environmental permits. X-33 Program manufacture and assembly at these facilities would require little or no modification of the existing permits. All hazardous testing of the assembled vehicle would be conducted at the launch site.

2.1.4 Flight Operations and Launch Support

Figure 2-7 illustrates the proposed flight operations and launch site arrangement. Propellant bulk storage areas for LH_2 and LOX are sized to hold approximately 48,500 kg (106,880 lb) and 363,500 kg (801,600 lb), respectively, and would be located on opposite sides of the launch pad to provide separation of these commodities for safety purposes during storage. Approximate

storage volumes of the LH_2 and LOX are 681,400 L (180,000 gal) and 318,000 L (84,000 gal), respectively. Minimum interline quantity distances (QD) for these quantities of LH_2 and LOX are 43 m (140 ft) and 61 m (200 ft), respectively. QDs are a function of the amount of explosive potential based on the maximum quantity of fuel or oxidizer in storage, storage conditions, mixing potential with fuels or oxidizers necessary to support combustion. QDs provide an adequate safety zone between storage and other infrastructure that might be hit by flying debris from an explosion.

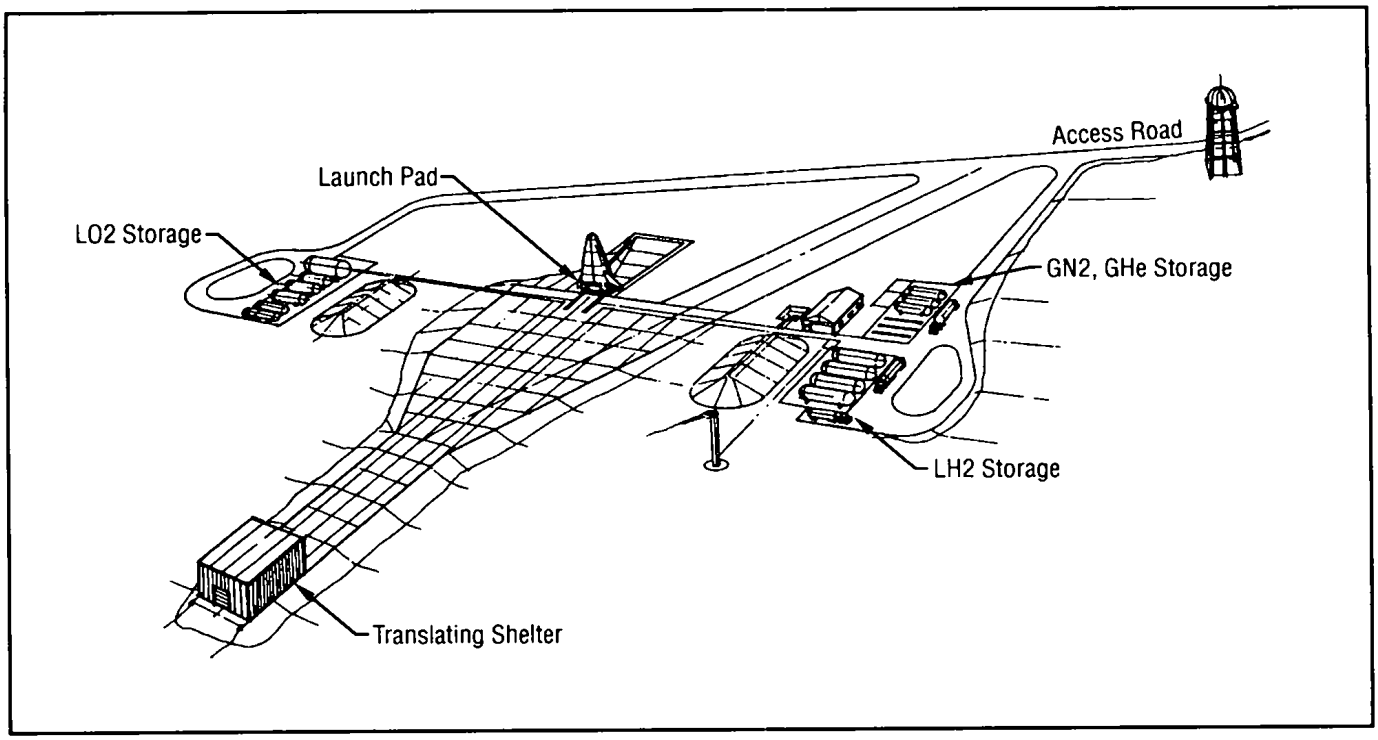


Figure 2-7. Proposed X-33 Launch Site Arrangement.

Bulk storage of gaseous helium (GHe) and gaseous nitrogen (GN_2) would be provided adjacent to the launch mount structure. These gases are inert (unreactive and will not burn) and are used for purging, pressurization, and cooling. An exhaust trench would be provided to deflect exhaust flows from the vehicle during testing and liftoff. Using a 60% TNT (trinitrotoluene, a common industrial explosive) equivalency to compute the equivalent explosive potential of the maximum amount of liquid hydrogen at the site, the launch pad would be sited with a QD of 620 m (2,030 ft) to support the fully fueled vehicle prepared for launch. When noise overpressures from launch and potential accidents are considered, personnel to support launch must be at a safe distance from the pad or protected by a substantial building commonly referred to as a bunker. Safety plans defining safe distances and protection of visitors, on-site personnel and essential launch personnel would be finalized and approved by Range Safety prior to first launch.

The sound suppression and deluge (cooling) water system would be capable of delivering 300,000 L (80,000 gal) of water from a water storage tower by gravity feed to the launch pad for each static flight readiness firing and test flight. The water storage tank would have multiple

compartments and a nominal total capacity of 950,000 L (250,000 gal). The water system may also be used for fire protection. The static head on the tank water would be 76 m (250 ft).

Basic components of the launch complex would include:

- launch mount structure that mates to the aft end of the X-33
- exhaust trench for channeling and deflecting engine hot exhaust flows
- bulk storage and delivery systems for LH_2, LOX, gaseous H_2 and gaseous oxygen
- bulk storage and delivery systems for gaseous nitrogen and gaseous helium
- a system for providing conditioned air and gaseous nitrogen for vehicle cooling and purging
- translating shelter for protection of the X-33 when in a horizontal position for processing
- rail system to move the translating shelter back during launch operations
- rotation device to move the X-33 from a horizontal to vertical position
- water system for suppression of launch ignition overpressure loads on the vehicle and cooling of the exhaust trench.

An Operations Control Center with launch and mission command and monitoring systems would be located near the launch site within Edwards. The Operations Control Center would house command and monitoring capabilities for ground and flight tests. Remote terminals would be located at the landing sites.

Other support facilities required in the vicinity of the launch site would include:

- office space
- storage space
- runway or dry lake bed for landing of the Boeing 747 carrier aircraft ferrying the X-33 from the manufacturing plant and landing sites
- de-mate facility for removing the X-33 from the Boeing 747 aircraft ferry and mounting it on a transporter for towing to the launch complex
- paved towways from the receiving runway to the de-mate area and launch complex.

2.1.5 Ground Testing (Infrastructure and Vehicle)

Various facility and vehicle components and systems would be tested prior to final commit to full flight tests of the X-33. The main purpose of ground testing is to ensure proper working of critical elements. Testing plans would be carefully developed to ensure safety of personnel, the public, property and equipment. It should be noted that of none of the facilities at the flight operations and launch support site or landing sites would be considered "critical action" facilities for purposes of Executive Order 11988, *Floodplain Management*. Consequently, the 100 year floodplain is the area of concern for siting purposes. Main elements of ground tests include:

- ground system tests
- X-33 carrier aircraft captive carry tests ("flying wind tunnel" tests)
- flight readiness firings (FRF)
- aerospike engine static tests.

2.1.5.1 Ground System Tests

All systems used to support X-33 launches would be tested once launch site preparation is complete. Ground systems would be checked-out to ensure proper operation according to design criteria site preparation plans. Ground system tests would be completed before the X-33 is brought to the site. Tests would include:

- ensuring proper flow and control of flow for all gas and liquid commodities, including LH_2, LOX, GN_2, GHe and gaseous oxygen, and gaseous hydrogen
- ensuring electric and electronic controls for all launch systems operate as designed, manufactured, and/or installed
- ensuring proper flow and operation of the deluge water system
- ensuring communications links operate correctly between the launch point and Operations Control Center and Range Control.

2.1.5.2 X-33 Carrier Aircraft Captive Carry Tests

The first time the X-33 vehicle becomes airborne, it would be structurally mated to the Shuttle Carrier Aircraft (SCA), a specially modified Boeing 747 airplane. This piggyback approach is the same method used to transport Space Shuttle Orbiters between launch, landing, and refurbishment sites. Figure 2-8 shows the X-33 and SCA in the ferry configuration.

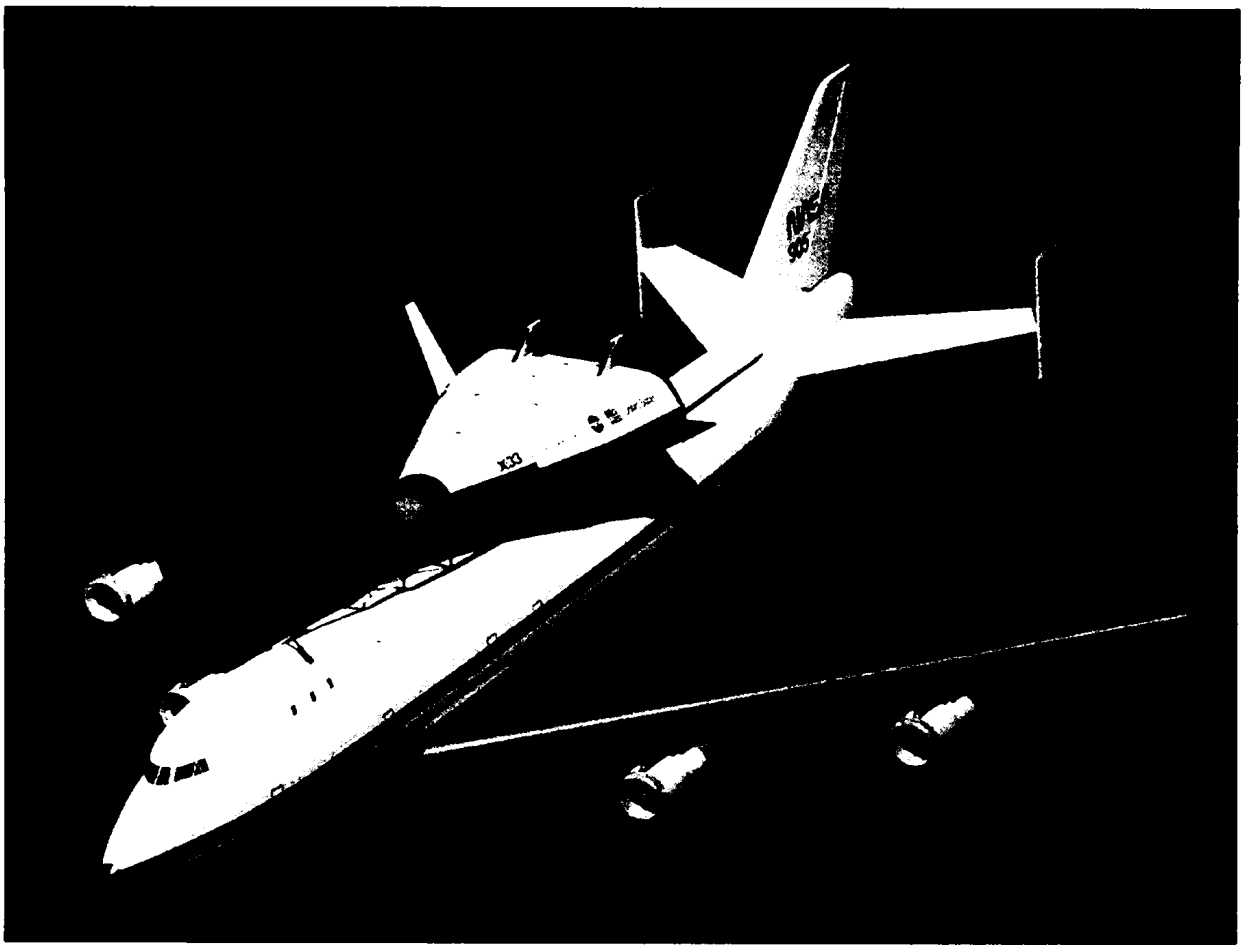


Figure 2-8. X-33 and Shuttle Carrier Aircraft in Ferry Configuration.

Captive carry testing provides "flying wind tunnel" and test data on interaction between the aerodynamics, avionics, and flight controls of the X-33 in a realistic operational environment before flying on its own. While it is on the SCA, tests on the X-33's systems would be performed. Tests include activating the guidance system to prove its location pinpointing ability. During these tests, the X-33 would be instrumented in order to collect key data that would be analyzed before further vehicle testing is conducted. In addition, a primary objective of the captive carry test is to verify compatibility of the SCA with the X-33 for ferry purposes. During actual flight tests, the X-33 would be returned to the flight operations site in this ferry mode.

As a minimum, captive carry testing would be performed when the X-33 vehicle is transported from final assembly at the Lockheed Martin Skunk Works X-33 manufacturing plant near the Palmdale Airport, Palmdale, California, to a landing area within the proposed installation for flight operations. After landing, it would be towed to the mate/demate facility for the Shuttle on the Dryden Flight Research Center within Edwards where the X-33 would be hoisted off the SCA and placed on a transporter for towing overland to the launch site. Additional captive carry tests may be performed depending on results from the first test.

2.1.5.3 Flight Readiness Firings

The X-33 would be transported overland by transporter to the launch pad within the confines of Edwards. The vehicle would be serviced and mated to the launch fixture over the exhaust duct. While the vehicle is structurally mated (secured) to the launch fixture, a complete countdown and test firing would be conducted. The cryogenic propellants (LH_2 and LOX) would be transferred into the X-33's tanks, the countdown sequence initiated, and engines fired. These tests are called flight readiness firings (FRF) and are routinely conducted on the Space Shuttle prior to the first launch of a new orbiter to ensure proper operation of the propulsion, communication, and instrumentation systems before actual flight. FRF's are short in duration, approximately 1 to 20 seconds. Three FRFs are planned prior to first flight of the X-33 and none thereafter.

2.1.5.4 Aerospike Engine Static Tests

The J-2S aerospike engines would be static tested by firing the engine(s) on an engine test stand while secured to the stand. This test procedure is commonly conducted to acquire critical data and certify every engine for flight worthiness. In the testing process, engines are subjected to more stress and fired for longer durations than required for launch in order to demonstrate required margins of safety. For the X-33, the J-2S engines would eventually be tested to approximately 110 percent of thrust and 1.5 times the engine firing duration (including abort scenarios) required for normal launch conditions .

2.1.6 Flight Tests

Upon successful completion of ground testing, flight testing would commence. The maximum altitude and speed that the X-33 is being designed to achieve is 75,800 m (250,000 ft) and Mach 15 (18,000 km/hr (11,000 mi/hr)), respectively. Mach 25 is required for a space launch vehicle to achieve a stable orbit around the Earth. The X-33 would launch in a vertical position like a space launch system, because of its shape and to reduce the weight of the landing gear and wheels to only that required to support an unfueled vehicle on landing, accelerate rapidly to hypersonic velocities and land horizontally. Flight profiles include launch with engine burn until flight speed and altitude are reached. In flight, mixture ratio adjustments by the J-2S engines would minimize the residual propellants at engine cut off. The vehicle would continue to glide in a unpropelled mode for approximately 160 to 1,530 km (100 to 950 mi) depending on the flight test and momentum generated during the powered or acceleration mode. Prior to landing and in the vicinity of the runway, the X-33 would begin a series of deceleration (slowing down) maneuvers. Throughout flight, the X-33 would be autonomously piloted with onboard control software and tracking systems. Flight path alterations, abort, etc., would be made by command signals from the Operations Control Center. A total of 15 test flights are planned for the Program from July 1999 until December 1999.

Flight test program objectives summarized by flight in Table 2-2 require landing sites at approximately 160, 720, and 1,530 km (100, 450, and 950 mi), respectively, downrange of the launch site. The mix of test flight objectives and distances may vary from that provided in Table 2-2, dependent on the results of prior flight tests. Landing sites meeting the above criteria and providing 3,050 m (10,000 ft) of hard surface are referred to as short-, mid-, and long-range landing sites, respectively. The X-33 Program prefers to land the vehicle on a dry lake bed at least for its first flight in order to have a wider and slightly safer landing area than conventional runways offer. The same philosophy was used for the Space Shuttle's and most X-planes' first landings. Approximately 2,400 m (8,000 ft) of landing strip are required to land the X-33. Approximately 3,050 m (10,000 ft) are needed to not only land the Boeing 747, but also for the Boeing 747 to take off with the X-33 piggyback. Optimally, three landing sites at progressively greater distances from the launch site are needed to conduct test flights which involve incremental expansion of distance and speed, also referred to as "flight envelope expansion." This approach allows the Program to minimize risk and acquire key test flight data before progressing on to the next step of increased flight speed and altitude. Maximum speeds of approximately Mach 4, 12, and 15 would be achieved using the three landing sites. Figure 2-9 displays the flight envelope expansion concept proposed for this Program.

Table 2-2. Specific Test Flight Objectives Based on the Optimal Scenario of Three Landing Sites (short-, mid-, and long- range).

Flight Number (s)	Landing Site	Distance, km (mi)	Estimated Maximum Mach Number	Estimated Maximum Altitude, m (ft)	Estimated Time to Main Engine Cutoff, sec	Mission Objectives
1-3	short-range	160 km (100 mi)	4	32,000 m (105,000 ft)	105	Shakedown flights; data collection for refinement of aerodynamic characteristics, stability and control, flutter, overall aero-performance (lift and drag);verify engine performance, overall vehicle and ground system performance; avionics and guidance systems; evaluate autonomous operations performance
4-6	mid-range	720 km (450 mi)	8.8-9.2	49,400 m (162,000 ft)	172-200	Evaluate performance of: TPS; computer modeling; electrical power system, RCS propellant management; propellant tanks' durability and reusability
7-9	mid-range	720 km (450 mi)	8.1-9.1	49,400 - 61,000 m (162,000-200,000)	155-176	Conduct three consecutive flights with 7-day turnaround and 48-hour turnaround operations
10	mid-range	720 km (450 mi)	10.8	53,300 m (175,000 ft)	204	Highest possible Mach number to evaluate overall vehicle performance before progressing to long-range missions.
11-13	long-range	1,530 km (950 mi)	14-15.1	75,600 - 79,300 m (248,000-260,000 ft)	192-267	Evaluate TPS durability, thermal cycling of TPS and propellant tanks, and control effectiveness
14-15	long-range	1,530 km (950 mi)	13.8-14.9	74,000 - 74,400 m (243,000-244,000 ft)	194-282	Continued evaluation of: TPS durability, thermal cycling effects; and propellant tank durability and reusability

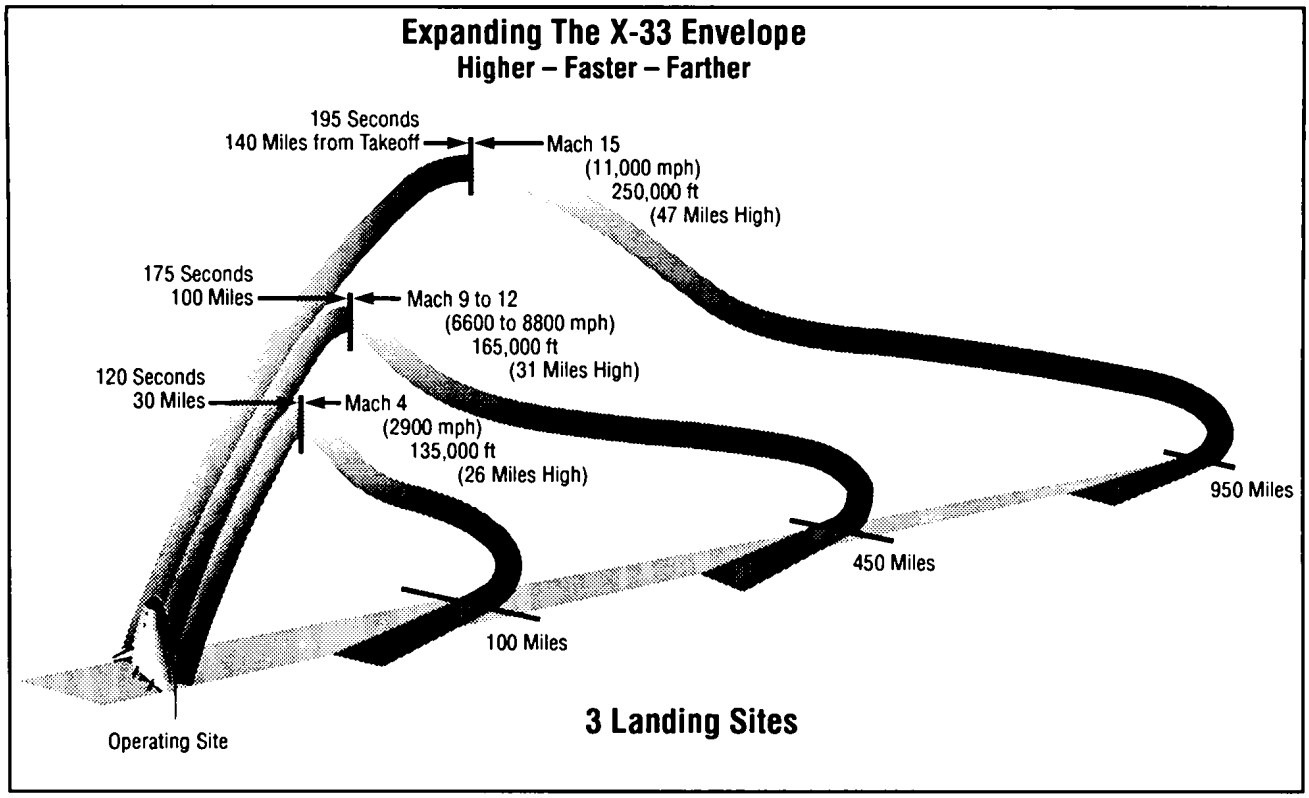


Figure 2-9. Baseline Flight Envelope Expansion Concept.

After landing, the X-33 would be "safed" (purged of residual propellant by venting to atmosphere and displacement with an inert gas such as helium or nitrogen), field inspected for major structural problems which might preclude immediate return to the flight operations site, hoisted for mating to the back of the SCA with two mobile cranes, and ferried back to the flight operations site for re-flight.

2.1.7 Propellant Transportation from Manufacturing Plant to Launch Site

Table 2-3 provides the per-flight and total Program estimate of propellant and gas requirements. These requirements would be met by transporting these commodities by truck from the manufacturing plant to the proposed launch site. No new facilities for manufacturing these gases and propellants are contemplated by the Program.

Table 2-3. Per-Flight and Total Program Propellant and Gas Requirements.

Commodity	Quantity Per Flight	Total Program Quantity
LH_2	38,600 kg (85,000 lb) 545,000 L (144,000 gal)	772,000 kg (1,700,000 lb) 10,900,000 L (2,880,000 gal)
LOX	136,078 kg (300,000 lb) 254,000 L (67,200 gal)	2,721,554 kg (6,000,000 lb) 5,080,000 L (1,344,000 gal)
GH_2	3600 m^3 (127,000 scf)	72,000 m^3 (2,540,000 scf)
GOX	1020 m^3 (36,000 scf)	20,400 m^3 (720,000 scf)
GHe	11,500 m^3 (406,000 scf)	230,000 m^3 (8,120,000 scf)
GN_2	8,600 m^3 (304,000 scf)	172,000 m^3 (6,080,000 scf)
LN_2	170,000 L (44,800 gal)	3,400,000 L (896,000 gal)

Notes: Quantity per flight based upon using 80% of the bulk storage capacity and worst case usage i.e. normal launch plus maximum hold and detanking. Use rates also include loss due to "boil off" on vaporization and venting.
Total program quantity based upon a multiplier of 20 derived from 15 flights, 3 flight readiness firings, and 2 tanking tests.

Liquid oxygen (LOX) and liquid hydrogen (LH_2) would be transported by rail cars or tank trucks from the vendor to Edwards launch site. Rail cars and tank trucks designed for shipping these propellants are specially insulated and approved by the Department of Transportation (DOT).

If shipments are received by rail, two railcars for LOX and five rail cars for LH_2 would be required for each launch or FRF. If these propellants are transported by truck, four truck loads of LOX and ten truck loads of LH_2 per launch or FRF would be required.

LOX and LH_2 can be supplied from at least three vendors. Depending on specific requirements and availability, shipments could originate from a variety of locations, including Ontario, CA; Wilmington, CA; Sacramento, CA; Sante Fe Springs, CA; New Orleans, LA; and Titusville, FL. Each truck shipment from these locations would be routed on highways approved for hazardous materials transportation. Typically, routes consist of interstate highways with interstate bypasses taken around major population centers. From interstate highways, normal hazardous materials transportation routes used routinely for supplies to Edwards would be used. Hazardous materials rail routes would be used for tank car shipments.

2.1.8 Contingency Planning and Abort Scenarios

Anomalies resulting in a flight path deviation could occur due to:

- deviations from predicted performance of the:
  - aeroshell or TPS
  - engines
  - flight controls, aerosurfaces and thrust vectoring
  - guidance and navigation system
- structural failure
- system/subsystem failure
- critical component failure causing loss of performance.

X-33 Program and safety personnel are studying proposed flight corridors to identify safe (unpopulated) areas in the event of an abort. X-33 flight failures could result from explosion during powered mode, mid-air physical breakup, and whole vehicle impact (crash).

2.1.9 Program Management and Miscellaneous Activities

The Office of Aeronautics and Space Transportation Technology at NASA Headquarters in Washington, DC, manages the Reusable Launch Vehicle (RLV) Technology Program. Marshall Space Flight Center (MSFC), Huntsville, Alabama, is Lead Center for the X-33 Program. Various government laboratories and installations are participating in this effort under task agreements to Lockheed-Martin to develop technologies and data necessary for the success of the X-33 Program. The following government owned facilities have X-33 task agreements: NASA/MSFC in Huntsville, Alabama; NASA/Dryden Flight Research Center on Edwards Air Force Base, California; NASA/Ames Research Center in Santa Clara County, California; NASA/Lewis Research Center in Cleveland, Ohio; NASA/Langley Research Center in Hampton, Virginia; NASA/Johnson Space Center in Houston, Texas; Jet Propulsion Laboratory (contractor operated) in Pasadena, California; NASA/Kennedy Space Center in Brevard County, Florida; NASA/Stennis Space Center in Hancock County, Mississippi; NASA/MSFC/Michoud Assembly Facility, New Orleans, Louisiana; U.S. Air Force Flight Test Center at Edwards Air Force Base near Lancaster, California; and USAF Wright-Patterson Laboratories in Dayton, Ohio. Additional task agreements would be prepared with other installations and agencies as required should the X-33 Program go forward and launch and landing site selections made after the Final X-33 EIS is issued.

2.2 Alternatives

Second level decisions are dependent on selecting launch, landing, and aerospike engine test sites. The Program has narrowed down potential sites to be carried forward in the Program and evaluated in the EIS to the set of reasonable alternatives shown in Table 2-4.

Table 2-4. X-33 Site Alternatives.

Purpose	Installation	Site/Facility
Flight operations and launch	Edwards Air Force Base, CA	Haystack Butte
		Space Port 2000
Short-range landing sites	Silurian Lake, CA	Undeveloped natural dry lake
	China Lake Naval Air Weapons Station, CA	Armitage Airfield
Mid-range landing sites	Dugway Proving Ground, UT	Michael Army Airfield
	Site selected for long-range landing	Base Airport Facility, Malmstrom Air Force Base, MT *or* Grant County Airport, Moses Lake, WA
Long-range landing sites	Malmstrom Air Force Base, MT	Base Airport Facility
	Moses Lake, WA	Grant County Airport

Descriptions for alternatives identified to meet Program needs in these areas are provided below.

2.2.1 Alternative Flight Operations and Launch Sites

Edwards is a large, diverse U.S. Air Force installation covering approximately 121,500 ha (300,000 ac) in southern California near Lancaster. Two reasonable alternative launch sites, Space Port 2000 and Haystack Butte, within Edwards Air Force Base have been identified through rigorous engineering, safety, and environmental analyses conducted in Phase I and continued in Phase II after the cooperative agreement between NASA and Lockheed Martin Skunk Works was finalized in July 1996. Other existing facilities on Edwards are proposed for use as described below. Functional operations flow, existing facilities, and launch complex areas proposed for flight operations and launch use are designated on Figure 2-10.

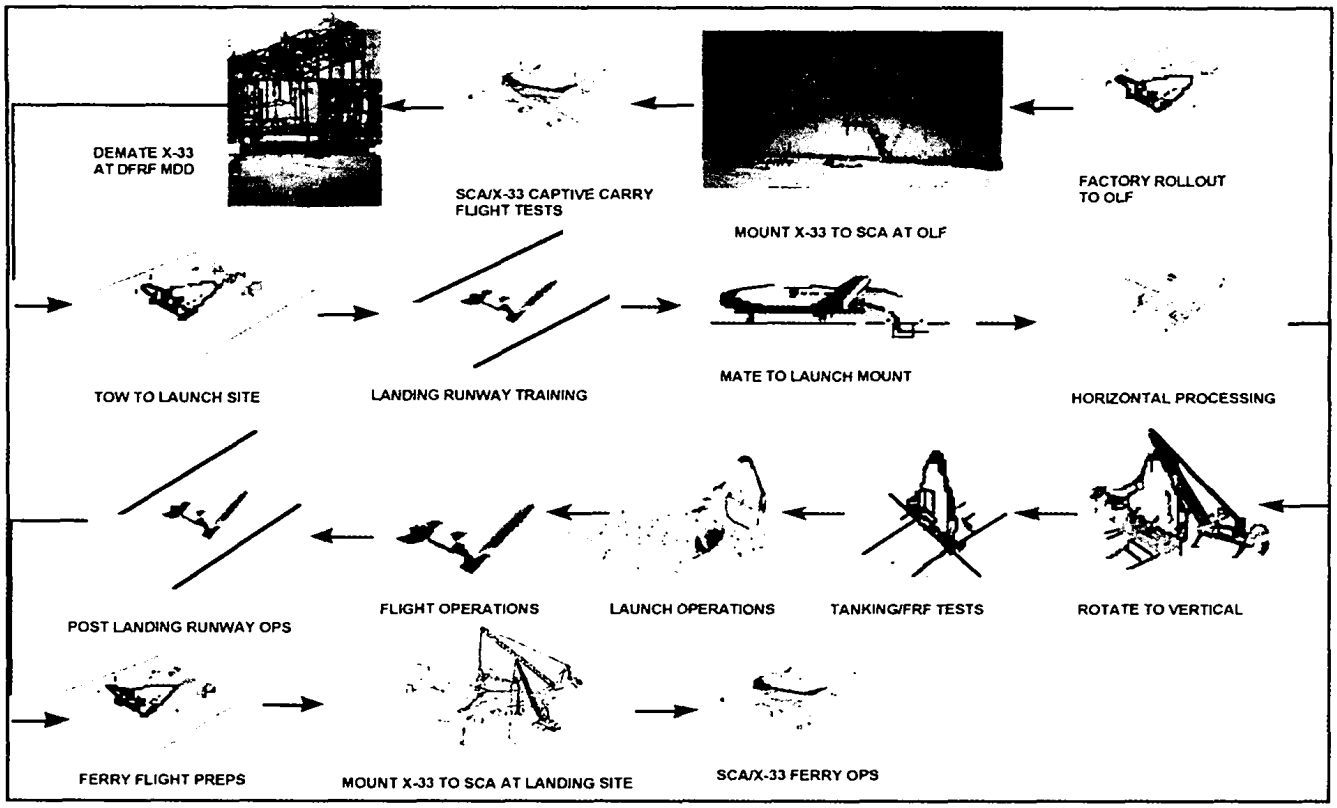


Figure 2-10. Functional Operational Flows.

It is proposed that the X-33 be air-ferried from the Palmdale Airport at Palmdale, California, to the paved landing strip on Edwards. After landing, the Boeing 747 with the X-33 mounted on its back would be towed to the Orbiter Mate/Demate Facility on Dryden Flight Research Center. Using existing towing and de-mating equipment acquired for the Space Shuttle Program, the X-33 would be decoupled from the Boeing 747 and mounted to a strongback for towing over existing surface roads (except for Haystack Butte) to the shelter facility at the launch complex for checkout and servicing. A new road linking Mars Boulevard to the X-33 launch site would have to be constructed if the Haystack Butte alternative is selected. The existing roads that would be used for towing the X-33 could include Lancaster Boulevard, Avenue B, and Mercury Boulevard. The X-33 would be transported overland within the confines of EAFB.

2.2.2 Alternative Landing Sites

Alternative landing sites were carefully identified based on environmental evaluations, potential for meeting AFFTC Range Safety criteria for X-plane programs, and distances from the launch site. Launch site alternatives are provided in Table 2-5.

Table 2-5. Alternative Landing Sites.

Landing Site/Facility	Short-Range	Mid-Range	Long-Range
Silurian Lake	X		
China Lake Naval Air Weapons Station	X		
Dugway Proving Ground		X[1]	
Malmstrom Air Force Base			X
Moses Lake			X

[1] If Dugway Proving Ground is an unacceptable landing site, Program objectives for mid-range test flights would be met by expanding the flight profile plan for either Malmstrom Air Force Base or Moses Lake.

The X-33 may land with up to 680 kg (1,500 lb) of LH_2 and up to 340 kg (750 lb) of LOX requiring safe release to the atmosphere. Following wheel stop at each of the proposed landing sites, the X-33 would automatically perform the following functions to safe subsystems, reduce power consumption, and minimize personnel safety risks:

- position aerosurfaces for ferry flight
- power down hydraulic control units
- stow air data probes
- configure vent doors for maximum venting
- depressurize reaction control system manifolds
- perform propellant tank pressure vent
- power off all non-safety critical subsystems
- power down turboalternator
- power down and purge gassifier.

Following auto-safing by the vehicle, the condition and safety of the vehicle would be determined by a field crew. The X-33 would be towed to an area prepared for field servicing, which may include additional venting, and mating the X-33 to the back of the Boeing 747 for return to launch site. Two mobile cranes with a special sling would be used to host the X-33 to the mounting structure on the back of the Boeing 747. At established aircraft maintenance facilities, an existing hangar would be used for servicing the X-33 and preparing it for return to launch site. All operations at the landing sites are projected to last approximately 12 hours unless a hold for adverse weather conditions is instituted.

2.2.2.1 Alternative Short-Range Landing Sites

Silurian Lake, California

Silurian Lake shown in Figure 2-11 is a lake bed that is dry the majority of each year. It is approximately 29 km (18 mi) north of Baker, California, and immediately east of California State Highway 127. Silurian Lake and the surrounding areas are Federal Public Lands administered by the Department of the Interior, Bureau of Land Management (BLM). The lake bed is classified by BLM as a Multiple-Use I (intensive use) area and such activities as commercial filming have been permitted at the site. Silurian Lake is also within the area proposed for expansion of Ft. Irwin (BLM 1996). If the Army acquires the property, the lake bed would only be available on a 2-week rotation basis.

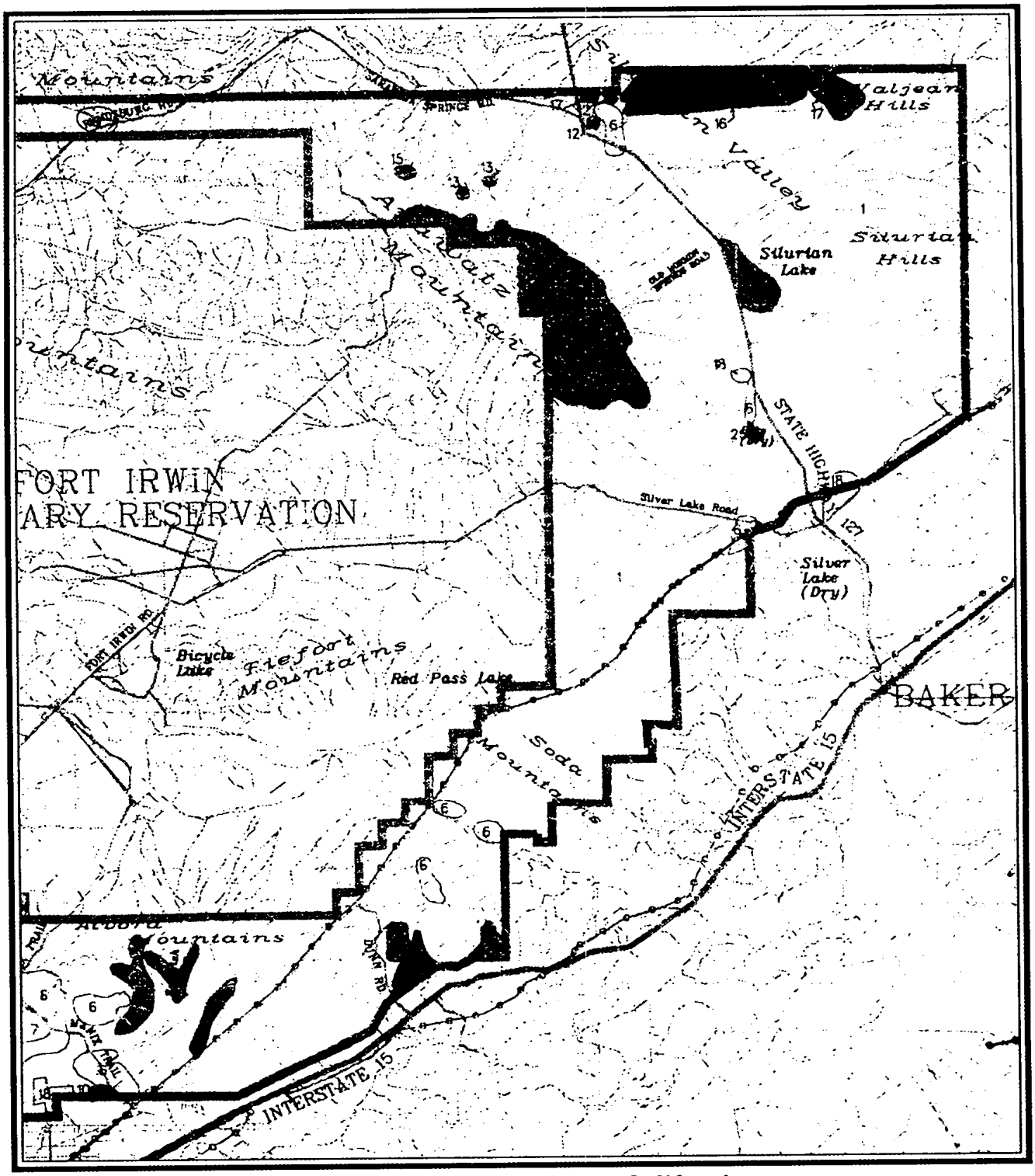


Figure 2-11. Silurian Lake, California.

The lake bed is approximately 3.8 km (2.4 mi) long by 0.6 km (0.4 mi) wide with a surface similar to the Rogers Dry Lake Bed on Edwards used for landing of the Space Shuttle Orbiter. Surrounding terrain is relatively flat. Proposed site layout for landing operations is provided in Appendix I.

Weather conditions for most of the year are extremely favorable for landing the X-33. The airspace of the lake bed is located within the Shoshone Military Operating Area of the R-2508 Complex described later in Section 3.1.6.

China Lake Naval Air Weapons Station, California

China Lake Naval Air Weapons Station is located in the high desert adjacent to the community of Ridgecrest, California. It is home to the Naval Air Warfare Center Weapons Division, the Naval Air Weapons Station, and the Naval Weapons Test Squadron. The Center covers approximately 486,000 ha (1.2 million ac).

Weather conditions for most of the year are extremely favorable for landing the X-33. The entire property is located within the military restricted air space flight corridor referred to as R-2508 described later in Section 3.1.6.

The Naval Air Weapons Station operates and maintains Base facilities, including the Armitage Airfield with paved runways shown in Figure 2-12 that is proposed for landing the X-33 and landing and takeoff of the Boeing 747. The airfield is located at the southern edge of the Base and has been used for several decades as a supersonic aircraft training facility. Runway 3-21 on Armitage Airfield is the proposed choice for X-33 landings. It is 3,050 m by 61 m (10,000 ft by 200 ft).

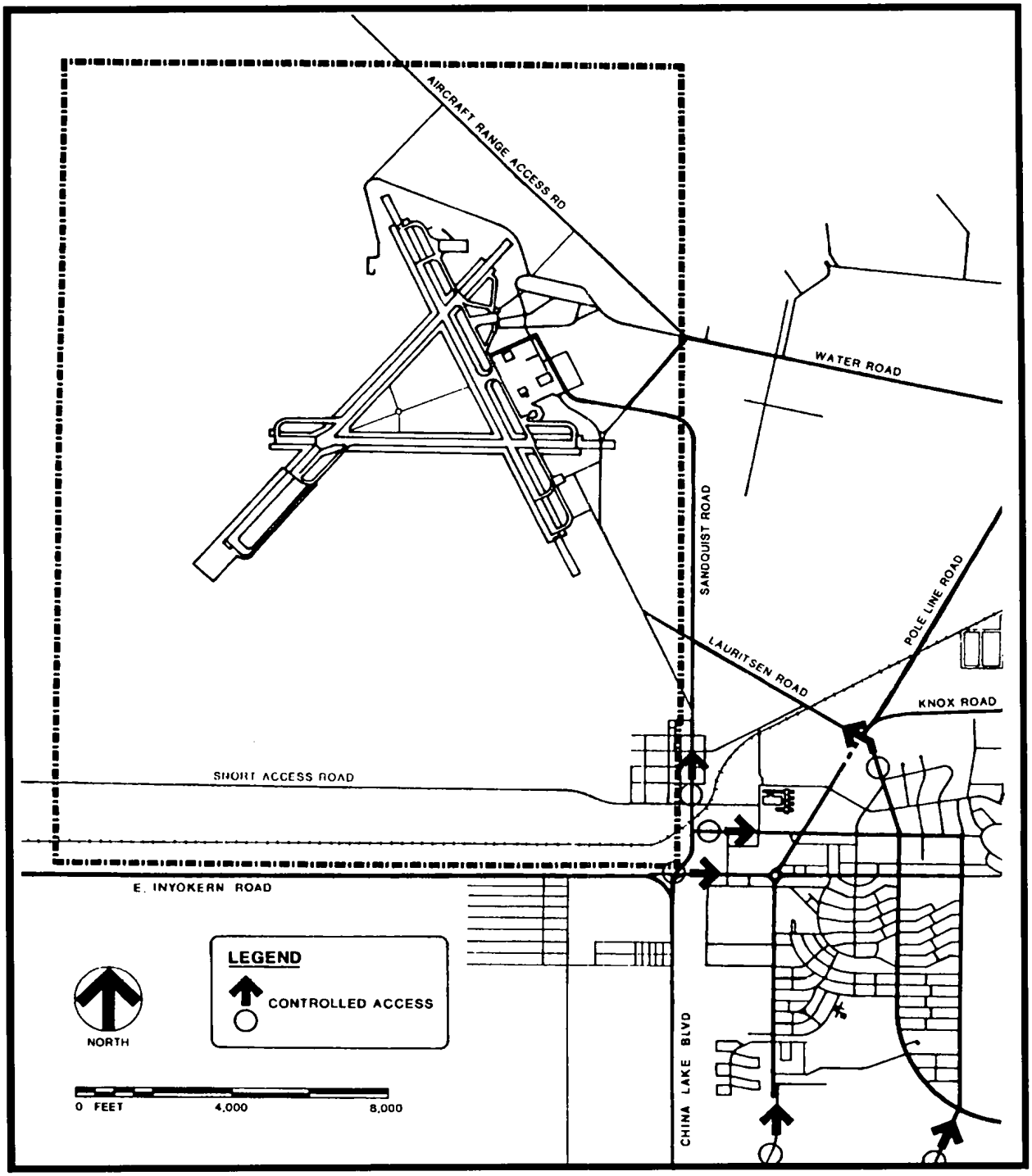


Figure 2-12. Armitage Airfield, China Lake Naval Air Weapons Station, California.

2.2.2.2 Alternative Mid-Range Landing Sites

Dugway Proving Ground, Utah

Dugway Proving Ground is located approximately 130 km (80 mi) southwest of Salt Lake City, Utah, near the town of Tooele. Dugway encompasses approximately 324,000 ha (800,000 ac) of the Great Salt Lake Desert. Dugway is part of the U.S. Army Test and Evaluation Command, headquartered at Aberdeen Proving Ground, Maryland.

The airfield within Dugway Proving Ground proposed for landing of the X-33 is called Michael Army Airfield. This airfield as shown in Figure 2-13 is situated on the eastern portion of Dugway. The airfield has a 3,960 m (13,000 ft) long by 61 m (200 ft) wide hard surfaced runway. Immediate surrounding terrain is relatively flat. It is a secure facility with a long history of flight operations. The airspace above Dugway is controlled by Hill Air Force Base which manages and approves use of the Utah Test and Training Range.

If use of Dugway is determined to not meet environmental and/or Program needs or suitability, test objectives for flying the X-33 to the long-range landing site will be modified, and all test flights except those to Silurian Lake or China Lake Naval Air Weapons Station will be conducted to the selected long-range landing site.

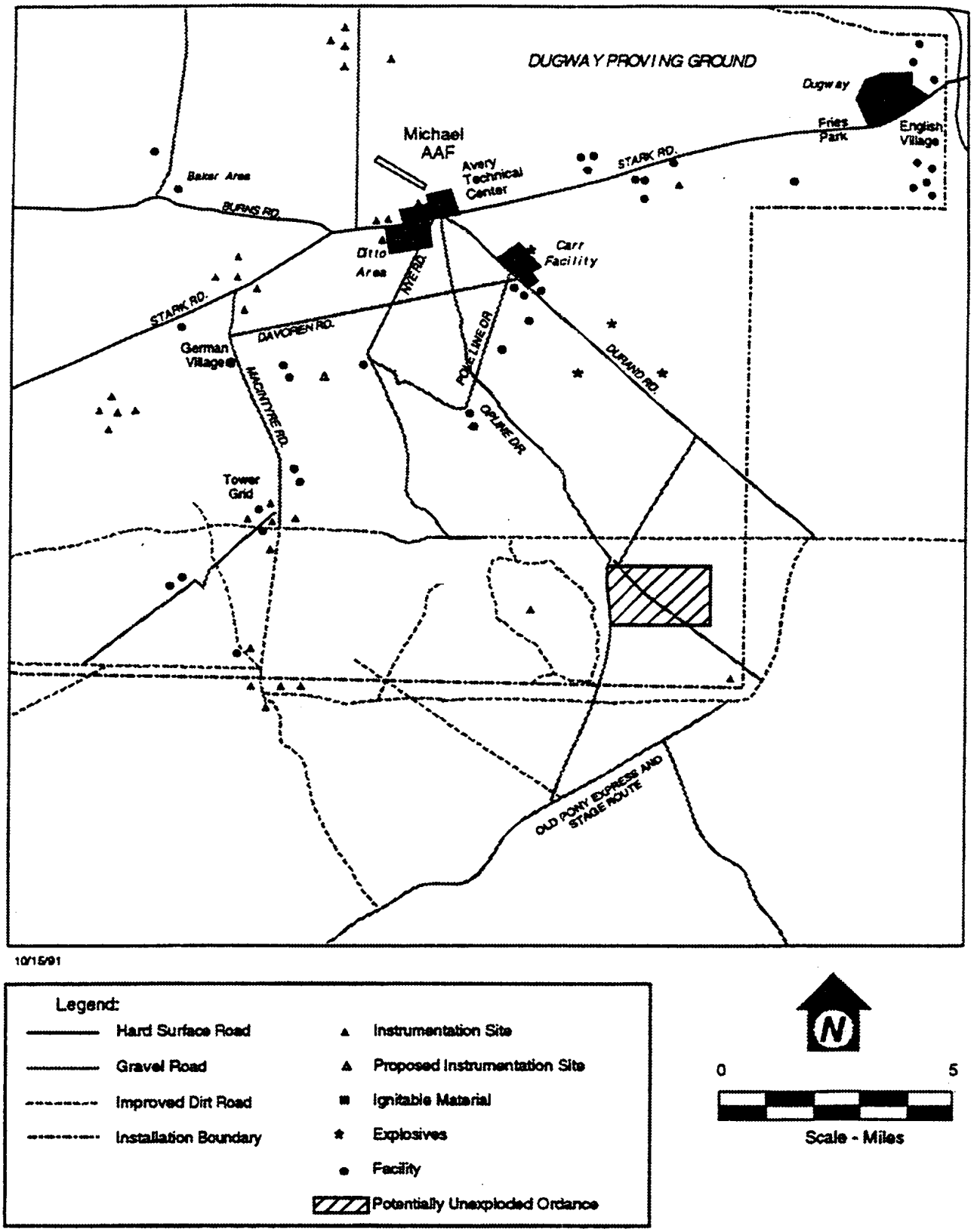


Figure 2-13. Michael Army Airfield Within Dugway Proving Ground, Utah.

2.2.2.3 Alternative Long-Range Landing Sites

Malmstrom Air Force Base, Montana

Malmstrom Air Force Base is located in Cascade County in north-central Montana in a relatively undeveloped area (Figure 2-14). The City of Great Falls lies approximately 0.6 km (0.4 mi) to the west of the Base (at its closest point) and 12 km (7 mi) from downtown. U.S. Highways 87/89 pass in close proximity to the installation's southern boundary. The Missouri River flows in an easterly direction 1.4 km (0.9 mi) to the north of the Base. The foothills of the Rocky Mountains lie about 81 km (50 mi) to the west. The installation occupies approximately 1,279 ha (3,159 ac). It is home to the 341st Missile Wing, which is responsible for operation, maintenance, and security of assigned intercontinental ballistic missile systems. Since the late 1980's, Malmstrom has been home to the 43rd Air Refueling Group. As a result of the Department of Defense's Base Realignment and Closure Plan, the 43rd Air Refueling Group was transferred to MacDill Air Force Base, Florida, in December 1996. After the move, all fixed-wing activity ended, the airfield was closed on December 31, 1996, except for the area used by helicopters of Malmstrom's Air Rescue Flight.

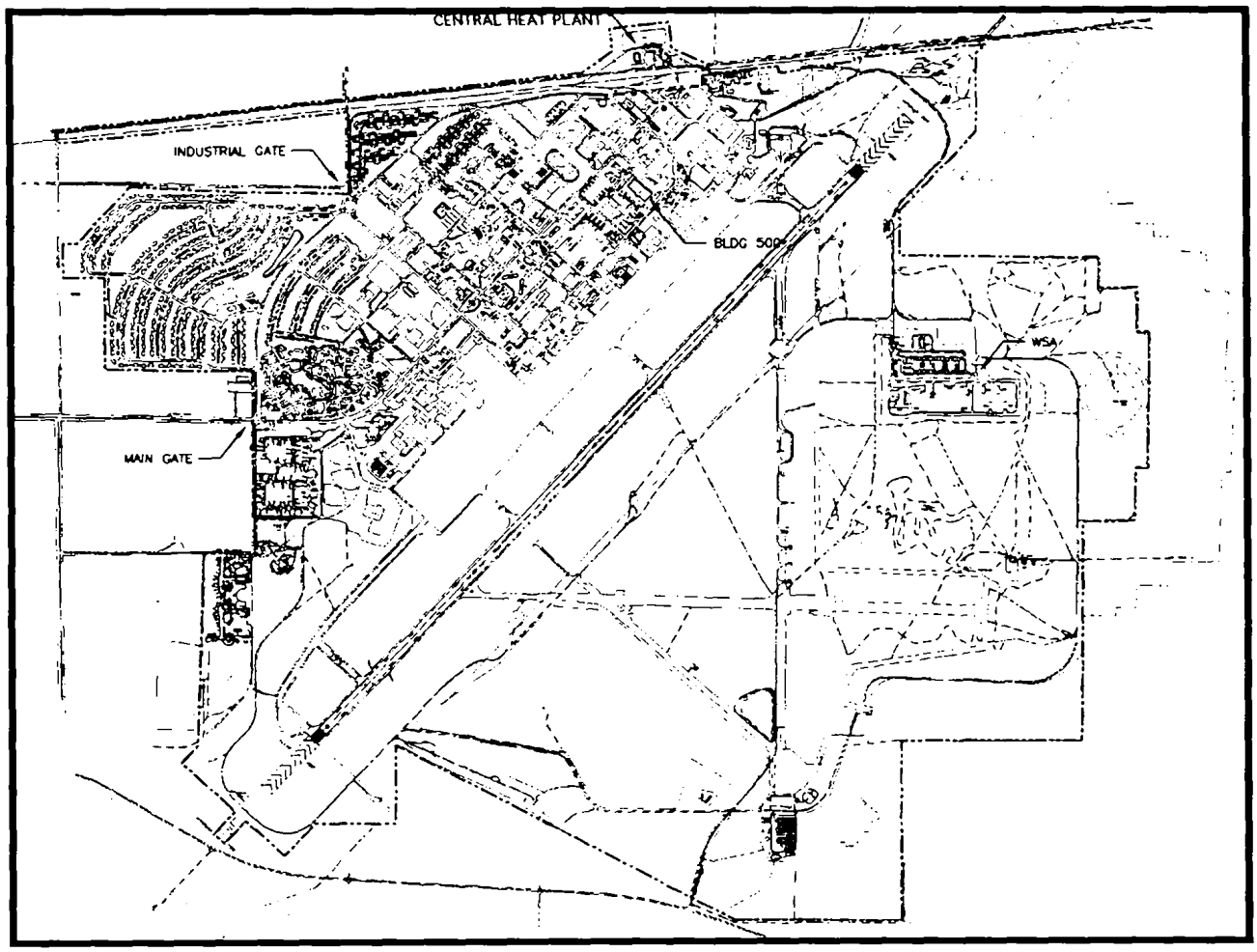


Figure 2-14. Malmstrom Air Force Base, Montana.

The airfield has a hard surface runway approximately 3,500 m (11,500 ft) long and 61 m (200 ft) wide with a 305 m (1,000 ft) overrun at each end. The terrain surrounding the airfield is relatively flat. No restricted airspace is associated with Malmstrom.

Moses Lake, Washington

The Port of Moses Lake, Washington, owns and operates the Grant County Airport shown in Figure 2-15. The airport is a former part of the Strategic Air Command known as Larson Field Air Force Base which was decommissioned in 1965 and became part of the Port of Moses Lake in 1966. The Port of Moses Lake is adjacent to the community of Moses Lake, Washington. Today, Grant County Airport is a regional aviation, industrial, and educational facility. It receives daily small commercial commuter airplanes. Part of the airport is leased to Japan Airlines for use as a flight training center for jumbo jet cockpit crews. This facility conducts significant flight testing and training of Boeing 747 flight crews.

McChord Air Force Base near Tacoma, Washington, plans to utlize the Grant County Airport as the location of the C-17 (a military cargo plane) shortfield. The USAF has included $2.4 million in its fiscal year 1999 military construction budget to fund infrastructure work at the Grant County Airport to support the C-17.

Runway 14L-32R is 4,115 m (13,500 ft) long and 46 m (150 ft) wide. No restricted airspace is associated with Moses Lake.

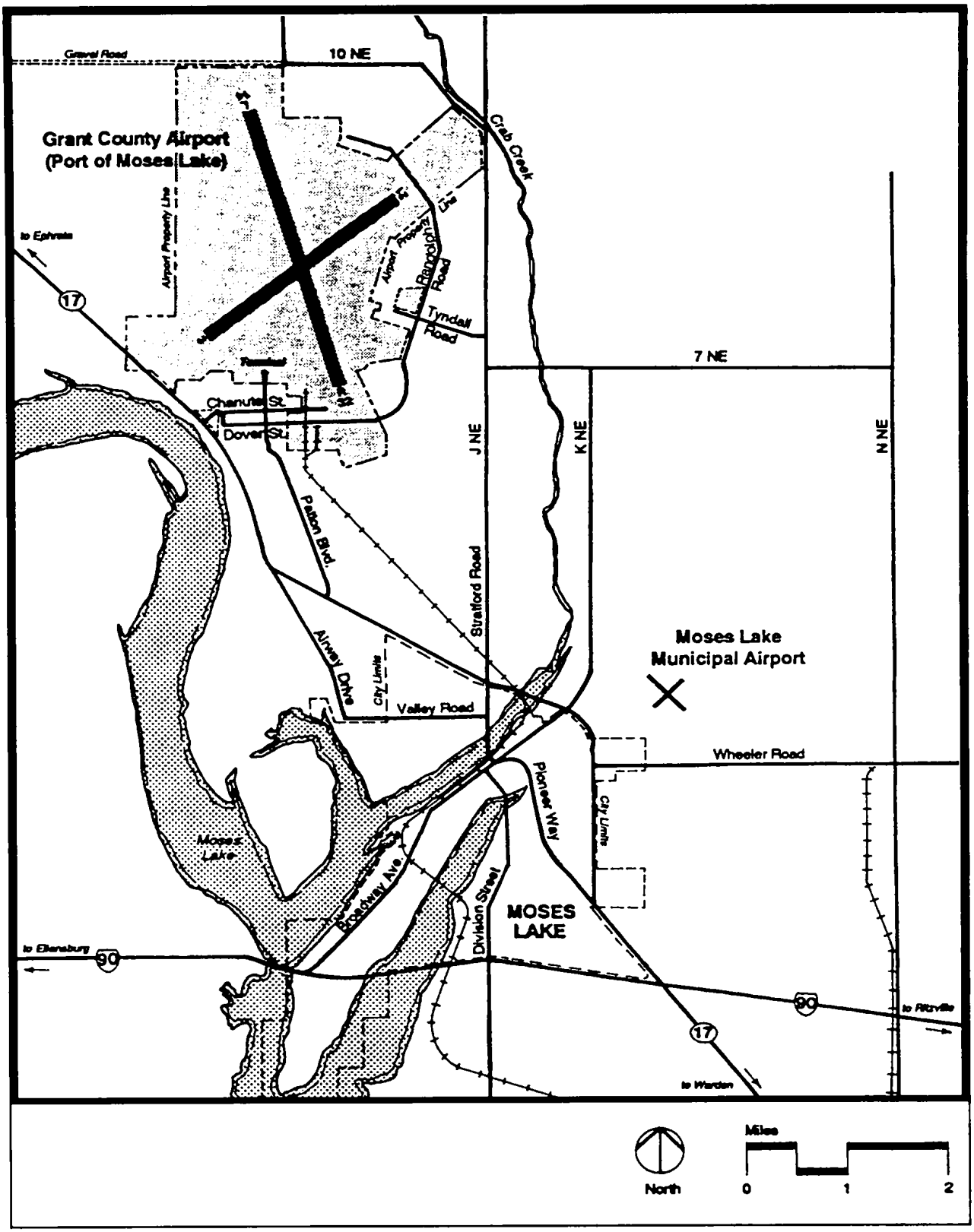


Figure 2-15. Grant County Airport, Port of Moses Lake, Washington.

2.2.2.4 Minor Test Flight Support Facilities

A minimum of two and possibly up to six mobile range tracking and telemetry stations would be required to track the X-33 during test flights. These stations will also provide signal relay capability for transmitting flight termination commands throughout each test flight. These mobile tracking stations will contain one or more radar and telemetry antennas, support trailers, and electric generators. One typical configuration is shown in Figure 2-16.

Figure 2-16. Typical Mobile Tracking Station Configuration.

Depending on the specific test flight, these stations would be placed at the landing site or overflight sites, for the long-range landing site alternatives. The locations of potential sites are listed in Table 2-6. Note that the proposed mobile tracking sites at Mountain Home and Winnemucca are overflight sites for the long-range landing site alternatives. These overflight sites provide continuous telemetry along the entire flight path for long-range flight tests.

Table 2-6. Mobile Tracking Station Locations.

Mobile Tracking Station Site	Function	Landing Site(s) Supported	Location
Silurian Lake	Landing Site Support	Silurian Lake	East of Silurian Dry Lake Bed
China Lake Naval Air Weapons Station	Landing Site Support	China Lake	Associated with runway
Michael Army Airfield, Dugway Proving Ground	Landing Site Support	Dugway	Associated with runway
Cedar Mountain	Landing Site and Overflight Support	Dugway and Malmstrom	Cedar Mountain, Utah
University of Utah	Landing Site and Overflight Support	Dugway and Malmstrom	In the area of Cedar Mountain, Utah
Malmstrom Air Force Base	Landing Site Support	Malmstrom	Immediately east of the runway
Mountain Home Air Force Base	Overflight Support	Malmstrom	Mountain Home, Idaho
Grant County Airport	Landing Site Support	Moses Lake	Associated with the runway
Winnemucca Site	Overflight Support	Moses Lake	Winnemucca, Nevada

With the exception of Silurian Lake, all the proposed mobile tracking locations use existing radar or communications sites or are associated directly with the runway at a proposed landing site. At Silurian, however, because there are no facilities, a small area just to the east of the lake bed would have to be prepared (see Figure 2-17). Area preparation would consist of laying a 4 by 4 m (12 by 12 ft) concrete pad to support the 6 m (18 ft) telemetry antenna and an adjacent area for four to six trailers. The total area to be disturbed would not be more than 31 by 31 m (100 by 100 ft). All equipment and the concrete pad would be removed at the end of the test flight program.

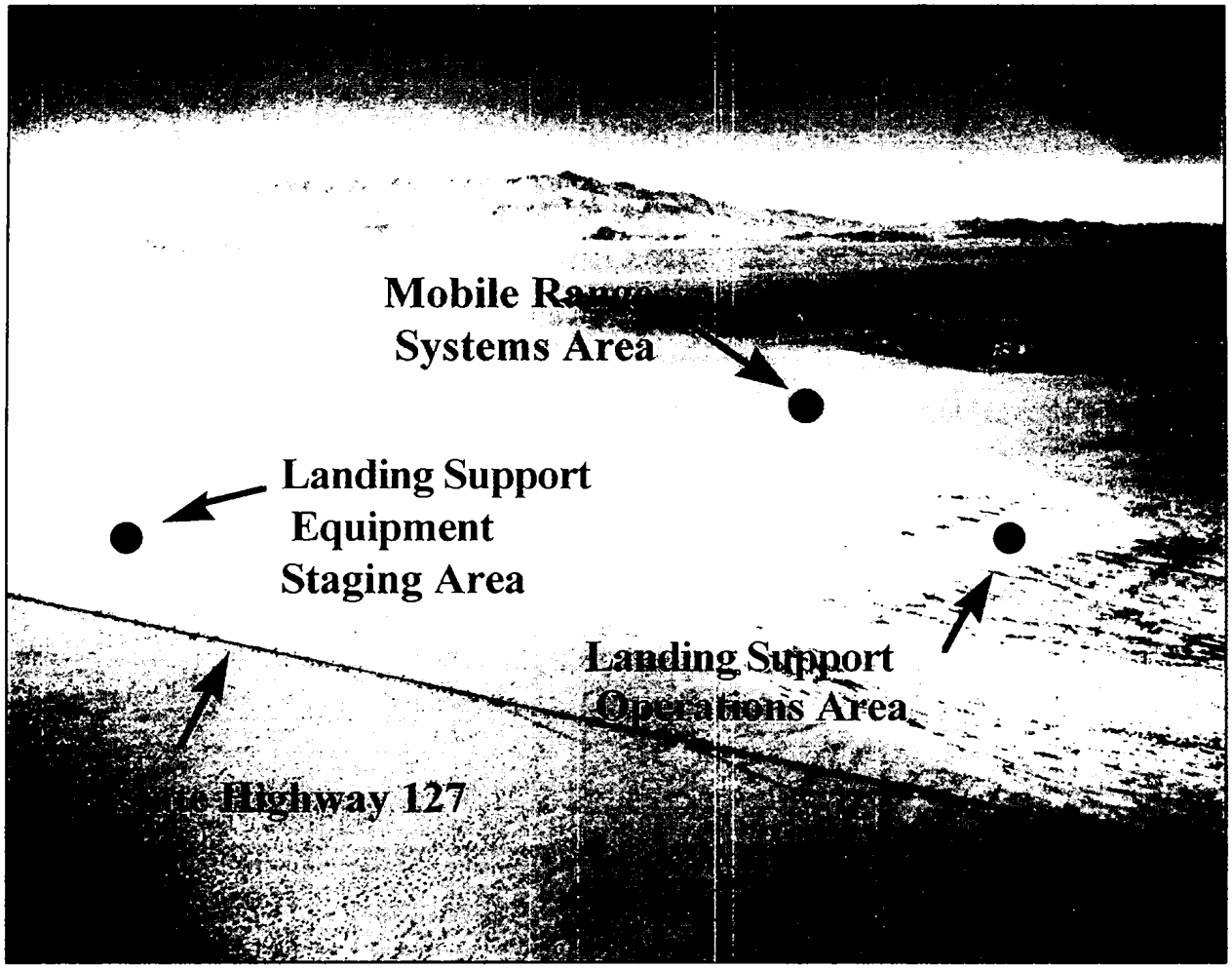


Figure 2-17. Mobile Tracking Station and Landing Support Equipment Locations at Silurian Lake.

2.2.3 Alternative Engine Test Facilities

The George C. Marshall Space Flight Center, Huntsville, Alabama, and the John C. Stennis Space Center, Hancock County, Mississippi, have existing facilities requiring minor modification to accommodate testing of the J-2S engines. The J-2S engine has approximately one-half the performance capability of the Space Shuttle main engine. Maximum thrust capability of the J-2S engine is approximately 890,000 newtons (N) (200,000 lbf). It utilizes LOX and LH_2 as propellants and produces water as its primary combustion product. Environmental impacts of a wide variety of engines including ones similar to the J-2S are covered in a recent Draft EIS for long-range planning of engine testing at these facilities (MSFC 1996C). No substantive environmental comments were raised by the public and federal, state, and local entities.

2.2.4 No Action Alternative

Defining the No Action alternative and comparing its environmental impact with those of the Proposed Action is a requirement of the CEQ regulations implementing the National Environmental Policy Act (40 CFR 1502.14(d)). The No Action alternative defines the baseline conditions which would prevail in the absence of the proposed project. For this project, the No Action alternative means that the X-33 Program would not be implemented, resulting in the lack of development and verification of key technologies needed for a successful Phase III as envisioned, with development and implementation of an operational single-stage-to-orbit RLV solely by private industry.

2.2.5 Alternatives Considered But Not Carried Forward

White Sands Missile Range (WSMR), New Mexico, was considered for both flight operations and landing. The installation was not pursued because of difficulty in planning flight trajectories to minimize public exposure, and meeting baseline Program plans to choose landing sites along a common corridor.

East and West coast flight operations and landing sites were also investigated. Potential coastal operations sites were the John F. Kennedy Space Center (KSC), Florida, and Vandenberg Air Force Base (VAFB), California. For both of these landing sites, the X-33 would have to fly over extensive U.S. territories with dense populations. Trajectories entirely over water would require landing the X-33 at non-U.S. territories which was highly undesirable due to the need for protection of unique U.S. technologies and the uncertainty of international negotiations. For VAFB, the longest over-water flight corridor that could be accommodated within U.S. territories was approximately 320 km (200 mi).

In Southern California, Bicycle Lake on Ft. Irwin, Three Sisters Lake, and Cuddeback Lake were considered for short-range landing sites. Bicycle Lake was eliminated due to significant surface preparation required to render the lake bed suitable for landing, and the latter two lake beds were too close to Edwards. Silver Lake southwest of Silurian Lake was considered, but eliminated because most of it has been Congressionally designated as a Wilderness Study Area (WSA). Surface disturbing uses of the magnitude proposed for the X-33 landing and recovery operations would not be authorized in the WSA. The Bonneville Salt Flats near Wendover, Nevada, was considered as a mid-range landing site, but was eliminated because of reduced distances to airspace boundaries as compared to the Michael Army Air Field. Glasgow, Montana, was considered as a long-range landing site, but eliminated because the X-33 would not be capable of gliding the distance between Edwards and Glasgow.

2.2.6 Preferred Alternatives

The preferred launch site is Haystack Butte due to lower risks to personnel and the public than Space Port 2000. The preferred landing site alternatives are Silurian Lake for short-range flights; Dugway Proving Ground for mid-range flights; and Malmstrom Air Force Base for long-range flights. These alternatives are preferred because technical and safety analyses indicate that these areas and airfields are within optimal ranges, afford incremental test flight capability along a common corridor, and are expected to meet risk guidelines. Silurian Lake and Malmstrom's risk assessments project lower risk to base personnel and the public than respective alternatives. The current X-33 design lacks performance capability to overcome required maneuvering and maintain sufficient energy to acheive safe landing at Moses Lake. Dugway affords flight testing of the X-33 at lower minimum speeds which would be required for the X-33 to acheive landing at a long range site. The X-33 program prefers mid-range flights to Dugway to minimize initial stresses on the X-33 while obtaining valuable flight test data. Neither the preferred launch site nor preferred landing sites exhibit major environmental or socioeconomic drawbacks when compared to the other reasonable alternatives.

2.2.7 Preferred Flight Test Plan

The X-33 Program is considering three flight test plan options based on the use of the preferred alternatives. The environmental analyses and impact projections, including safety analyses, would remain unchanged regardless of which flight test plan option is used. Launch, landing , and safety approval authorities, as indicated in Section 4.3, must be satisfied through sufficient ground testing of the vehicle's critical components and systems that the vehicle and its flight termination system would perform within design specifications. Flight test options include a baseline total of 15 flights. Actual flights to each landing site may vary from those indicated below depending on data evaluation following each flight. The options are as follows:

Flight Test Options	Landing Site	Baseline Flight Number
1 (Baseline)	Silurian Lake	3
	Dugway	7
	Malmstrom	5
2	Silurian Lake	3
	Malmstrom	12
3	Dugway	10
	Malmstrom	5

The preferred flight test plan is option 3. For short range flights, current analyses indicate that modifications to the vehicle would be required due to the low weight of the propellants at lift off. These modifications would lower the maximum performance capability of the X-33, precluding

Mach 15 flights and causing the Program to not meet ultimate test objectives. If approving authorites impose requirements on the X-33 Program that are not addressed in this EIS as a result of selecting a flight test plan option other than number 1 above, environmental impacts would be re-evaluated and environmental documentation prepared, as appropriate.

2.3 Comparison of Environmental Impacts

Potential environmental effects of X-33 test flight activities at each alternative site are described in detail in Section 4. A summary comparison of influencing factors and environmental impacts on each resource potentially affected by the Proposed Action is presented in Tables 2-7, 2-8, and 2-9. Since no direct and immediate environmental impacts are expected for the No Action alternative, a separate column identifying the No Action alternative's impacts is not included.

Table 2-7. Summary of Environmental Impacts: Launch Site Alternatives within Edwards Air Force Base.

Issues	Proposed Launch Site Alternatives	
	Haystack Butte	Space Port 2000
Utilities and Infrastructure	Increase in demands on utilities and services is minimal compared to existing capacities of these systems. Extensions of existing systems would be developed, however, no new systems would be needed to service this site.	Increase in demands on utilities and services is minimal compared to existing capacities of these systems. Extensions of existing systems would be developed, however, no new systems would be needed to service this site.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. Minimal impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. Minimal impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Minimal impact to existing airspace due to its location within R-2508. Lowest risk to personnel and public from launch and powered flight.	Minimal impact to existing airspace due to its location within R-2508. Slightly higher risk to personnel and public in powered mode than Haystack Butte.
Biological Resources	Site preparation activities will impact 19 ha (47 ac) of Joshua tree woodland and creosote bush scrub. This area represents less than 0.1% of these habitats on Edwards. Impacts would be minimal.	Site preparation activities will impact 9.3 ha (23 ac) of halophytic phase saltbush scrub. This area represents less than 0.1% of this habitat on Edwards. Impacts would be minimal.
Threatened, Endangered and Sensitive Species	Part of launch site is within critical habitat for the desert tortoise. Approximately 15 to 20 individual tortoises could be affected. Mitigation measures would reduce impacts.	Launch site not within critical habitat. Impacts to desert tortoise are unlikely.
Cultural Resources	No eligible archeological sites located within project area. Several sites located within close proximity will be protected. No impacts expected.	One archeological site located within the project boundary will be mitigated by appropriate measures if required.
Water Resources	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.
Geology and Soils	Minimal impacts to soils from earth moving and related activities. No impacts to geological features expected.	Minimal impacts to soils from earth moving and related activities. No impacts to geological features expected.

Table 2-7. Summary of Environmental Impacts: Launch Site Alternatives within Edwards Air Force Base (Continued).

	Proposed Launch Site Alternatives	
Issues	**Haystack Butte**	**Space Port 2000**
Health and Safety	Unexploded ordinance from previous activities must be removed. Base has appropriately trained personnel to perform this function; therefore, no impacts to safety are expected. Based on the relatively small amounts and proven track record for the industry, transportation of LH_2/LOX on public and Base transportation routes are not expected to impact transportation safety. This site poses minimal debris hazard due to early flight not being over facilities or populations.	This site has not been used as a test or training site for ordnance; therefore, no safety issues expected. Based on the relatively small amounts and proven track record for the industry, transportation of LH_2/LOX on public and Base transportation routes are not expected to impact transportation safety. Liftoff trajectories from this site may present debris hazards to some Edwards' facilities from potential breakup of the X-33 during launch and early flight. No personnel would be at risk due to clearing of all personnel to safe distances.
Operational Noise	Normal, non-flight operations would be similar to existing Base operations; therefore, no impacts are expected.	Normal, non-flight operations would be similar to existing Base operations; therefore, no impacts are expected.
Transportation	No off-site ground transportation corridors would be affected either through modification or increased usage or closure. On-site systems could be affected during road modifications or vehicle towing operations.	No off-site ground transportation corridors would be affected either through modification or increased usage or closure. On-site systems could be affected during vehicle towing operations.
Population and Employment	Short-term increase of relatively small number of workers would produce minimal positive impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal positive impacts on local economy.
Land Use	Land use change for this area from undisturbed to operational is considered within the overall mission of the Base.	Land use change for this area from undisturbed to operational is considered within the overall mission of the Base.
Snow Avalanche	No impacts expected.	No impacts expected.
Flight Noise and Sonic Booms	Operational and liftoff noise will be minimal. Minimal impacts from sonic booms may occur in the form of cracked windows.	Operational and liftoff noise will be minimal. Minimal impacts from sonic booms may occur in the form of cracked windows.
Flight Safety	Flight trajectories have been carefully selected, resulting in expected risk factors being well under Edwards' criteria established as safe. Therefore, safety impacts are expected to be minimal.	Flight trajectories have been carefully selected, resulting in expected risk factors being well under Edwards' criteria established as safe. Therefore, safety impacts are expected to be minimal.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

Table 2-8. Summary of Environmental Impacts: Short-Range Landing Site Alternatives.

Issues	Proposed Short-Range Landing Site Aternatives	
	Silurian Lake	China Lake
Infrastructure	There are no facilities at this site; therefore, all equipment will be temporary. No long-term impacts are expected.	No modifications to infrastructure required; existing systems can accommodate Program needs.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Airspace impacts are expected to be minimal since the majority of the trajectory is in R-2508 airspace. A special use permit for 1.5 to 4 hours restricted airspace during reentry and landing would have minimal effect on general aviation.	Airspace impacts are expected to be minimal since the trajectory is in R-2508 airspace and ascent and descent would be in military restricted airspace. Impact on general aviation is expected to be minimal.
Biological Resources	Landing activities will occur on lake bed which is essentially devoid of vegetation and wildlife. Support activities will include loss of scrub habitat. Minimal impacts expected.	No impacts expected because no facility construction or modifications needed
Threatened, Endangered and Sensitive Species	Impacts to desert tortoise are expected to be minimal.	No species are expected to be adversely affected.
Cultural Resources	No properties are expected to be affected.	No properties are expected to be affected.
Water Resources	No impacts to water resources expected.	No impacts to water resources expected.
Geology and Soils	Minimal impacts to soils from staging area preparation and related activities. No impacts to geological features expected.	No impacts to geology or soils are expected because no construction is required.
Health and Safety	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.
Operational Noise	Non-flight operations are expected to produce minimal impacts due to the lack of noise receptors.	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.
Transportation	State Highway 127 would be closed for up to 4 hours 1 to 3 times during the early portion of the flight program. Impacts would be mitigated through advance notices and coordination with appropriate state agencies and are therefore expected to be moderate.	No impacts to on-site or off-site transportation systems are expected.
Population and Employment	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.
Land Use	The lake bed is classified as a BLM Multiple-Use I (intensive use) area. Therefore, the use of the lake bed as a landing area would represent minimal impact.	Base is considered to support similar activities; therefore, no impact

Table 2-8. Summary of Environmental Impacts: Short-Range Landing Site Alternatives (Continued).

Issues	Proposed Short-Range Landing Site Aternatives	
	Silurian Lake	China Lake
Snow Avalanche	No impacts expected.	No impacts expected.
Flight Noise and Sonic Booms	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.
Flight Safety	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

Table 2-9. Summary of Environmental Impacts: Mid- and Long-Range Landing Site Alternatives.

	Proposed Mid- and Long-Range Landing Site Alternatives		
Issues	**Dugway**	**Malmstrom**	**Moses Lake**
Infrastructure	No modifications to infrastructure required; existing systems can accommodate Program needs.	Runway maintenance and restoration of flight support or placement of mobile equipment would be required.	No modifications to infrastructure required; existing systems can accommodate Program needs.
Hazardous Materials and Waste	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.	Materials used and wastes produced are relatively small and can be handled by existing management systems. No impacts expected.
Air Quality	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.	Emissions will be below *de minimis* levels for all criteria pollutants.
Airspace and Air Traffic	Minimal impact to airspace is expected because descent and landing are all within restricted airspace.	Moderate impact to airspace and air traffic is expected due to temporary restriction of all aircraft from airspace within a 19.2 km (12 mi) by 33.6 km (21 mi) area of the landing site for 1 to 2.5 hours.	Moderate impact to airspace and air traffic is expected due to temporary restriction of all aircraft from airspace within a 19.2-km (12 mi) by 33.6 km (21 mi) area of the landing site for 1 to 2.5 hours.
Biological Resources	No impacts expected because no facility construction or modifications needed.	No impacts expected because no facility construction or modifications needed.	No impacts expected because no facility construction or modifications needed.
Threatened, Endangered and Sensitive Species	No species are expected to be adversely affected.	No species are expected to be adversely affected.	No species are expected to be adversely affected.
Cultural Resources	No properties are expected to be affected.	No properties are expected to be affected.	No properties are expected to be affected.
Water Resources	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.	Minimal impacts to water resources expected.
Geology and Soils	No impacts to geology or soils are expected because no construction is required.	No impacts to geology or soils are expected because no construction is required.	No impacts to geology or soils are expected because no construction is required.
Health and Safety	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.	Minimal impact is expected due to landing with only residual LH_2 and LOX.
Operational Noise	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.	Non-flight operations would be similar to existing Base operations; therefore, minimal impacts are expected.	Non-flight operations would be similar to existing operations; therefore, minimal impacts are expected.

Table 2-9. Summary of Environmental Impacts: Mid- and Long-Range Landing Site Alternatives (Continued).

	Proposed Mid- and Long-Range Landing Site Alternatives		
Issues	**Dugway**	**Malmstrom**	**Moses Lake**
Transportation	Minimal impacts to on-site or off-site transportation systems are expected.	Minimal impacts to on-site or off-site transportation systems are expected.	Minimal impacts to on-site or off-site transportation systems are expected.
Population and Employment	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.	Short-term increase of relatively small number of workers would produce minimal impacts on local economy.
Land Use	Base is considered to support similar activities; therefore no impact.	Base is considered to support similar activities; therefore no impact.	Site is considered to support similar activities; therefore no impact.
Snow Avalanche	No impacts expected.	No impacts expected. Launch time will be delayed if avalanche conditions exist under the flightline until standard avalanche control measures are conducted.	No impacts expected. Launch time will be delayed if avalanche conditions exist under the flightline until standard avalanche control measures are conducted.
Flight Noise and Sonic Booms	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.	Minimal impacts are expected from sonic booms along the length of the trajectory.
Flight Safety	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.	Minimal to no impacts are expected due to established Range Safety criteria which must be met prior to launch approval. The X-33 will land in unpowered mode.
Environmental Justice	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.	No highly disproportionate impacts to minority or low-income populations are expected from on-site operations or flight operations.

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENTS

3.1 Proposed Launch Sites Within Edwards Air Force Base

There are two reasonable alternative sites on Edwards available for preparation and operation of launch facilities for the X-33 spaceplane. These sites are Space Port 2000 and Haystack Butte (Figure 3-1). As the environments associated with these sites are very similar in character, they are discussed collectively below. Major differences or specific issues between the sites will be highlighted within the text.

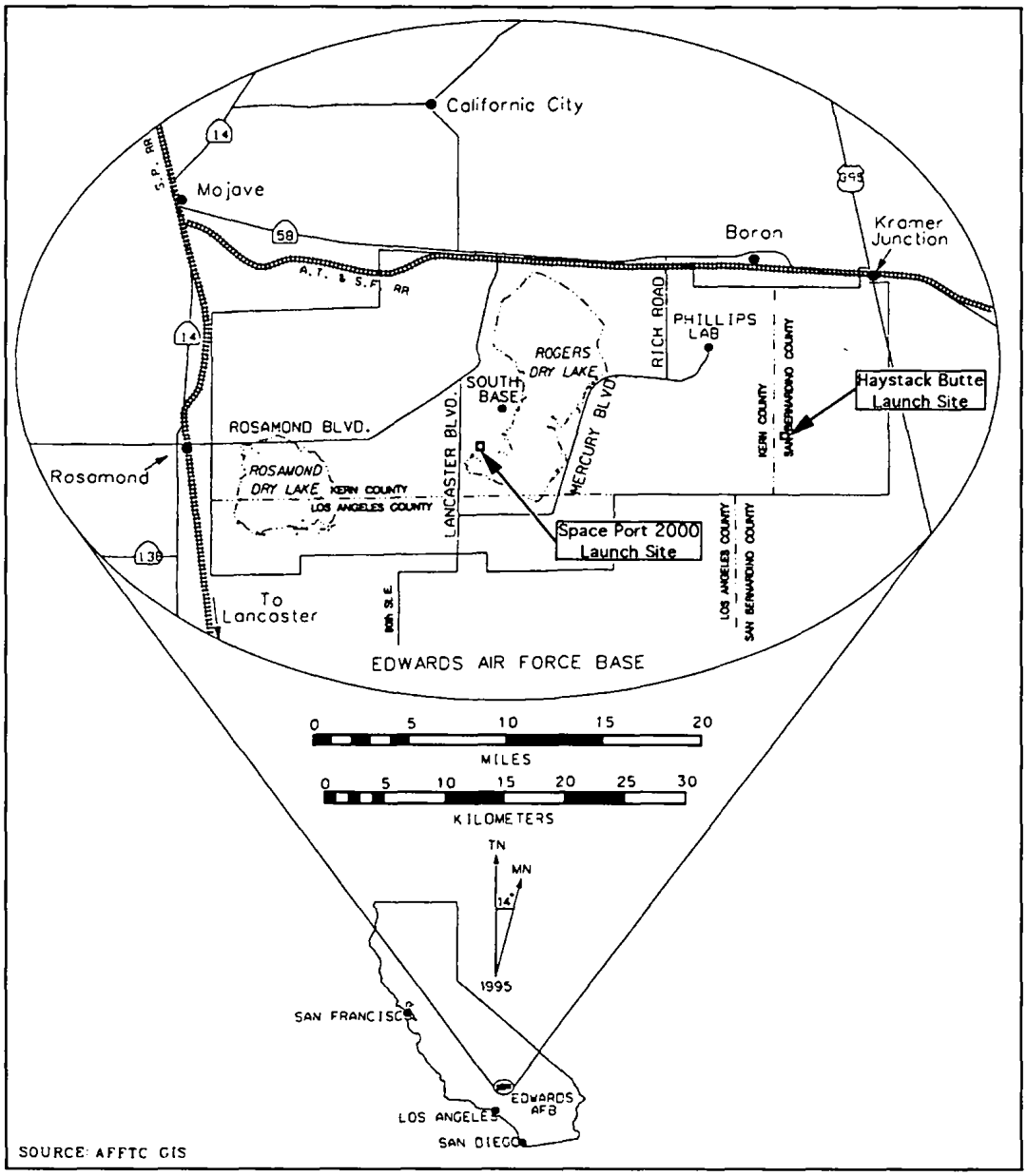


Figure 3-1. Two Alternative Launch Sites on Edwards.

3.1.1 Site Infrastructure

Runways

Edwards is served by 3 paved runways, 18 runways painted onto the Rogers and Rosamond Dry Lakes, and the remaining lake bed areas that are designated as emergency vehicular recovery landing sites. Principal landing areas for the base are the three paved runways with the Class B Main Base runway being the primary operational airstrip. Runways at North and South Bases are designated Class A and are used primarily for small, light aircraft. Class B runways accommodate heavy aircraft or have the potential by development to heavy aircraft use. Runway 4/22, the Main Base paved runway, is 91 m (300 ft) wide and 4,570 m (14,995 ft) long. The North Base runway, 6/24, is 46 m (150 ft) wide and 1,829 m (6,000 ft) long. The paved runway at South Base, also designated 6/24, is 15 m (50 ft) wide and 1,524 m (5,000 ft) long. Neither the North nor South Base runways can accommodate landing the X-33. Painted lake bed runways are used as emergency and practice landing areas only. Aircraft ground transport is accomplished through use of a network of taxiways, six of which are located along the Main Base flightline. Runway 4/22 would be used for X-33 return (EAFB 1994A).

Water Supply and Distribution

The Main Base, North Base, and South Base at Edwards are supplied with potable and non-potable water from the local groundwater supply through the use of on-base wells and from the purchase of state project water through a local distributor. Commercially supplied water comes to the base from the California state aqueduct through the local water purveyor, Antelope Valley-Eastern Kern County Water Agency (AVEK). AVEK purchases the state project water, then distributes and resells it to public and private agencies. Three on-base well fields, the North Base Well Field, South Base Well Field, and the South Track Well Field, provide potable water. Water is dispersed through an interconnected pipeline supply network (EAFB 1994A).

Non-potable water is supplied from the Graham Ranch Well Field. This water is principally used for irrigation purposes and is supplemented with potable well water. Since installation of the new wastewater treatment plant, a large portion of the irrigation water demand has been supplied from the treatment facility, thereby lessening demands on the groundwater supply (EAFB 1994A).

Three ground storage tanks at Main Family Housing and two at North Base provide a potable water storage capacity of 16.3 million L (4.3 million gal). Additional tanks located throughout the base are dedicated to fire suppression. A Corps of Engineers-Omaha study conducted in 1992 reported that the maximum capacity of the potable water system was 31.8 MLD (8.4 MGD). The South Base-South Track Well Field system provides 26.5 MLD (7.0 MGD) and the North Base system provides 5.3 MLD (1.4 MGD). Improvements to the southern well system, including two additional wells, a collection line, increased booster station capacity, and a new transmission line to the Main Family Housing storage tanks should increase the well water supply system capacity

by 15.9 MLD (4.2 MGD). With the addition of water from the northern well, when demands dictate, the peak capacity of the base system to supply potable water is 62.8 MLD (16.6 MGD) with an additional 16.3 million L (4.3 million gal) in storage (EAFB 1994A).

Water supply for the Phillips Laboratory area comes from the AVEK Water Agency, as described for the other portions of the base, and from the Phillips Laboratory Well Field. The Phillips Laboratory Well Field is composed of two sets of wells known as Mary's Wells and the Rocketdyne Wells. Together, these wells produce approximately 7.2 MLD (1.9 MGD). Water is first pumped to storage tanks with a total capacity of 2.3 million L (600,000 gal) and then to reservoir tanks which have a total capacity of 2 million L (525,000 gal). Only one of Mary's Wells is acceptable for use and its volume of 3.5 MLD (0.9 MGD) capacity is dedicated for domestic use, fire protection, and rocket deluge systems. The Rocketdyne Wells have a capacity of 3.8 MLD (1.0 MGD), are tied into the domestic water system and are also used for the rocket deluge systems (EAFB 1996C).

Wastewater

There are three individual sanitary sewer collection and treatment systems at Edwards, each serving the Main, South, and North Base areas, and Phillips Laboratory.

Recently, a new WWTP was constructed and came on line in mid 1996 to handle the peak effluent and additional capacity in the future. The new WWTP design capacity is 9.5 MLD (2.5 MGD). The existing collection system from the old WWTP network is composed of gravity lines, force mains, and pump stations. Portions of these are being used during the operation of the new WWTP and a new updated collection system has also been added. The new WWTP also discharges to evaporation ponds.

The remaining WWTP's are located at North Base and Phillips Laboratory. The North Base facility utilizes an inground Imhoff tank system, with effluent discharging directly into an evaporation pond. Components of the collection system include gravity lines, force mains and pump station. The Phillips Laboratory treatment plant is similar in design to the one at North Base with an Imhoff tank system. Both systems are sized to handle a limited area and are not readily expandable. In addition to an Imhoff tank, the plant includes seven unlined 0.2 ha (0.5 ac) evaporation ponds and three unlined drying beds. The Phillips Laboratory WWTP has a design capacity of 519,230 LPD (137,000 GPD) and provides primary treatment up to 189,500 LPD (50,000 GPD), which is approximately 37 percent of operating capacity. The Air Force is proposing to relocate and upgrade the Phillips Laboratory WWTP to secondary treatment levels. The upgraded facility would continue to treat industrial and domestic wastewater pursuant to the State of California Regional Water Quality Control Board criteria (EAFB 1996B).

Deluge water (if required for cooling water from testing) is collected after each Phillips Laboratory test. The water is recycled, evaporated, or tested and approved for discharge onsite in accordance with the California Water Resources Control Board, Lahontan District (Burrell

1997). Following evaporation, the resultant sludge (containing some hazardous materials) is removed and transported as hazardous waste to an approved off-base site. Deluge water is not pre-treated or taken to the Phillips Laboratory WWTP because of the unknown reactions that could occur when wastewater mixes with the WWTP process.

Electricity

Southern California Edison (SCE) provides electricity to Edwards. Edison transforms the voltage to 34.5 kilovolt (kV) and delivers it to the base where it is distributed to the Main and South Base areas and Phillips Laboratory area at 34.5 and 12.47 kV. SCE serves Edwards through its 115 kV transmission system. The 115 kV line enters the North Base where it serves two 115/34 kV substations. The line is then carried on wood poles to the South Base area where it feeds a 25 megavolt-ampere (MVA), 115/34 kV substation. This line is conservatively rated at 480 amps or 95.6 MVA (EAFB 1994A).

The peak demand at Edwards is less than 40 MVA; therefore, the present SCE line can feed over twice the present requirement. SCE will enlarge its facilities to meet any future needs (EAFB 1994A).

Communications

Electronic support at Edwards is provided by Command, Control, Communications, and Computer Systems. The Air Force Flight Test Center (AFFTC) Telecommunications Facility and Distribution System supplies telephone services, voice mail, Defense Switch Network, and Federal Telephone Service (FTS 2000). It is connected with an 81 km (50 mi), 48-strand, single-mode fiberoptic loop. All AFFTC core facilities, North Base, South Base, and Phillips Laboratory are connected to the fiberoptic ring. Only 4 strands are required to support the telephone system, leaving 44 strands available for computer networking and future growth. The land mobile radio system is a trunked system. A state-of-the-art computer controlled, ultrahigh frequency network allows over-the-air net customizing that enables users to change who they are talking to and who can listen to their transmission. The system is also Digital Encryption Standard compatible. The Air Traffic Control and Landing System and meteorological systems provide users with ground-based flight navigational systems which receive and transmit flight safety information to air and ground-to-ground radio equipment (EAFB 1994A).

Fuel

Edwards liquid fuel system is comprised of the receiving, shipping and distribution of jet fuel, including JP-5, JP-7, JP-8, JP-10, mogas, unleaded gasoline, and diesel fuel. JP-8 jet fuel is the predominant form of liquid fuel utilized at Edwards. It is brought onto the base via a commercial pipeline, stored primarily in two large tank areas and dispensed to aircraft through either refueling vehicles or hydrant systems. It is then dispensed into refueling trucks which in turn are used to refuel aircraft or replenish local storage tanks.

JP-5, JP-7, JP-10, mogas, gasoline and diesel fuel, are stored in smaller tanks throughout the base and are brought in by tank trucks. An average of 10 to 20 tank trucks deliver fuel to Edwards daily. The Main Base Bulk Fuel Storage Facility contains three tanks for JP-7, each having a capacity of 1,271,760 L (336,000 gal). Jet fuels, other than JP-8, are dispensed primarily through the use of refueling trucks or local pumping facilities. Fuels such as the mogas, gasoline and diesel fuel are dispensed to the aircraft support vehicles and privately-owned vehicles at refueling stations.

Edwards does not currently use large quantities of liquid hydrogen (LH_2) or liquid oxygen (LOX). However, Phillips Laboratory is currently adding this capability as part of a new engine testing program, thereby, enhancing Edwards' operational handling of these cryogenic propellants

3.1.2 Hazardous Materials and Hazardous Waste

Edwards has established strict usage procedures for the management of hazardous materials and hazardous wastes. A Hazardous Materials Pharmacy allows Edwards' tenants to obtain hazardous materials from assigned on-base distribution centers. The pharmacy works with users to identify exact quantities required and appropriate substitutes. Unopened materials are returned to the pharmacy for subsequent users. A list of all hazardous chemicals, including appropriate Material Safety Data Sheets, is maintained by Environmental Management (EAFB 1997). Hazardous waste transported off the Main Base is disposed of through coordination AFFTC/EM. Most unknown samples are sent to Armstrong Laboratories at Brooks Air Force Base in Texas for analysis. A hazardous waste management plan was prepared and implemented to ensure compliance with the Resource Conservation and Recovery Act (RCRA). All personnel who manage or handle hazardous waste are required to receive annual safety and documentation protocol training, in addition to annual RCRA and hazard communication training (EAFB 1994B).

The base is currently operating as a large-quantity generator. Edwards generated approximately 10,256 kg (22,611 lb) of hazardous waste per month in 1992. Categories contributing over 87 percent of the hazardous waste stream were motor oil/lubricants (22.7 percent), hazardous material disposal (22.1 percent), waste fuel (21.2 percent), paints and solvents (11.1 percent), ethylene glycol (4.4 percent), installation restoration (3.5 percent), and hydraulic fluid (2.6 percent)(EAFB 1994B).

Individual organizations fund and manage their own waste minimization programs and initiatives. Current programs include solvent recovery from maintenance operations, cleaner substitutions, and solvent substitution. In 1992, Edwards recycled approximately 34,807 kg (76,735 lb) of waste each month. Waste fuel (75.2 percent) and hazardous material disposal (13.5

percent) contributed 90 percent of the recycled waste. Edwards also has an active Pollution Prevention Program managed by AFFTC/EM (EAFB 1994A).

The Installation Restoration Program (IRP) originated under the Department of Defense (DOD) to ensure compliance with Comprehensive Environmental Response Compensation and Liability Act regulations. The purpose of the IRP is to identify, characterize, and remediate environmental contamination at DOD installations. IRP sites are locations where investigations have been conducted and soil and groundwater contamination from leakage of underground and aboveground storage tanks containing hazardous fuels, heating oils, solvents, or other liquid waste chemicals have been confirmed. IRP sites are currently divided into areas referred to as operable units (OU's). The proposed project occurs in OU 2, OU 4, OU 7, and OU 9. Space Port 2000 site occurs in OU 2 while OU 4 is associated with the Phillips Laboratory area. The tow routes along Lancaster Boulevard, Avenue B, and Mercury Boulevard just prior to where the Phillips Laboratory entrance gate is located are associated with OU 7. Haystack Butte is associated with OU 9 (EAFB 1994B). Thus the Haystack Butte alternative involves OU 7 and OU 9; the Space Port 2000 option involves OU 2 and OU 9.

Potential Release Location 180, a catch basin, is associated with Test Area 1-56 in OU 9. This concrete catch basin is built into the northwestern slope of Haystack Butte, approximately 120 m (400 ft) north of Buildings 9800 and 9804. In the past, the catch basin had been used as an oxidation pond for sewage effluent from Building 9800. There are other pipes draining into the catch basin, but their origin is unknown. A proposed fiberoptic route beginning at the launch site would be trenched just east and within 31 m (100 ft) of Potential Release Location 180. The end point of the fiberoptic route is Building 9800.

In 1993, sediment sampling in the catch basin was performed, and analytical tests detected chloroform (0.0073 mg/kg) and tetrachloroethene (0.0070 mg/kg). Samples from boreholes around the catch basin detected petroleum hydrocarbons ranging from 21-33 mg/kg and cyanide at 2.7 mg/kg. Low concentrations of extractable hydrocarbons were detected at 0.9 to 1.5 m (3.0 to 5.0 ft) below ground surface. Cyanide detected at 1 m (3 ft) below ground surface is well below its industrial preliminary remediation goal of 14,000 mg/kg. Therefore, no further investigation of soils is recommended for Potential Release Location 180. Perchloroethylene was detected in the sediment sample taken from the catch basin. The sampling strategy according to the document, includes two rounds of sampling at 6-month intervals. To date, sampling of groundwater for contamination in the area surrounding Potential Release Location 180 has not been accomplished (EAFB 1996C).

Many of the structures on Edwards were constructed prior to enactment of current legislation regarding asbestos. The EPA and the State of California has established that any material containing more than 1 percent asbestos by weight is considered to be asbestos-containing material. Disturbance of regulated asbestos-containing material without the use of proper engineering controls or personal protective equipment, and which causes visible emissions is a violation of the *National Emission Standard for Hazardous Air Pollutants* (40 CFR 61,

Subpart M). According to 40 CFR 61.141, "friable asbestos material means any material containing more than 1 percent asbestos that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure."

An asbestos baseline survey was conducted in Buildings 9800 and 9804 in August 1996 (McLaughlin 1997). Baseline surveys are limited surveys only and serve a two-fold purpose: to identify to new tenants any asbestos containing material which may be present in a building, and to identify any friable asbestos in poor condition for prioritizing asbestos abatement. Baseline sampling results of Building 9800 revealed 5 percent chrysotile asbestos present in the pipe elbow insulation within the interior of the structure. Baseline sampling results of Building 9804 revealed 10 percent chrysotile asbestos in the pipe elbow insulation within the interior of the structure and 25 percent chrysotile present to the lagging jacket on the duct work on the exterior north side of the structure. However, the wallboard/joint compound on the interior walls, the wallboard/joint compound of ceiling tiles, and the 23 by 23 cm (9 by 9 in) floor tiles in Building 9800 and the wallboard/joint compound and the 23 by 23 cm (9 by 9 in) floor tile in Building 9804 were not sampled (McLaughlin 1997).

The U.S. banned the use of lead-based paint in residential homes in 1978. However, lead-based paints are not banned from industrial use. Because of the age of the buildings on Edwards, lead may be present on exterior or interior painted surfaces of structures on base. The EPA has established that paint, varnish, shellac, or other coatings on surfaces that contain more than 1.0 $\mu g/cm^3$ of lead or more than 0.5 percent lead by weight is considered lead-based paint. Lead-based paint becomes a health hazard when the paint is damaged, creating dust, chips, and/or fumes. Flat white exterior and interior paints are present in Building 9800. No lead-base paint surveys were conducted in Building 9800. No paint is present on the exterior or interior of Building 9804.

Polychlorinated biphenyls (PCB's) are a group of organic chemical mixtures historically used as insulators in electrical equipment such as transformers, switches, voltage regulators, capacitors, and pre-1976 fluorescent light ballasts due to their excellent cooling properties and low electrical conductivity, but they are no longer manufactured in the U.S. Some PCB's were also used in hydraulic and heat transfer fluids, paints, adhesives, caulking compounds, road covering sealant, and electrical equipment. PCB's range in consistency from heavy, oily liquids to waxy solids and are extremely toxic and hazardous to human health and the environment. The Air Force Materiel Command has established a "PCB-free" date of December 31, 1998, for all Air Force facilities. The Exterior Electric Shop (95 CES/CEQUEE) manages transformer repair, including tests to determine the PCB content of transformers, and keeps an inventory of PCB-filled electrical equipment. At Edwards, a fluorescent light ballast is considered to contain PCB unless it is specifically marked "non-PCB."

Three transformer units containing PCB's are present outside Building 9804. There is no evidence of leaking or damage to the transformers; however, they are scheduled for removal in 1997.

3.1.3 Solid Waste

The USAF owns and operates a landfill on base that is used for the disposal of non-hazardous solid waste. Private contractors provide solid waste collection services. The Main Base Landfill is active and located approximately 2.1 km (1.3 mi) north of the Base Family Housing area and northeast of Mojave Boulevard. It is a permitted Class III landfill accepting non-liquid, non-hazardous wastes including residential, construction/demolition, commercial, and industrial. It is owned and operated by the USAF and is not open to the public. The principal areas contributing solid waste to this landfill are the Main Base, South Base, and North Base, Dryden, and Phillips Laboratory. A recycling center with both recycling and salvaging operations is located separately from the Main Base Landfill. It is operated by Civil Engineering contract personnel. Materials recycled at the center include newspapers, magazines, shredded high grade white paper, high density polyethylene plastic, clear and colored glass, and ferrous and non-ferrous metals (EAFB 1994A).

A study conducted in December 1991 found that Main Base Landfill was accepting approximately 51 metric tons (56 tons) per weekday or 13,152 metric tons (14,500 tons) per year of solid waste (EAFB 1994A). Approximately 1,633 metric tons (1,800 tons) of recyclable materials were being recovered. Solid waste generated at Edwards includes an estimated 7,437 metric tons (8,200 tons) of residential and commercial waste, 5,779 metric tons (6,370 tons) of construction/demolition waste, and 14 metric tons (15 tons) of household hazardous waste per year.

3.1.4 Climate

Summers in the Antelope Valley are hot and dry, while winters are mild and humid. Ninety percent of the annual average precipitation (12.55 cm (4.94 in)) occurs from November through April.

July is the warmest summer month, while January and February are the coolest months. Average monthly high temperatures range from 42.4° C (108° F) in July to 13.8° C (57° F) in January. Average monthly low temperatures range from about 26.7° C (80° F) in July to about 4.4° C (40° F) in January. An average of 36 days per year have temperatures exceeding 37.3° C (100° F) (EAFB 1994A).

The relative humidity in summer is very low, averaging 30 to 50 percent in the early morning and 10 to 20 percent during the late afternoon. These conditions promote intense heating during the day in summer and marked cooling at night. The intense solar radiation in the summer is highly conducive to photochemical formation of ozone and other oxidants in the atmosphere. The prevailing wind direction at Edwards throughout the year is west-southwest to southwest (Figure 3-2). The average annual wind speed is approximately 13 km/hr (8 mi/hr). The highest average wind speeds occur during the spring and summer, and the lowest during the winter (EAFB 1994A).

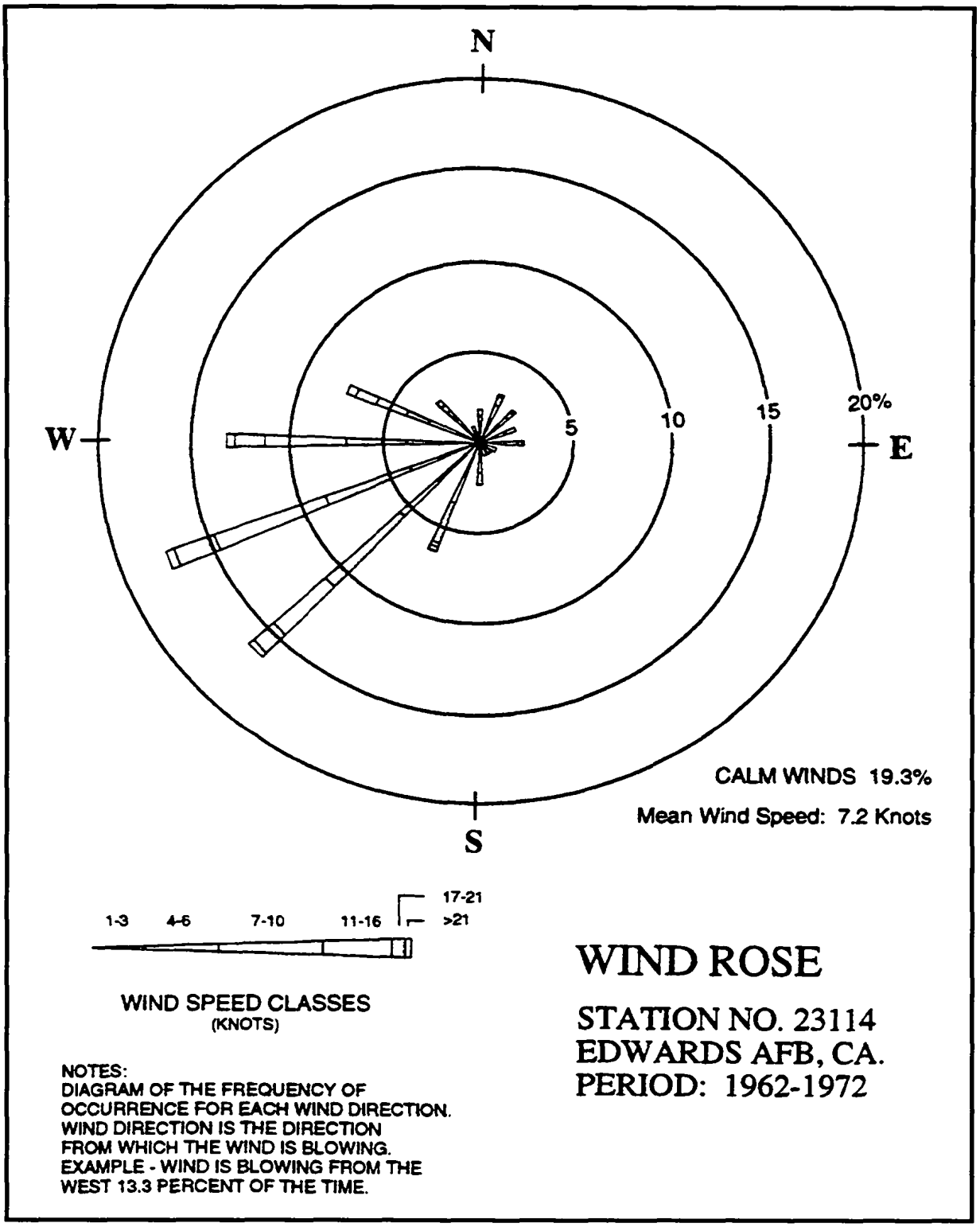


Figure 3-2. Wind Rose for Edwards.

3.1.5 Air Quality

Federal and state air quality regulations for Edwards are delegated to and enforced by three regional air quality management or air pollution control districts (APCD's): Kern County Air Pollution Control District (KCAPCD), Mojave Desert Air Quality Management District (MDAQMD), and Antelope Valley Air Pollution Control District (AVAPCD). The KCAPCD has jurisdiction over the portion of Edwards located in Kern County. The MDAQMD has jurisdiction over the portion of Edwards location in San Bernardino County. The AVAPCD has jurisdiction over the portion of Edwards located in Los Angeles County. The boundaries of these three APCD's are shown in Figure 3-3.

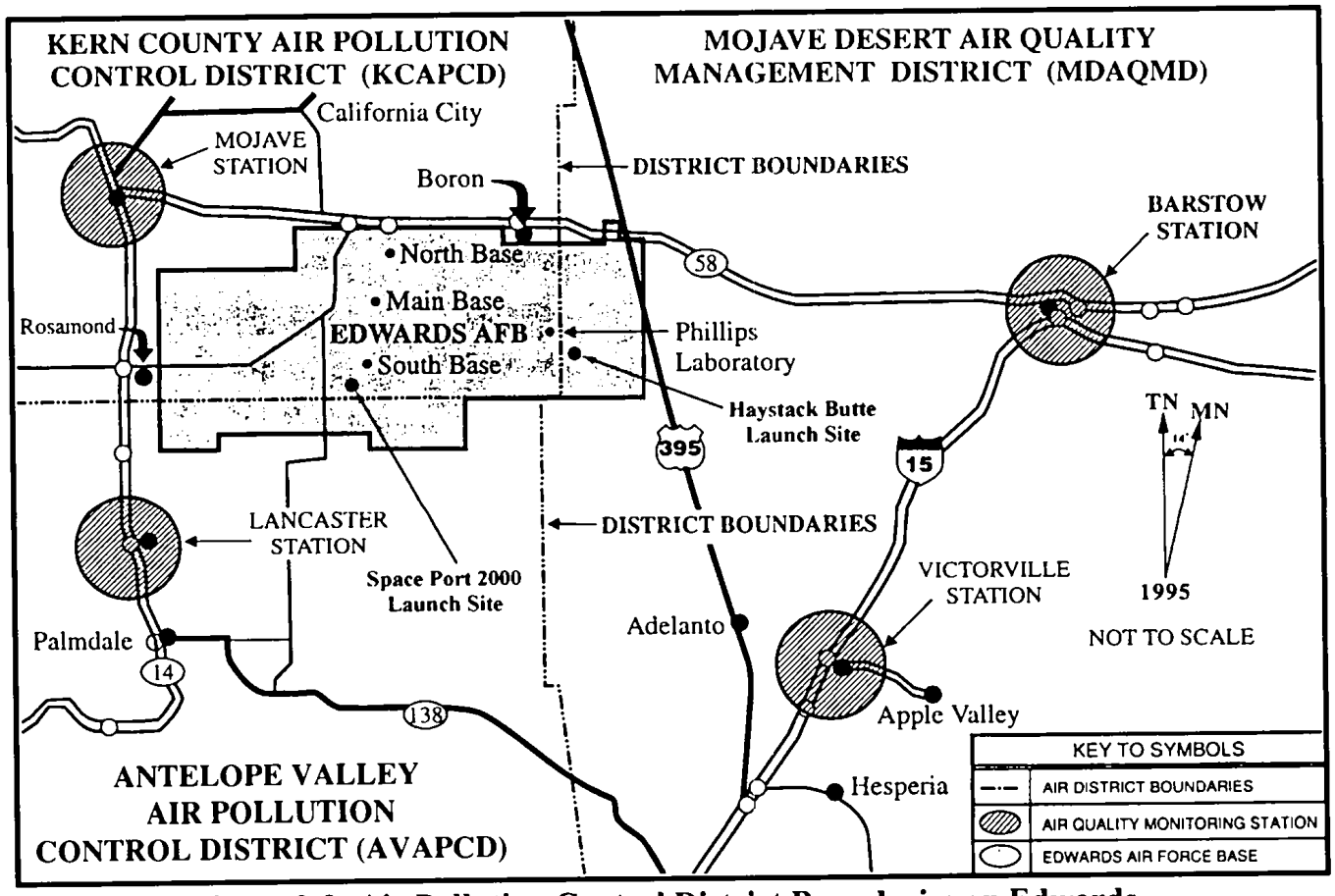


Figure 3-3. Air Pollution Control District Boundaries on Edwards.

The alternative Haystack Butte launch site is located in the MDAQMD, which enforces the federal and state air quality regulations that limit allowable emission levels for particulate matter smaller than 10 microns (PM_{10}), ozone (O_3) precursor compounds (oxides of nitrogen (NO_X) and volatile organic compounds), carbon monoxide, sulfur dioxide, and other substances. This area is considered a *Severe 17* (17 years to attain) federal non-attainment for O_3. The *de minimis* emissions level set for general conformity analysis of O_3 precursor pollutants per year per action

is 23 metric tons (25 tons). The PM_{10} *de minimis* level for this area is due to 91 metric tons (100 tons) per year per action for areas of "moderate" federal non-attainment status.

The KCAPCD portion of Edwards at the alternative Space Port 2000 launch site is located in a federal "serious" non-attainment area for O_3 precursor pollutants and is classified as a federal attainment area for PM_{10}. In a "serious" non-attainment area the conformity *de minimis* level is 40 metric tons (50 tons).

Return of the X-33 from a test flight would utilize the Edwards' main runway, located in Kern County, which is designated serious non-attainment for O_3. The impacts are addressed in Section 4.0.

Ambient concentrations for areas around Edwards are given in Table 3-1.

Table 3-1. National Ambient Air Quality Standards (NAAQS) and Local Monitoring Data.

Pollutant	Averaging Time	NAAQS µg/m³ (ppm)		Maximum Observed Concentrations by Monitoring Location µg/m³ (ppm)		
				Haystack Butte	Space Port 2000	
		Primary	Secondary	(Barstow)	(Mojave)	(Lancaster)
SO_2	24 Hour	365 (0.14)	None	nm	nm	nm
	3 Hour	None	1310 (0.5)	nm	nm	nm
	annual	80 (0.03)	None	nm	nm	nm
NO_2	annual	100 (0.053)	100 (0.053)	240 (0.12)	240 (0.12)	280 (0.14)
CO	8 Hour	10 (9) mg/m³	None	2.3 (1.98) mg/m³	nm	nm
	1 Hour	40 (35) mg/m³	None	6.9 (6.1) mg/m³	nm	nm
PM_{10}	24 Hour	150	150	116	43	61
	annual	50	50	28.73	nm	nm
Lead	quarterly	1.5	1.5	nm	nm	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	236 (0.12)	236 (0.12)	275 (0.14)

NAAQS are as listed in 40 CFR, Part 50.
1995 Monitoring Data presented.
nm = not monitored.

Because visibility degradation adversely affects flight and test operations, visibility in the Mojave Desert is of concern to Edwards. A decrease in visibility in the desert areas has been occurring since the 1940's. Visibility degradation has resulted in concern at desert military test centers that additional reduction in visibility could cause adverse effects on their operations. DOD conducted an extensive air quality study called Research on Operations Limiting Visual Extinction from 1983 to 1986. Results indicated that on good visibility days, visibility ranged from about 145 km (90 mi) to over 161 km (100 mi), while on poor visibility days, visibility ranged from 43 to 60 km (27 to 37 mi). On average, the single most significant source of visibility degradation in the Mojave Desert was manmade aerosols that were transported from the San Joaquin Valley. These aerosols accounted for about one-half the visibility reduction. Continuing long-term trend analysis indicates visibility degradation has been halted due to enforcement of San Joaquin Valley air pollution regulations. In the Edwards' area, aerosol

contributions from the Los Angeles basin were also significant. On the lowest visibility days, aerosol transport from the Los Angeles basin appeared to be more significant than transport from the San Joaquin Valley (EAFB 1994A).

Air quality monitoring stations are located at six sites in the Mojave MDAQMD. In 1993 there were two exceedences of the federal O_3 standards. In 1994 and 1995, no federal exceedences occurred. Only the state standard was exceeded for O_3 in both 1994 and 1995. Stationary (or point) sources for air pollutants are regulated by the KCAPCD. APCD's require a permit to build a new or modified stationary source. Mobile (or non-point) source emissions, such as automobiles or rockets, are not directly regulated by MDAQMD or KCAPCD, and permits are not required (EAFB 1994A).

3.1.6 Airspace and Air Traffic

Airspace is defined dimensionally by limitations describing its height, depth, width, and period of use (time). Changes in airspace usage such as activity intensity (few flights versus numerous flights), altitudes (low-level versus high-level) and speeds (subsonic versus supersonic) can affect other resource areas (noise and/or health and safety) or limit airspace availability to other users. The Department of Transportation, Federal Aviation Administration (FAA), is charged with overall management of airspace and has established certain criteria and limits for use of various sectors of the airspace.

Restricted airspace subjects some or all aircraft to air traffic control, and confines certain flight activities, entry and cautions of other aircraft operating within specific boundaries. Specific permission is required from the controlling agency to penetrate active restricted areas.

Military Operating Areas (MOA's) are established outside Class A airspace area (below 5,500 m (18,000 ft)) to separate and segregate certain nonhazardous military activities from instrument flight rules (IFR) traffic. MOA's are identified by marking on appropriate aeronautical charts and are open to aircraft operating under visual flight rules (VFR). They are used to conduct training activities such as air combat maneuvers, air intercepts, aerobatics, low-altitude tactics and other military specific activities.

The X-33 would be delivered from the Lockheed Martin Skunk Works Manufacturing Facility in Palmdale, California, near Air Force Plant 42 which serves as the Palmdale Regional Airport under a Joint Use Agreement with the Los Angeles Department of Airports. The X-33 would be air ferried by the Boeing 747 Space Shuttle Carrier Aircraft. The Palmdale Regional Airport comprises 22 ha (54 ac) of AF Plant 42 and offers commercial air travel capabilities to Antelope Valley. This airport also provides an alternative to Ontario and Los Angeles airports. Existing runways at Edwards and AF Plant 42 would be used for carrier aircraft return of the X-33 spaceplane (USAF 1992A). This operation would be conducted under authority of the FAA and AFFTC, Edwards.

All X-33 flight paths would originate within the R-2515 military restricted airspace of Edwards. Edwards is a member user of the R-2508 Airspace Complex shown in Figure 3-4. This airspace is over 51,800 sq km (20,000 sq mi) in area, and reaches from the Western Mojave Desert to the Southern Sierra Nevada Desert. There are two supersonic corridors (one high altitude and one low-level) and four spin test facilities within the Test Range airspace. This airspace also contains a Precision Impact Range Area that is divided into the east, west, and PB-6 ranges. A precision bombing circle and an air-to-ground rocket range are contained in the east range. The west range has six precision bombing circles and an air-to-ground gunnery, bombing, and rocket range. The PB-6 range is used for rescue helicopter gunfire (EAFB 1994A). All airfield facilities at Edwards are governed by regulations established for the operation of military airfields contained in Air Force Regulation 86-14 titled *Airfield and Heliport Planning Criteria*.

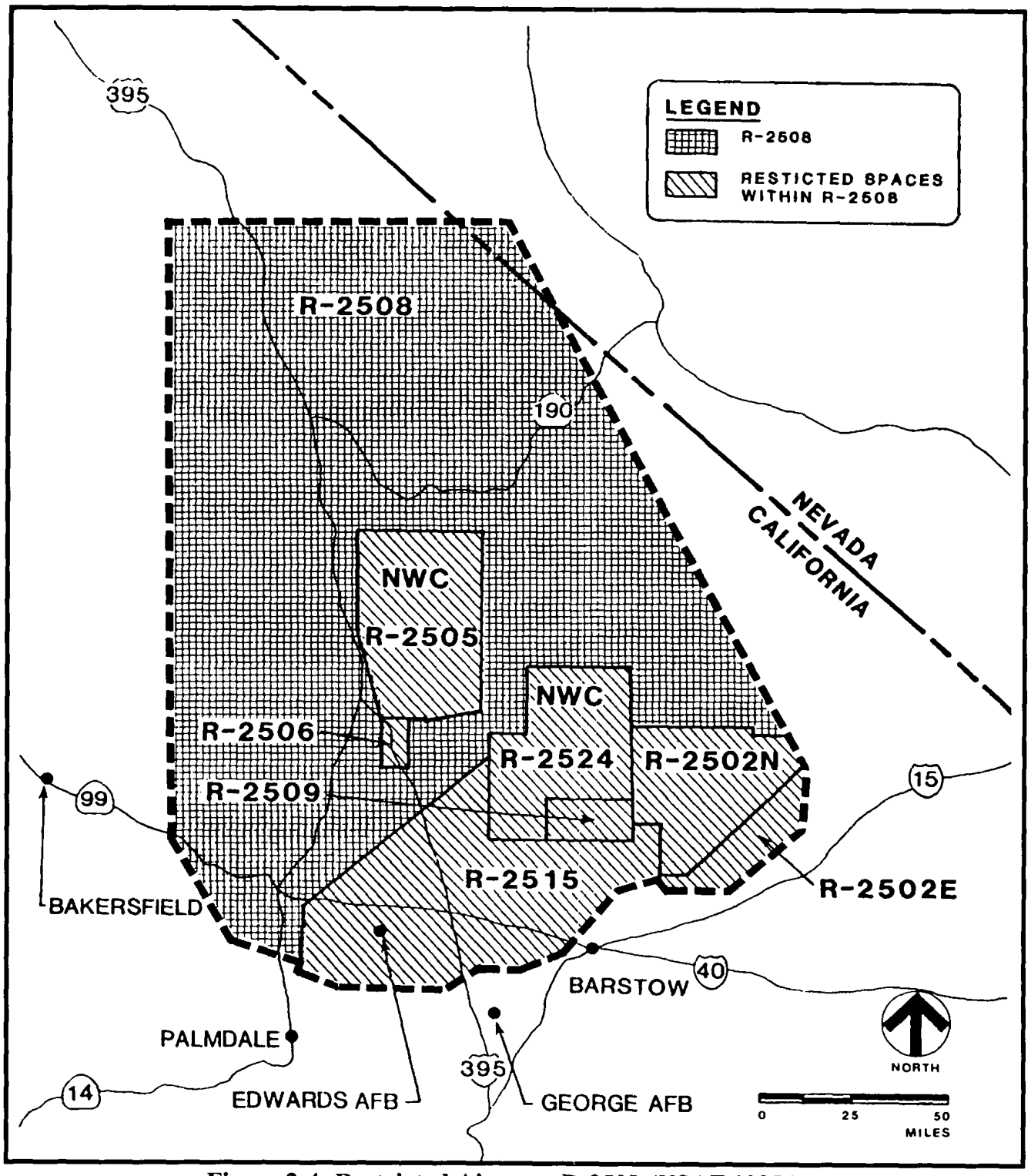


Figure 3-4 Restricted Airspace R-2508 (USAF 1995A).

The R-2508 Complex airspace is a tri-service test complex of restricted airspaces in the upper Mojave desert and is used by DOD for the advancement of weapons systems technology. The airspaces were established in 1955 to protect military flight activities. The R-2508 Complex is roughly 320 km (200 mi) long by 177 km (110 mi) wide. The land below the airspace ranges in elevation from 86 m (282 ft) below mean sea level (MSL) at Death Valley to 4,418 m (14,495 ft) MSL at Mount Whitney. The R-2508 Complex includes all the land and airspace managed by three major military installations in the upper Mojave Desert: (1) China Lake Naval Air Weapons Station, (2) the Air Force Flight Test Center at Edwards, and (3) Fort Irwin National Training Center. In addition to the restricted airspaces, Military Operating Areas (MOAs) and Air Traffic Control Assigned Airspace Areas are designated on Figures 3-5 and 3-6. Within the R-2508 Complex, general aviation aircraft are permitted to operate under visual flight rules without restriction under 5,500 m (18,000 ft). Instrument flight rule traffic is kept out of these areas unless standard separation can be provided from any military activity. Military aircraft operate on a see-and-avoid basis under an air traffic control clearance in these areas. Restricted areas R-2502N, R-2502E, R-2505, R-2506, and R-2515 may be used to provide complete segregation of military air activities at all levels. A complete listing of restrictions imposed on civil aviation within the restricted airspace sectors and MOA's of the R-2508 Complex are provided in Tables 3-2 and 3-3, respectively. All test flights of the X-33 are proposed to originate from either Haystack Butte or Space Port 2000; therefore, the AFFTC would coordinate all use of range space within R-2508 as well as all other intervening airspace under the authority of other ranges or the FAA, as described in sections concerning landing sites (USAF 1995A).

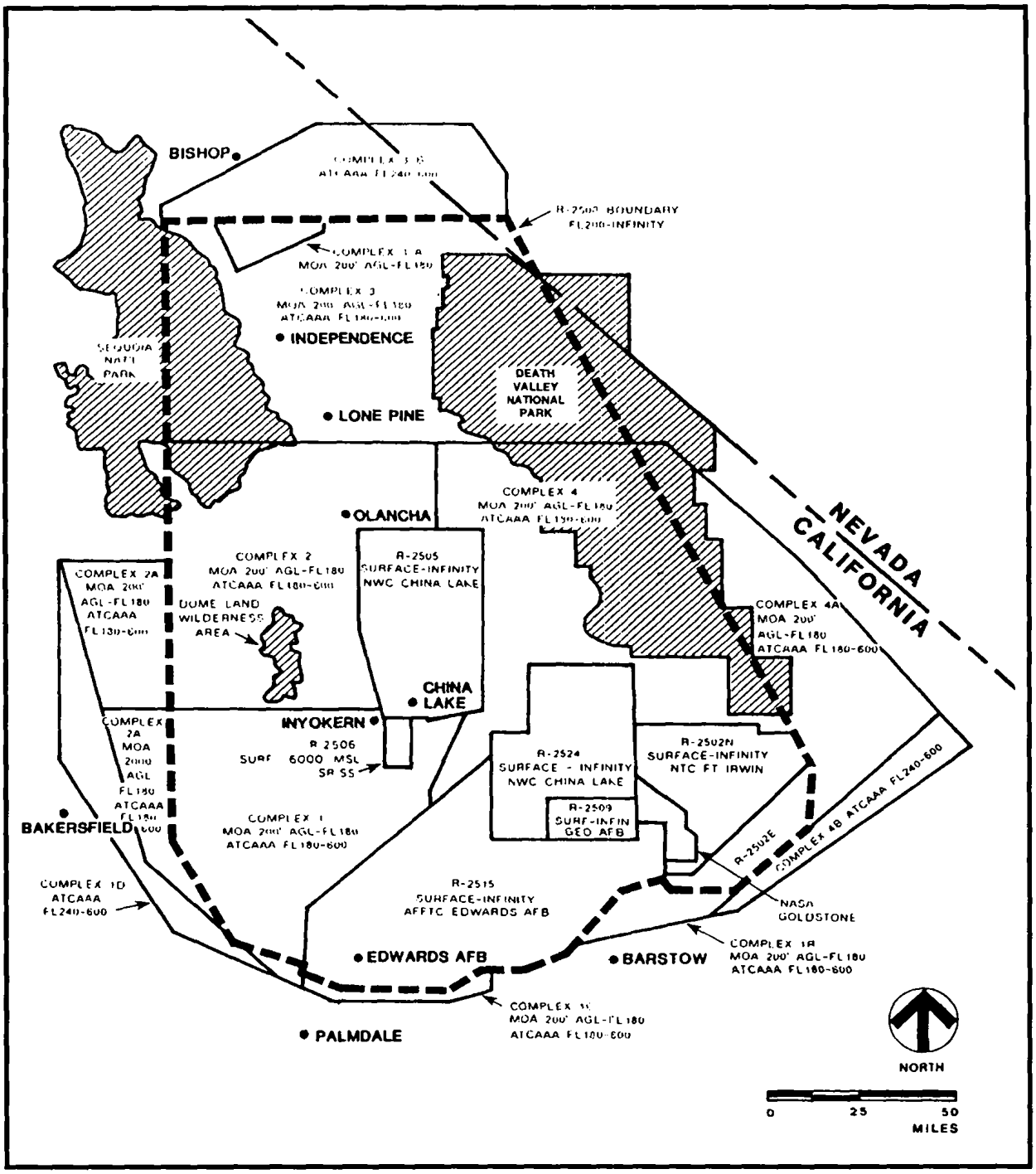


Figure 3-5. R-2508 Complex with ATCAA (USAF 1995A).

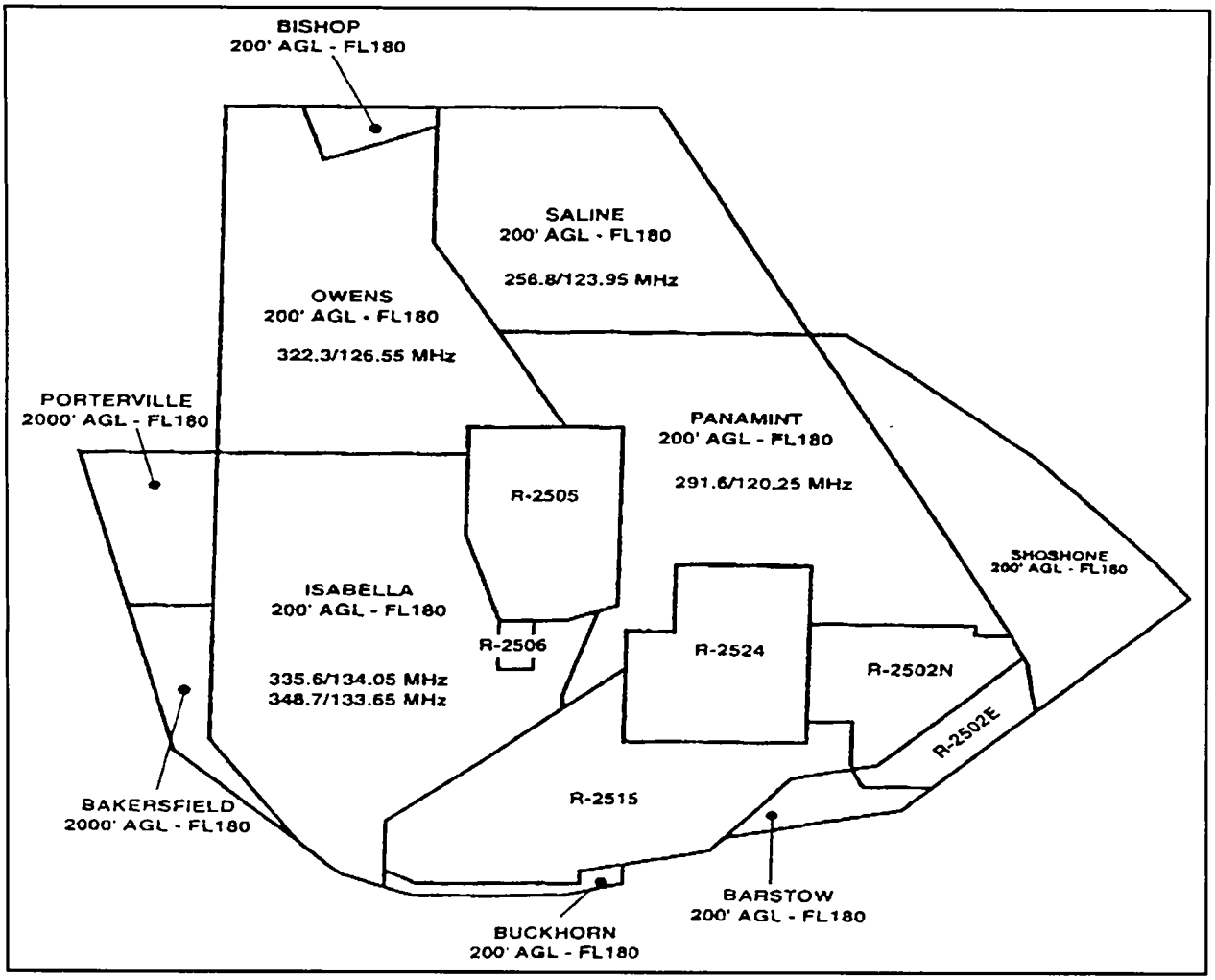


Figure 3-6. R-2508 MOAs and Military Restricted Airspace (USAF 1995A). (FL = Flight Level. FL times 100 = altitude in feet.)

Table 3-2. R-2508 Complex Restrictions by Restricted Airspace Sectors (NOAA 1997-A).

RESTRICTION ID NUMBER	TIME USED	ALTITUDE RESTRICTION
R-2502N	Continuous	Unlimited
R-2515	Continuous	Unlimited
R-2524	Continuous	Unlimited
R-2508	Continuous	6,100 m (20,000 ft) - Unlimited
R-2505	Continuous	Unlimited

Table 3-3. R-2508 Complex Restrictions by MOA's (NOAA 1997-A).

MILITARY OPERATIONS AREA NAME	TIME USED	ALTITUDE OF USE
Panamint	Mon-Fri	61 m (200 ft) AGL to 5,500 m (18,000 ft)
Shoshone	Mon-Fri	61 m (200ft) AGL to 5,500 m (18,000 ft)
Isabella	Mon-Fri	61 m (200 ft) AGL to but not including 5500 m (18,000 ft), excluding 915 m (3,000 ft) and below over Domeland Wilderness Areas
Desert	Mon-Sat	31 m (100 ft) AGL to but not including 5500 m (18,000 ft)
Owens	Mon-Fri	61 m (200 ft) AGL to but not including 5500 m (18,000 ft), excludes airspace below 915 m (3,000 ft) over Wilderness Areas, National Parks and Monuments
Saline	Mon-Fri	61 m (200 ft) AGL to but not including 5500 m (18,000 ft), excludes airspace below 915 m (3,000 ft) over Wilderness Areas, National Parks and Monuments
Gabbs South	Continuous	31 m (100 ft) AGL to but not including 5500 m (18,000 ft)
Gabbs Central	Continuous	31 m (100 ft) AGL to but not including 5500 m (18,000 ft)
Gabbs North	Continuous	31 m (100 ft) AGL to but not including 5500 m (18,000 ft)
Paradise	0500-2100	4400 m (14,500 ft) AGL to but not including 5500 m (18,000 ft)
Saddle B	Intermittent by "Notice to Airmen" (NOTAM)	2400 m (8,000 ft) AGL to but not including 5500 m (18,000 ft)

Note: All times noted on the individual tabulations are in "Zulu" (z), or Coordinated Universal Time. To arrive at local time, subtract the following from the indicated times:

Los Angeles Center	-8 hours
Oakland	-8 hours
Salt Lake City	-7 hours

3.1.7 Biological Resources

Vegetation

There are five major plant communities that exist on the base. Joshua tree (*Yucca brevifolia*) woodland makes up approximately 20 percent of the base. Creosote bush scrub is present on about 30 percent, halophytic ("salt loving") phase saltbush scrub accounts for 15 percent, and arid phase saltbush scrub covers approximately 20 percent. Mesquite woodlands account for only 1 percent of the base area. The remainder of the base consists of dry lake beds (12 percent) and developed areas (2 percent) (Figure 3-7) (EAFB 1994A).

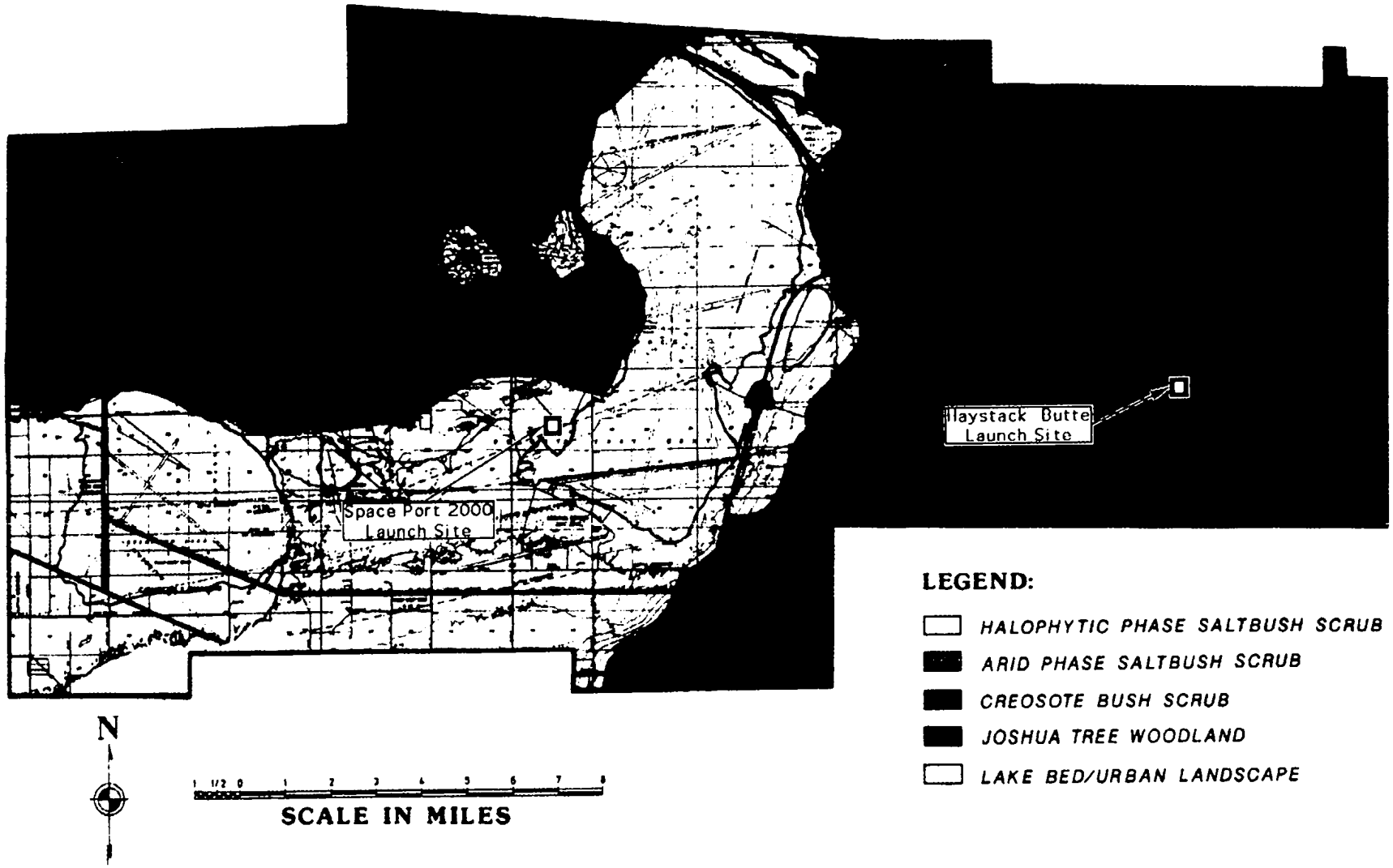


Figure 3-7. Vegetation Map of Edwards.

Vegetation surveys indicated a trend of increasing species richness from east to west in creosote bush scrub and low species richness and proportion of native species in the mesquite woodlands (EAFB 1993). Joshua tree woodland is most prevalent east of Rogers Dry Lake with smaller patches occurring in the northwest. Creosote bush scrub is unevenly distributed in the northwest and occurs throughout the eastern portion of the base. The dominant plant community in the southwest area of the base is halophytic phase saltbush scrub. It also occurs in narrow bands around dry lake beds and in claypan and dune complex areas. Much of the unpaved area on the Main Base is dominated by the arid phase saltbush scrub community. It is prevalent in the extreme northwest portion of the base. Mesquite woodlands are restricted to the mesic washes and drainages within the halophytic phase saltbush scrub in the southwestern part of the base (EAFB 1994A).

The Haystack Butte site is dominated by Joshua tree woodland and creosote bush scrub. Vegetation on the Space Port 2000 site is a halophytic phase of saltbush scrub dominated by a variety of low shrubs. The most common are Mojave saltbush or spinescale (*Atriplex spinifera*) and allscale (*Atriplex polycarpa*). Phillips Laboratory is located on Leuhman Ridge in the northeastern portion of the base. Leuhman Ridge includes rock outcrops and creosote bush scrub habitat with relatively extensive Joshua tree cover and has been extensively developed for rocket motor/engine testing and related activities (USAF 1992A).

Wetlands and Floodplains

The most critical floodplain areas on Edwards are Rogers Dry Lake, Rosamond Dry Lake, Mojave Creek (Cache Creek), residential areas, and several low lying areas in the main cantonment area where positive drainage is not available (EAFB 1994A).

Rogers Dry Lake floods every winter. Space Port 2000 would be located immediately adjacent to the lake bed; therefore, flood protection would be critical. The typical flood elevation for Rogers Dry Lake is 2277.4 North American Vertical Datum 1988 (EAFB 1994A). The Space Port 2000 site is located in the Mojave Creek drainage and within the acknowledged probable floodplain (EAFB 1994A). The Haystack Butte site is well removed from the floodplains of the Rogers Dry Lake, and therefore, flood protection would not be necessary at this alternative.

Rosamond Boulevard is the main access route to Edwards, and is threatened with possible flooding by Rosamond Dry Lake every winter. The typical flood level of Rosamond Lake is 15.2 cm (6.0 in) above the roadway crown elevation of Rosamond Boulevard at its low point at an elevation of 2279.0 North American Vertical Datum 1988. During high intensity storms, Mojave Creek causes periodic flooding adjacent to the residential areas and downstream of Rosamond Boulevard. The residential areas also experience periodic flooding during high intensity storms. Some of these areas are adjacent to Mojave Creek, but much of the flooding comes from a smaller drainage area tributary to the residential areas (EAFB 1994A). Although all of these areas are considered floodplains, they have not been classified jurisdictional wetlands by the U.S. Army Corps of Engineers.

Wildlife

Surveys were conducted in 1992 and 1993 to establish baseline biological resource conditions for the Installation Restoration Program at Edwards. Focused surveys were conducted for the desert tortoise (*Gopherus agassizii*), Mohave ground squirrel (*Spermophilus mohavensis*), eubranchiopods, and three sensitive plant species. Random transect surveys were also conducted in the five major plant communities (Joshua tree woodland, mesquite woodland, creosote bush scrub, arid phase saltbush scrub, and halophytic phase saltbush scrub) for vegetation, large mammals, small mammals, birds, and herpetofauna (EAFB 1993).

Ten large mammal species were observed on base during general wildlife field surveys conducted in the spring of 1993. The most common species were the black-tailed jackrabbit (*Lepus californicus*), which was present on every transect survey day; and the desert cottontail (*Sylvilagusauduboni*), which occurred on 78 percent of the transects surveyed. Large mammal species richness was consistent across vegetation communities but relative abundance was substantially higher in mesquite woodlands. These areas usually provide cover and a water source for large mammals (EAFB 1993; EAFB 1994A).

Eleven nocturnal small mammal species were captured during trapping surveys on the base, including California voles (*Microtus californicus*) which had not previously been documented in the wild on Edwards, and a previously undescribed species of *Perognathus*. The most commonly trapped species were Merriam's kangaroo rats (*Dipodomys meriami*) and deer mice (*Peromyscus maniculatus*). Species richness was highest in halophytic phase and Joshua tree woodland communities, and relative abundance was highest in mesquite and Joshua tree woodlands (EAFB 1993).

Bird surveys conducted in the spring of 1993 detected a total of 60 avian species utilizing the transect areas surveyed on Edwards. In addition, other species were observed as flyovers and/or incidental to other studies, including western meadowlarks (*Sturnella neglecta*) and loggerhead shrikes *(Lanius ludovicianus*). Avian species richness and relative abundance were substantially higher in mesquite woodlands followed by Joshua tree woodlands than in other communities (EAFB 1994A).

Fifteen reptile species were observed during herpetofauna transect surveys. Common species detected include desert spiny lizards (*Sceloporus magister*) and side-blotched lizards (*Uta stansburiana*). Herpetofauna species richness and relative abundance values were relatively consistent among the plant communities.

Surveys also identified four major types of Eubranchiopod habitat on the base: playas, edge playas, claypans, and road pools. These habitat types differ from each other in size, physical, and chemical properties. They support three species of fairy shrimp, *Branchinecta gigas*, *B. mackini*,

and *B. lindahli*; one species of tadpole shrimp, *Lepiduras lemmoni*; and one species of clam shrimp, *Eocyzicus digueti* (EAFB 1993).

Common mammals known or expected to occur on the Space Port 2000 site include: the black-tailed jackrabbit, coyote (*Canis latrans*), desert cottontail, and desert kit fox (*Vulpes macrotis arsipis*), which utilize all habitat types of the area except those substantially altered by human activity. The antelope ground squirrel (*Ammospermophilus leucurus*), Merriam's kangaroo rat, southern grasshopper mouse (*Onychomys torridus*), and little pocket mouse (*Perognathus longimembris*) occur in saltbush scrub with loose, sandy soils. Also found in the area were pallid bats (*Antrozous pallidus*) and western mastiff bats (*Eumops perotis*) (USAF 1992A).

Birds indigenous to the Space Port 2000 site include: the common raven (*Corvus corax*), horned lark (*Eremophila alpestris*), loggerhead shrike (*Lanius ludovicianus*), mourning dove (*Zenaida macroura*), quail (*Callipella*sp.), greater roadrunner (*Geococcyz californianus*), lesser nighthawk (*Chrodeiles acutipennis*), Say's phoebe (*Sayornis saya*), LeConte's thrasher (*Toxostoma lecontei*), Bendire's thrasher (*Toxostoma bendirei*), white-crowned sparrow (*Zonotrichia leucophrys*), and song sparrow (*Melospiza melodia*). Raptors such as the red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), American kestrel (*Falco sparverius*), barn owl (*Tyto alba*), and great horned owl (*Bubo virginianus*) are likely to forage in the desert scrub. The rock dove (*Columba livia*), barn owl, and house finch (*Carpodacus mexicanus*) are associated with developed areas. The golden eagle (*Aquila chrysaetos*) occurs during migration seasons. Burrowing owls (*Athene cunicularia*) may nest within the area (USAF 1992A).

Reptiles are abundant on the Space Port 2000 site. Resident species include: the side-blotched lizard (*Uta stansburiana*), California whiptail (*Cnemidophorus tigris*), zebra-tailed lizard (*Callisauris draconoides*), desert spiny lizard (*Sceloperus magister*), desert horned lizard (*Phrynosoma platyrhinos*), long-nosed leopard lizard (*Gambelia wislizenii*), western patch-nosed snake (*Salvadora hexalepis*), Mohave rattlesnake (*Crotalus scutulatus*), and western shovel-nosed snake (*Chionactis occipitalis*) (USAF 1992A).

Wildlife at the Haystack Butte site is very similar to that of the Spaceport 2000 site. In addition, bobcats (*Felis rufus*), prairie falcons (*Falco mexicanus*), and rock wrens (*Salpinctes obsoletus*) occur at Haytack Butte (USAF 1992A).

3.1.8 Threatened, Endangered, and Sensitive Species

Vegetation

In Appendix F, Table F-1 lists species of concern that have been identified or potentially occur on Edwards. No federal or state-listed plant species have been identified. Sensitive plant surveys focused on several populations of desert cymopterus (*Cymopterus deserticola*), Barstow woolly sunflower (*Eriphylyum mohavense*), and alkali mariposa lily (*Calochortus striatus*) on the east side of the base. These surveys confirmed the presence of previously identified populations, and determined approximate boundaries and numbers of individuals associated with each (EAFB 1994A).

Wildlife

Table F-1 also lists sensitive wildlife species that have been identified or potentially occur on Edwards. The federal and state-threatened desert tortoise occurs throughout the base (Figure 3-8). The southern central and southeastern areas of the base support the highest densities of this species. Rosamond and Bissell Hills in the northwestern part of the base also support relatively high numbers of tortoises. The arid phase saltbush scrub community in the southwestern portion of Edwards supports the least number of tortoises (EAFB 1994A).

The relative density estimate of tortoises at Haystack Butte for Section 16, T.9N, R.7W (proposed X-33 launch site) is 13 desert tortoises per 2.6 sq km (1.0 sq mi) (EAFB 1996A). A site visit revealed two inactive and six collapsed adult desert tortoise burrows at the southeastern corner of the proposed launch site. Live desert tortoises and scat were not observed during this visit. The Haystack Butte X-33 site is located within the Fremont-Kramer Critical Habitat Unit for the desert tortoise which was designated by the U.S. Fish and Wildlife Service. The relative estimated density for sections associated with the Space Port 2000 site is 0 to 6 tortoises per 2.6 sq km (1.0 sq mi) (Hagan 1997).

On March 10, 1994, the U.S. Fish and Wildlife Service issued a biological opinion for the Precision Impact Range Area (PIRA) (FWS 1994). The PIRA is divided into three Management Zones for desert tortoise (see Figure 3-9; note: Desert Tortoise Zone definitions on map.). Boundaries of these zones were based on desert tortoise densities and levels of activity associated with the use of the PIRA. More than one-half of the Haystack Butte X-33 launch site is located within Zone 1 (defined as having a desert tortoise density of 0–2.3 tortoise/km^2 (0–6/mi^2)). The remaining portion of the Haystack Butte launch site and proposed road construction are located within the Phillips Laboratory boundary (Zone 2, 2.7–12.4 tortoise/km^2 (7–32/mi^2)). Zone 1 generally corresponds to areas of low desert tortoise density, are most heavily used for operations, and involve minimal protection measures as described in the PIRA Biological Opinion. Being the primary mission support area, Zone 1 would continue to receive impacts from operation activities.

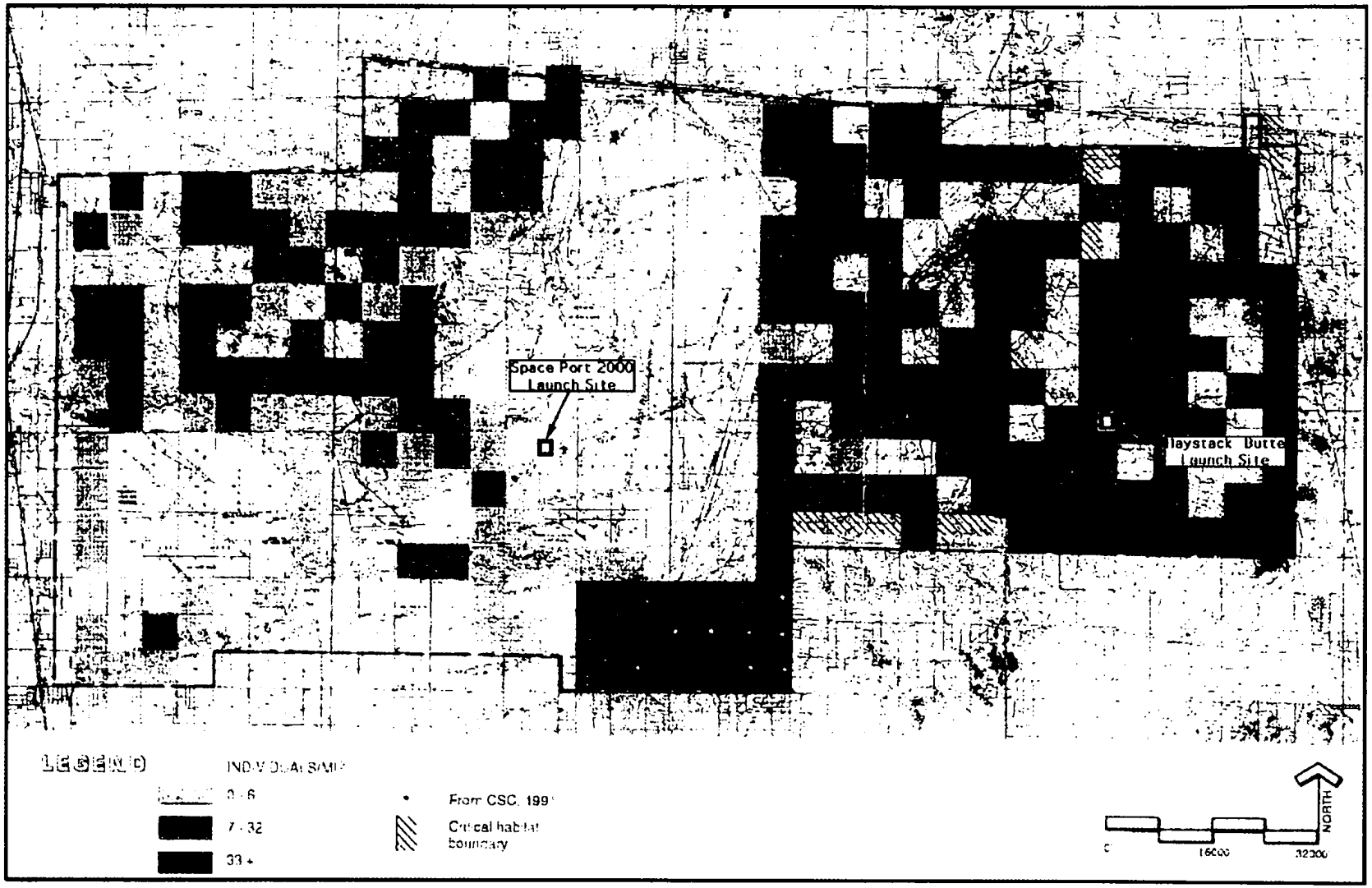


Figure 3-8. Desert Tortoise Relative Densities Surveyed Areas of Edwards.

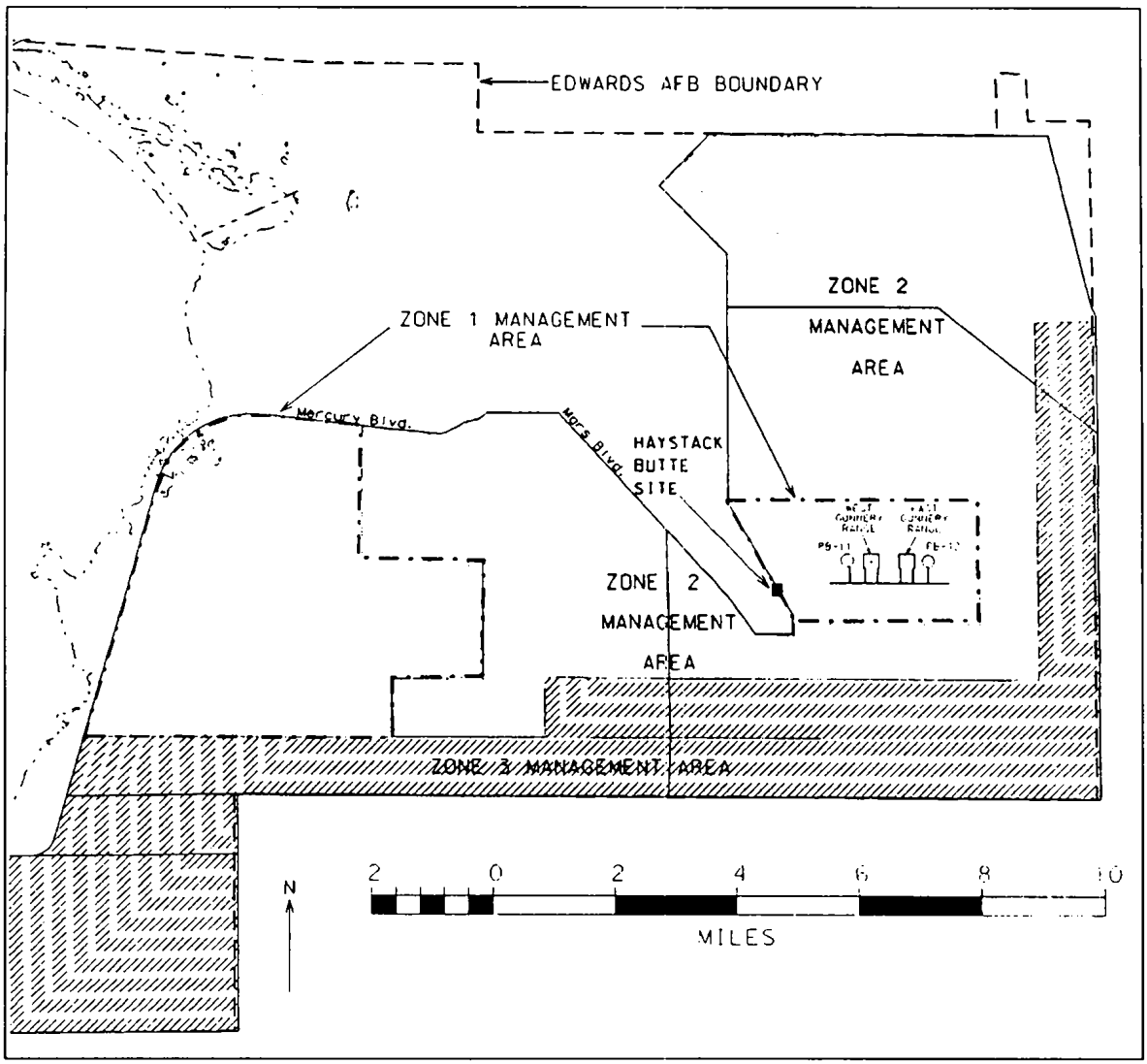


Figure 3-9. Desert Tortoise Management Zones on Edwards.

Currently, the "threatened" California status of the Mohave ground squirrel (*Spermophilus mohavensis*) is in litigation. The Mojhave ground squirrel was delisted by the California Fish and Game Commission in 1993. The California Supreme Court ruled in August 1997 that the delisting was not proper (Ecology USA, 25 August 1997). However, this species is still a Category 2 candidate for federal listing. A Mohave ground squirrel study has taken place on Edwards (EAFB 1995A). There are several known populations of Mohave ground squirrels on base. The Complex 1 Charlie area and the area northeast of Rogers Dry Lake and west of Rich Road were intensively trapped in the spring of 1993. During these surveys, Mohave ground squirrels were also incidentally identified on most of the eastern side of the base and in several areas on the western side (EAFB 1994A). Mohave ground squirrels may be found in arid phase saltbush scrub, Joshua tree woodland, and creosote bush scrub zonal habitats. Although none of these studies took place at the proposed X-33 sites, Mohave ground squirrels have been observed near Haystack Butte and may exist on site.

Six bat species classified by the California Department of Fish and Game Species of Special Concern may inhabit the base. The California mastiff bat (*Eumops perotis californicus*), spotted bat *(Euderma maculatum*), and Townsend's western big-eared bat (*Plecotus townsendii townsendii*) are federal Category 2 candidates for listing by the U.S. Fish and Wildlife Service. Bats typically roost in communal groups and are not widespread. On Edwards, one of the most likely roosting areas for bats is expected to be rock outcrops. Returning each year to bear young, bats commonly use the same maternity roosts for several years. Roost availability is considered a key limiting resource determining the distribution and abundance of bat species (Brown/Berry 1992). Haystack Butte, comprised of rock outcrops, may provide roosting habitat for bat species. There are no such outcrops associated with the Space Port 2000 site.

Three sensitive reptile species were identified at Edwards: desert tortoises, chuckwallas, and Mojave fringe toed lizards. Eighteen species of sensitive birds have been sighted at Edwards, and many are winter migrants unlikely to nest in the area. Others may nest on base including prairie falcons, short-eared owls, long-eared owls, burrowing owls, Le Conte's thrashers, and loggerhead shrikes (EAFB 1994A).

Two sensitive mammal species were identified on the base: American badgers and desert kit foxes.

Sensitive habitats on Edwards include designated critical habitat area for the desert tortoise, playa and pool areas, areas of significant topographic relief, sensitive plant populations, and the areas considered sensitive by Los Angeles County (EAFB 1994A).

Los Angeles County has identified two Sensitive Ecological Areas (SEA's) on Edwards. Piute Ponds support waterfowl and provide a stopover area for migratory birds. This area also supports much of the recreational hunting on base. Mesquite woodlands located near the south gate of the base are also classified as a Los Angeles County SEA (EAFB 1994A).

3.1.9 Cultural Resources

Ethnographic evidence reveals that four cultural groups—the Kawaiisu, the Kitanemuk, the Tataviam, and the Vanyume—made seasonal use of the Mojave Desert on Edwards and the surrounding areas at the time of European contact (EAFB 1995C). During the mid-1800's in the Antelope Valley, European land use was primarily limited to exploration. During the late 1800's and early 1900's, land use development included mines, homesteads, ranches, and railroads. A more detailed summary of the cultural history of the area can be found in the *Cultural Resources Overview and Management Plan for EAFB, California, Volume 1: Overview of Prehistoric Cultural Resources* (EAFB 1997) and the *Historic Resources Overview and Management Plan* (EAFB 1991).

More than 2,000 archaeological sites have been recorded on Edwards. Prehistoric sites include villages, temporary camps, rock shelters, milling stations, lithic scatters, quarries, cremations, rock features, and rock art. Historical sites which have been identified include town sites, mines, home sites, camps, railroads, refuse deposits, and military sites and structures (EAFB 1994A).

The alternative Haystack Butte launch site involves the use of Buildings 9800 and 9804 during X-33 testing. These buildings may have cultural resource potential and are located in the High Thrust Rocket Research Facility, Test Area 1-56, on Phillips Laboratory. Work in these buildings involves removing equipment presently located in Building 9800 and replacing it with the equipment necessary for control and observation of the X-33. If the decision is made to utilize Building 9804, work would include removal of items currently stored in this building and would free up necessary storage space.

Initial research revealed Building 9800 is a Control Room and Building 9804 is a Rocket Assembly Shop. The first phase of the High Thrust Rocket Research Facility was completed in 1966. This facility was unique during its inception due to its firing options (horizontal, vertical, and 15°), high thrust capacity (44.5 million N (10 million lb)), ability to launch free flight vehicles over the Bombing Range located to the north, and the Shaft Pressurization and Rocket Thrust Facility (EAFB 1995B).

The area of potential effects at the Space Port 2000 site was previously surveyed for cultural resources (EAFB 1997). One potential prehistoric site was found to be in proximity of the area of potential effects (Pittman 1996).

3.1.10 Water Resources

Groundwater

Antelope Valley is one of the largest groundwater basins in southern California (USAF 1992A). Groundwater occurs in two primary aquifers which are separated by a relatively continuous horizontal layer of low permeability lacustrine deposits extending from the center of Antelope Valley to outlying foothills and alluvial fans (EAFB 1994B).

The upper aquifer is recharged in the mountainous southern and western areas which receive higher precipitation, and in turn, recharges the lower aquifer under the foothill and alluvial fan areas (EAFB 1994A). Groundwater flows from recharge areas at the basin margins to discharge areas in the valley, following the same general patterns as surface water. Springs and seeps were common around the dry lakes before extensive groundwater pumping began. Wells flowed without pumping in a greater than 647 sq km (250 sq mi) area at the turn of the century. Groundwater levels dropped rapidly with extensive agricultural development during the first half of the century, and groundwater depressions, which still exist, formed in areas with high pumpage rates. However, groundwater levels dropped less rapidly when importation of water from northern California began after awareness of the problem increased and cost of pumping

water from greater depths made agricultural use less economically feasible. Although current pumpage still greatly exceeds the safe yield of the basin, 51,000 million L (13,400 million gal) of water per year estimated in 1975, groundwater elevations leveled and in some cases even rose during the 1980's. Groundwater use was projected to increase from approximately 159,000 million L (42,000 million gal) in 1983 to approximately 190,000 million L (50,000 million gal) per year in the year 2000. This rate includes industrial, residential, and agricultural water use as well as groundwater pumped at Edwards (USAF 1992A).

Surface Water

Antelope Valley is an approximately 6,216 sq km (2,400 sq mi) watershed in which storm runoff is directed towards its central dry lake beds (Rogers, Rosamond, and Buckhorn Dry Lakes). Earthen channels and drainage structures are used at Edwards to collect and channelize stormwater. These facilities direct the runoff to either a dry lake or stormwater retention ponds. Stormwater runoff from the flightline area is intercepted by the industrial evaporation ponds east of the flightline. This interception prevents possible industrial area contaminants from polluting Rogers Dry Lake (EAFB 1994A).

Most of the development at Edwards except the East Base area (Phillips Laboratory and Haystack Butte areas) is located in low-lying areas along the western perimeter of Rogers Dry Lake. Upstream runoff reaching developed areas flows overland and is collected with localized runoff by stormwater drainage improvements. The base stormwater collection system is comprised primarily of drainage ditches with some storm sewer structures in the developed areas. These ditches and storm sewers generally flow west to east and eventually empty into the Rogers Dry Lake or the stormwater retention ponds located east of the Main Base flightline. Stormwater runoff from the undeveloped portions of the base flows into the nearest dry lake (EAFB 1994A).

3.1.11 Geology and Soils

The U.S. Department of Agriculture, Natural Resources Conservation Service, is in the process of finalizing a report based on more recent surveys. Earlier surveys were completed prior to 1988 but only covered 16 percent of the base area (EAFB 1994A). The new surveys include a more comprehensive survey basewide and characterize the overall soil conditions on Edwards (SCS 1996). Based on the initial surveys (SCS 1988), the majority of the soils consist of loams, sandy loams, and loamy sands. Some soils are deep soils while others may lie on a bedrock of granite rock at a depth of only 2 m (7 ft). Others on or adjacent to the lake bed have a silt or clay component.

Soils at Edwards are alkaline, with pH values ranging from 7 to 8 for most soils and greater than 8 on lake bed soils. Some have a fairly high corrosion hazard for steel. The high salinity and exchangeable sodium ion content of some soils, particularly those in the lake bed basins, inhibit plant growth. Generally, soils are moderately to highly susceptible to erosion by wind, especially

in areas disturbed by construction or vehicular traffic. Water erosion of soils ranges from slight to moderate and is partially dependent on slope (EAFB 1994A).

The area in the vicinity of Edwards is considered geologically active. Several major and smaller faults are present within 160 km (100 mi) of the Edwards region. These faults include the San Andreas, Big Pine, White Wolf, and Garlock faults. Some of the faults are capable of generating large damaging earthquakes. A major earthquake, estimated at 8.3 on the Richter scale, occured along the San Andreas fault in 1857 approximately 100 km (60 mi) from Edwards. There is a high probability that Southern California will experience a significant earthquake during the next 30 years that would generate strong ground motion at Edwards.

3.1.12 Health and Safety

Edwards routinely conducts test flights of experimental aircraft and has comprehensive occupational and flight safety programs and plans in place to effectively address the hazards resulting from these operations. These plans include contingency planning and emergency response capability to deal with all worst case scenarios. Operations conducted must comply with Occupational Safety and Health Administration (OSHA) requirements (California-OSHA where contractor personnel are utilized) as well as applicable Air Force and Edwards regulations.

The 412th Test Wing Range Safety Office ensures that safety is a priority during all range activities. Air Force Flight Test Center Instruction 11-1, Aircrew Operations, sets policies and defines procedures for aircrews operating aircraft at Edwards. Instructions address topics including ground and inflight procedures, traffic patterns, emergency procedures, and flight restrictions.

Fire protection and rescue on Edwards is provided by the 95th Civil Engineer Group. Five fire stations serve the base. Medical care is provided by the Edwards hospital, which has a 15-bed capacity and provides both medical and dental services. Dryden maintains a medical dispensary for routine evaluations and emergency response operations. There are also three hospitals in Lancaster and one in Palmdale (EAFB 1994A).

The PIRA has been the testing site for development and evaluation of Air Force aircraft and weapon delivery systems for over 60 years. Weapons tested included those using live ammunition, high explosives, and chemical devices. Bombing targets on the PIRA have no real boundaries because live rounds of ammunition, high explosive bombs, or chemical weapons occasionally missed their targets or skipped off into areas surrounding the targets. In the past, chemical weapons and ordnance have been discovered buried on the PIRA. Areas of concern, with respect to the health and safety of project personnel, would include these bombing targets/disposal areas surrounding these sites.

The Haystack Butte launch site is located near two range Precision Bombing (PB) targets (PB-11 and PB-12). Target areas PB-11 and PB-12 are located approximately 1.6 km (1.0 mi) east and 3.2 km (2.0 mi) east of the launch site, respectively. Both of these target areas are instrumented bombing circles. This condition is not shared by the Space Port 2000 site.

3.1.13 Noise

Background Noise Information

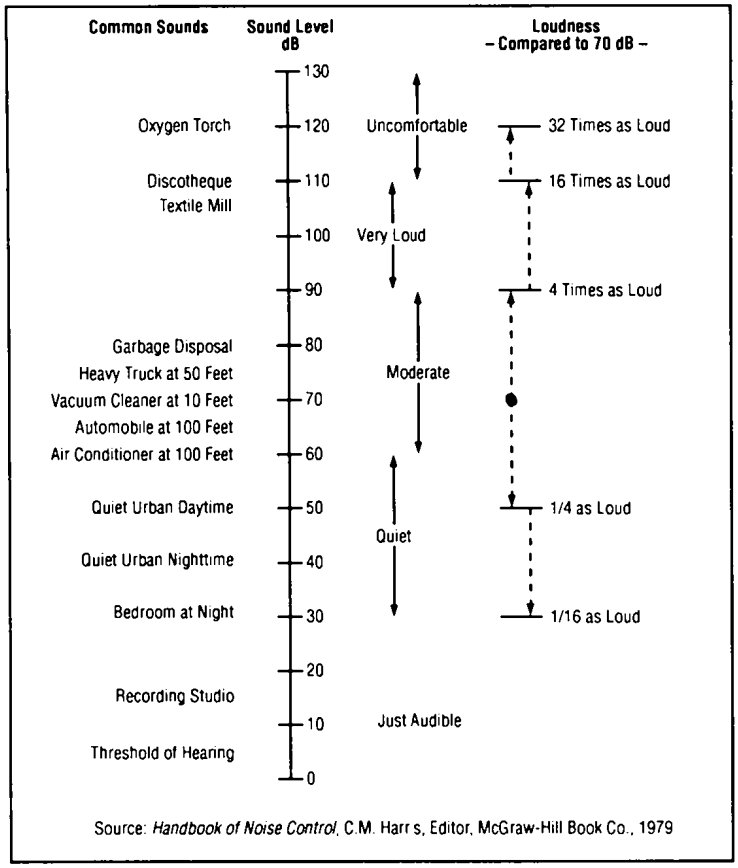
Noise is generally defined as unwanted sound. Whether that sound is interpreted as pleasant (music, for example) or unpleasant depends largely on the listener's current activity, experience, and attitude toward the source of the sound. For example, during a NASA Orbiter reentry event, some individuals will go outside to observe the Orbiter and look forward to hearing its sonic boom, while others will be annoyed by it. Hence, the attitude of the listener as well as the intensity and frequency of the sound determines the degree of annoyance.

Noise is measured and described in several ways. Table 3-4 provides units and definitions of noise terminology and measurements that are used in the following discussions. For comparison purposes, maximum A-weighted sound levels for typical events are shown in Table 3-5. Details of noise impacts and threshold levels and ranges are provided in the following sections to enhance understanding of the preliminary X-33 noise projections.

Table 3-4. Noise Level Units and Definitions or Explanations.

Symbol/Unit	Term	Definition
dB $L = 10 \bullet \log_{10}\left(p^{-2} / p_{ref}^{2}\right)$ $p_{ref} = 20\mu Pa$ L = level N - Newton, m - meter, p - pressure	decibel	Unit of measurement of sound amplitude; logarithmic scale.
dB A	A-weighted sound level	Sound level filtered to the approximate response of the human ear.
dBC	C-weighted sound level	Sound level filtered to the range from approximately 20 Hz to 20,000 Hz.
Hz	frequency	Number of times per second air vibrates or oscillates as sound travels through it.
OASPL	Overall Sound Pressure Level	Total sound pressure level using all frequencies.
L_{dn}	Day-Night average sound level	The 24-hour energy average A-weighted sound level with a 10 dB weighting added to those levels occurring between 10 p.m. and 7 a.m. the following morning.
p (psf or Pa) psf = pounds per square foot Pa = Pascal = N/m^2	Peak Overpressure	Maximum pressure which the sonic boom produces above existing atmospheric pressure.

Table 3-5. Typical A-Weighted Sound Levels of Common Sounds.



Source: *Handbook of Noise Control*, C.M. Harr s, Editor, McGraw-Hill Book Co., 1979

Because of the variability of individuals' reactions to noise and attitudes toward noise sources, it is impossible to accurately predict how an individual will react toward a particular noise. However, when entire communities are considered, community reaction to noise may be represented with a high degree of confidence. A standard unit for measuring noise that affects communities is the Day-Night Average Sound Level (L_{dn}). L_{dn} averages sound levels at a location over a 24-hour period, with a 10 dB adjustment added to noise events that occur between 10 p.m. and 7 a.m. local time. The 10 dB "penalty" represents the added intrusiveness of sounds that occur during normal sleeping hours.

In June 1980, an ad hoc Federal Interagency Committee on Urban Noise published guidelines (FIC 1980) relating L_{dn} levels to compatible land uses (and reaffirmed those guidelines in 1990) (FIC 1992). Federal agencies have since adopted these guidelines for noise analyses.

Following the lead of the committee, the Department of Defense and the Federal Aviation Administration adopted the concept of land-use compatibility as the accepted measure of aircraft noise effect. These guidelines and explanatory notes are reprinted in Table 3-6. Although these guidelines are not mandatory, they provide standard means for determining noise impacts in airport communities. For example, Table 3-6 illustrates that a guideline of L_{dn} of 65 dBA or less is considered compatible for all residential land uses.

Table 3-6. Land-Use Compatibility with Yearly Day-Night Average Sound Levels, L_{dn}.

Land—Use Compatibility With Yearly Day—Night Average Sound Levels

Land Use	Yearly Day-Night Average Sound Level (L_{dn}) in decibels					
	Below 65	65-70	70-75	75-80	80-85	Over 85
Residential						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
Public Use						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoria, and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
Commercial Use						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail—building materials, hardware, and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade—general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
Manufacturing and Production						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
Recreational						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	Y	N	N	N
Amusements, parks, resorts, and camps	Y	Y	Y	N	N	N
Golf courses, riding stables, and water recreation	Y	Y	25	30	N	N

Numbers in parentheses refer to notes.

• The designations contained in this table do not constitute a federal determination that any use of land covered by the program is acceptable or unacceptable under federal, state, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise–compatible land uses.

KEY TO TABLE

SLUCM=Standard Land–Use Coding Manual.
Y (Yes)=Land Use and related structures compatible without restrictions.
N (No)=Land Use and related structures are not compatible and should be prohibited
NLR=Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30, or 35=Land Use and related structures generally compatible, measures to achieve NLR of 25, 30, or 35 dB must be incorporated into design and construction of structures.

NOTES FOR TABLE

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor-to-indoor Noise Level reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide an NLR of 20 dB; thus the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year-round. However, the use of NLR criteria will not eliminate outdoor noise problems.
(2) Measures to achieve NLR 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is now
(3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, of where the normal noise level is low.
(4) Measures to achieve NLR 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal level is low.
(5) Land–Use compatible provided special sound reinforcement systems are installed.
(6) Residential buildings require an NLR of 25
(7) Residential buildings require an NLR of 30.
(8) Residential buildings not permitted

Operational Noise

The major noise sources at Edwards are vehicle traffic and aircraft operations, including fixed and rotary wing air traffic, jet air traffic, engine testing, and sonic booms. The USAF has adopted the Air Installation Compatible Use Zones (AICUZ) Program to encourage land uses that are compatible with airfield-related noise and safety requirements. The AICUZ Program is used to evaluate impacts within established compatible use zones. Figure 3-10 illustrates the 1994 AICUZ noise contours for Edwards. Sonic booms are a significant aircraft-related noise source. All supersonic activities are conducted within designated test corridors (EAFB 1994A).

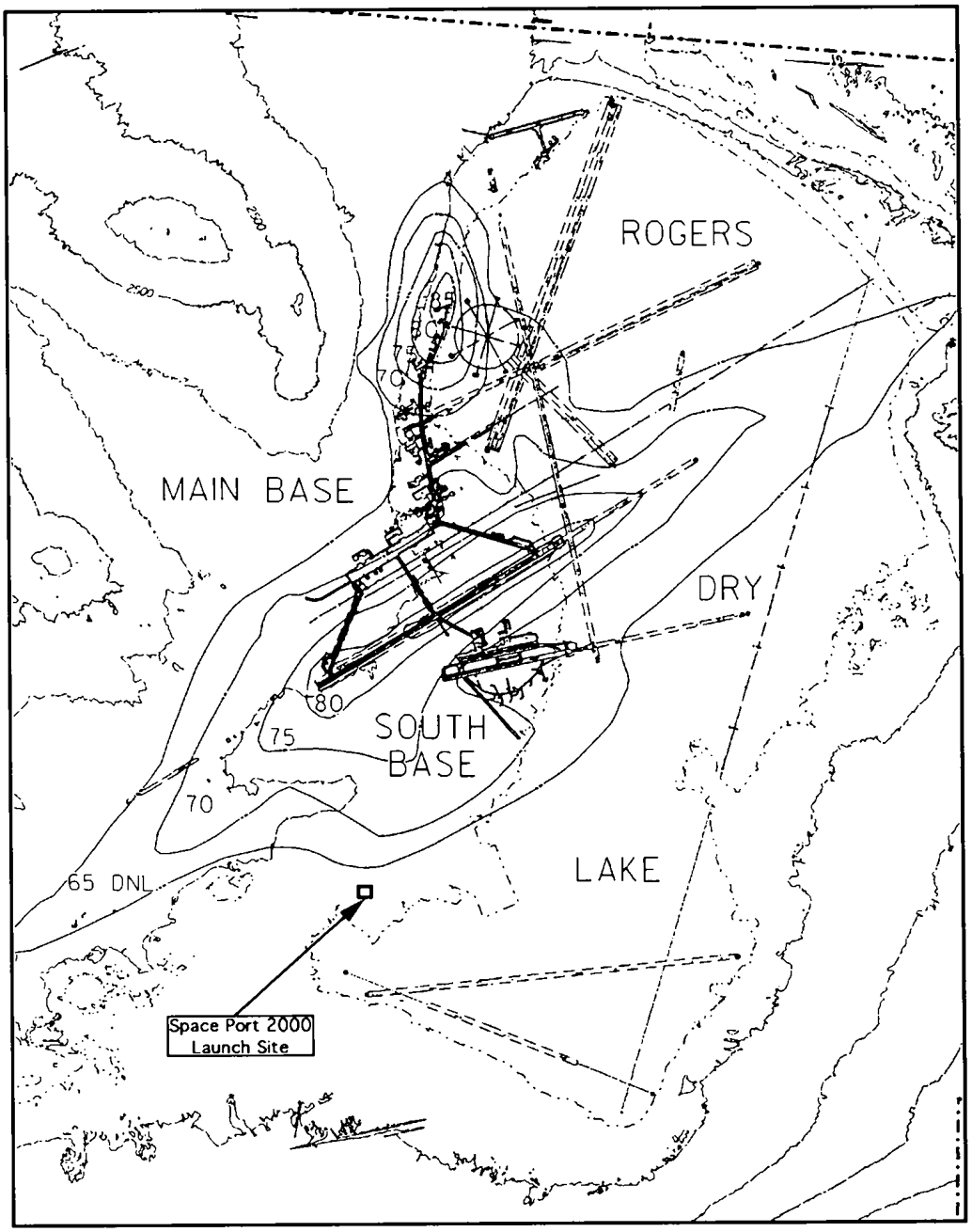


Figure 3-10. Noise Contours for Edwards.

Noise level measurements are routinely performed to monitor conditions and provide a basis for corrective actions, if necessary. Background noise monitoring was conducted in May 1993 to obtain a representative day/night equivalent noise level measure of existing sound levels on Edwards. The L_{dn} noise levels ranged from 37 to 68 dBA. In general, the lowest noise levels were recorded in the housing area and Phillips Laboratory, while the highest levels were recorded on Main and South Bases (EAFB 1994A).

Noise contours for 65 L_{dn} and greater extend as far as 10 km (6.3 mi) from Runway 04/22, but lie completely within the boundaries of Edwards. The Main Base residential area is outside of the 65 L_{dn} contour; however, one smaller residential area separate from the main community lies between the 65 to 70 L_{dn} contours. The Main Base has a range of exposure from 65 to 85 L_{dn}, and the South Base has a range of exposure from 70 to 75 L_{dn}. On-base land under the 85 dBA noise contours is primarily open space and test program support areas. The South Base and a small portion of the Main Base are currently within the 80 L_{dn} noise level. Therefore, small areas of administrative, commercial, and industrial land are subject to these noise levels. The residential area and hospital are located outside of the 65 L_{dn} contours.

Launch Noise

The area around Phillips Laboratory is currently subject to very high levels of noise during rocket engine tests. Figure 3-10A shows the estimated single event (dB AL) noise contours from Titan rocket engine test. Test firings occur during daytime hours for 1 to 3 minutes on an infrequent basis. Personnel at the test site remain in buildings designed to protect them from high noise levels. Testing of smaller engines is also conducted at this location, and noise levels are less than half of those produced by the large Titan engines.

3.1.14 Transportation

The existing transportation systems in the vicinity of the Haystack Butte launch site consist of paved and dirt roads. Two major highways, State Highway 58 to the north and U.S. Highway 395 to the east, border the Phillips Laboratory boundary at Edwards (Figure 3-11). There is one entrance to Phillips Laboratory on Mercury Boulevard through the security gate. Thereare two dirt roads which lead to the site from the north and south.

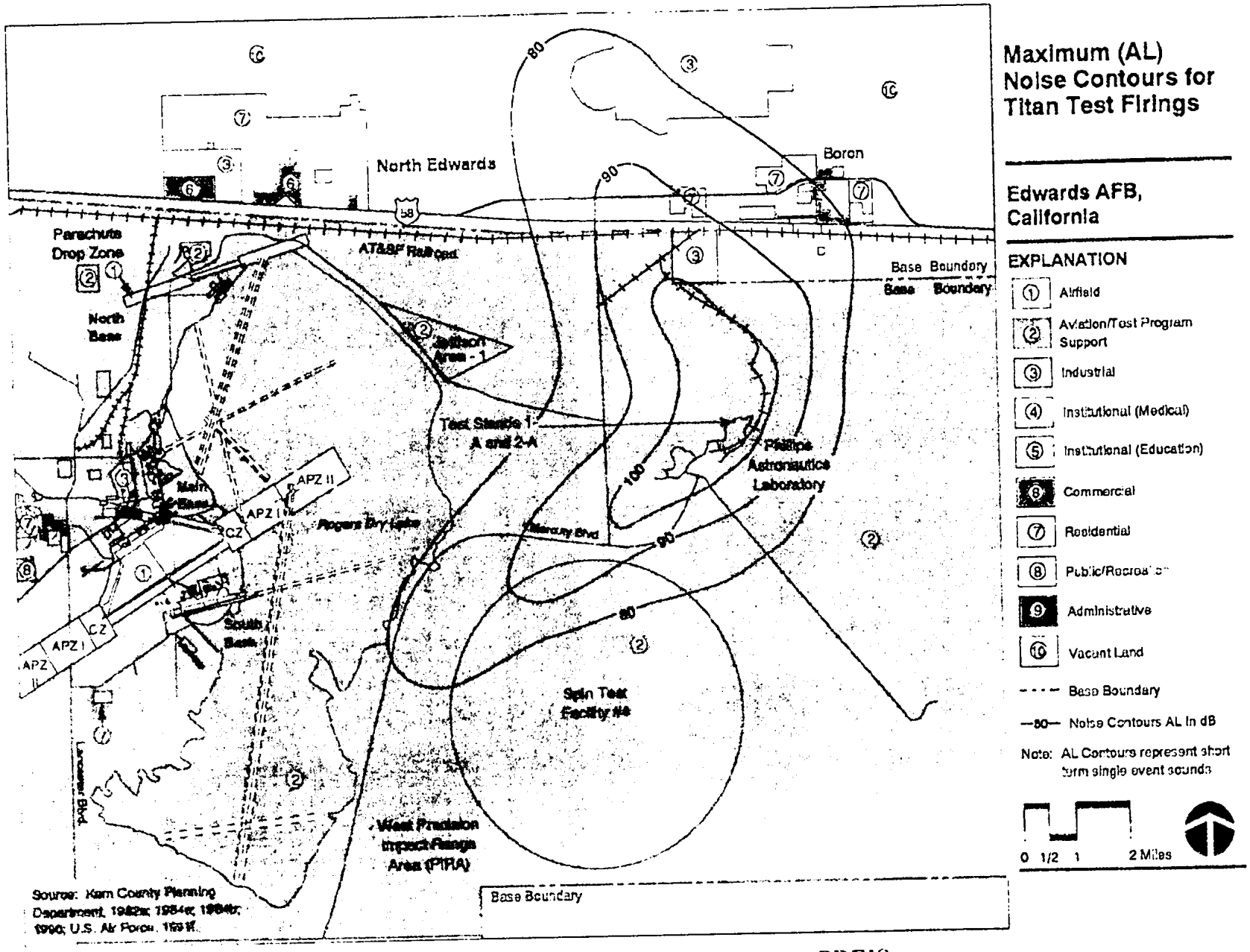


Figure 3-10A. NASP Flight Test Program PDEIS

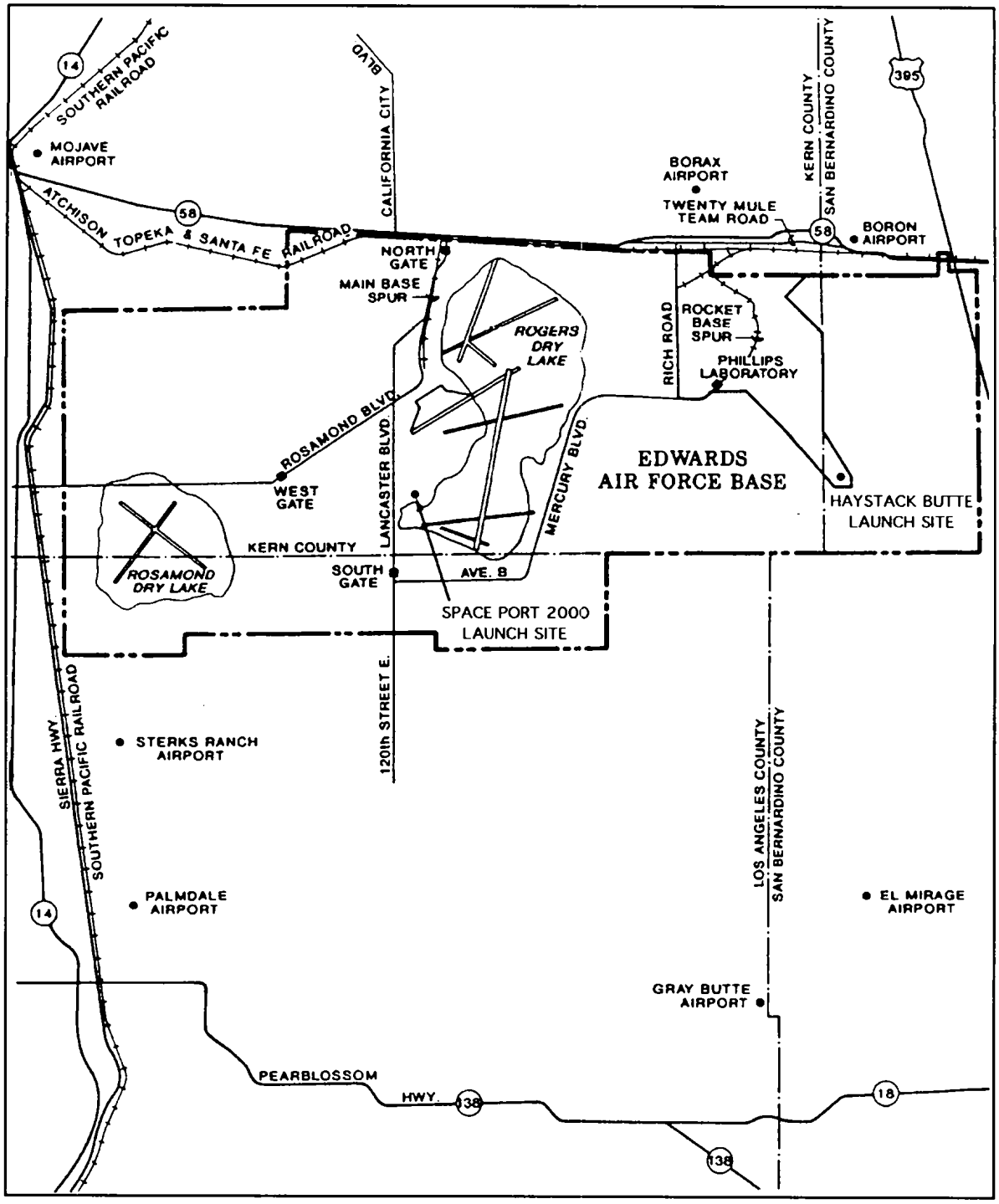


Figure 3-11. Transportation Map of Edwards.

The existing transportation system in the vicinity of the Space Port 2000 site consists of paved and dirt roads. There is a dirt road leading from South Base to the launch site.

There are a few other improved roadways immediately adjacent to the approximately 756 sq km (470 sq mi) base due to the sparse population and undeveloped, desert character of the area. Many local roads adjacent to the base boundary are simply tracks in the desert, subject to infrequent use and little maintenance. The principal paved local roadways adjacent to the base are two-lane rural asphalt roads, which include Sierra Highway, parallel to and just west of the base western boundary; East Avenue E, along the southern boundary; and 120th Street East, 140th Street East, and 200th Street East. 120th Street becomes Lancaster Boulevard on base. 140th Street intersects Mercury Boulevard and provides access to the southeastern portion of the base, and 200th Street parallels a portion of the southeastern base boundary (EAFB 1994A).

Roadway access to Edwards is by way of Rosamond Boulevard from the west or north and by Lancaster Boulevard/120th Street East from the south. The eastern portions of the base may be reached from CA 58 by Twenty Mule Team Road to Rich Road and Mercury Boulevard from the north and 140th Street East and Mercury Boulevard from the south. There is no improved access to the base from the east. Outlying areas of the installation may be accessed by automobiles from unimproved roadways (EAFB 1994A).

3.1.15 Population and Employment

Estimated population figures for the region surrounding Edwards are summarized in Table 3-7. The socioeconomic region of influence (ROI) for the X-33 Program was determined to include all areas within a 80.5 km (50 mi) radius of the main base area at Edwards. Table 3-7 lists total population for selected communities, but only the portions falling within the 80.5 km (50 mi) radius were considered in the ROI totals. A large population increase has been projected for Antelope Valley. The projected 186 percent increase reflects lower cost housing as compared to the area job centers of Los Angeles and Orange County. Most Valley residents commute more than 1 hour to work. Edwards and AF Plant 42 would continue to be a major job center of the Antelope Valley (EAFB 1994C).

Table 3-7. Estimated 1994 Region of Influence Population of Selected Communities Near Edwards.

COMMUNITY	POPULATION
Los Angeles County:	
Lancaster	115,524[1]
Palmdale	98,314[1]
Quartz Hill	20,000[2]
ROI Total within Los Angeles County	340,432[3]
Kern County:	
Boron	2,300[4]
California City	8,601[5]
Mojave	5,300[5]
North Edwards	1,259[5]
Rosamond	13,000[5]
Tehachapi	28,283[6]
ROI Total within Kern County	63,019[5]
San Bernardino County:	
Adelanto	12,039[7]
Barstow	28,983[8]
Hesperia	58,065[7]
Victorville	53,664[7]
ROI Total within San Bernardino County	40,763[3]
TOTAL ROI Population	444,214

[1]California Department of Finance, 1994.
[2]Quartz Hill Chamber of Commerce, 1994.
[3]Southern California Association of Governments, 1994.
[4]Boron Chamber of Commerce, 1994.
[5]Kern County Planning Department, 1994.
[6]Tehachapi Chamber of Commerce, 1994.
[7]San Bernardino County Planning Department, 1994.
[8]Barstow Chamber of Commerce, 1994.

The top three job categories by industry (manufacturing, trade, and services) provide 69 percent of all jobs in the Valley. Civilians account for approximately 93 percent of these jobs despite the large military presence at Edwards. Northrop is the predominant manufacturing employer providing 2,500 jobs. The principal nonmanufacturing employer is Edwards, with approximately 14,000 civilian and military jobs (EAFB 1994A).

3.1.16 Land Use

Approximately 93 percent of the Edwards installation land is used to directly support the flight test mission of the base. The dry lake beds are used primarily for aircraft development flight tests and emergency landing. Primary missions are to: conduct and support tests of aircraft systems; conduct flight evaluation and recovery of aerospace research vehicles, and develop and test aerodynamic decelerators; operate the Air Force Test Pilot School; manage, operate, and maintain the Utah Test and Training Range and the Edwards Flight Test Range; and support and participate in Air Force, DOD, other governmental agency, foreign, and contractor test and evaluation programs. Rocket engines using a variety of propellants are currently tested at Phillips Laboratory. The PIRA is characterized as an aircraft test range, preempting other uses of the area due to safety, noise, or other hazardous condition. The base also provides an alternative landing site for NASA's Space Shuttle (MSFC 1996A; EAFB 1994B).

Off base, the adjacent land use is predominantly sparsely populated arid desert. To the west, the community of Rosamond is the largest urbanized land use immediately adjacent to the base. To the north, undeveloped desert predominates, with scattered ranches and sections of publicly owned land. The residential villages of North Edwards and Boron are located along the northeastern boundary, along with the industrial uses of borax pits and solar energy facilities. East of Edwards, nearly all the adjacent land is undeveloped and publicly owned. Along the southern boundary, undeveloped land predominates to the east, with scattered rural residential and agricultural areas along the southwest boundary. The community of Lancaster is the largest urban area in the region, located just south of the southwest corner of the base. Although not immediately adjacent to the base, suburban commercial and light industrial land uses that support the community are located in the area adjacent to the Edwards' southern boundary (EAFB 1994B).

3.1.17 Snow Conditions

During scoping, the potential for sonic booms to trigger snow avalanche was raised in Great Falls, Montana. Due to low frozen precipitation potential in southern California, this issue is not applicable to Edwards.

3.2 Proposed Landing Sites

Several landing sites would be required for flight testing of the X-33 as described in Section 2.2.2. Each of the reasonable alternatives proposed for landing are described below.

3.2.1 Silurian Lake, California

Silurian Lake is located 29 km (18 mi) north of Baker, California, on State Highway 127 and east of Fort Irwin Military Reservation which lies north of Interstate 15 and west of State Highway 127 (see Figure 2-11). Public lands in the area are administered by the Bureau of Land Management (BLM) in Barstow, California.

3.2.1.1 Site Infrastructure

Landing Site

The landing area at Silurian Lake is the hard surface dry lake bed. The lake bed is 3,840 m long by 640 m wide (12,600 by 2,100 ft). Approximately 10 percent to 15 percent of the landing area on the lake bed could be subject to grading.

Water Supply and Distribution

No potable or nonpotable water lines exist at Silurian Lake.

Wastewater

There are no wastewater treatment facilities in the vicinity of Silurian Lake.

Electricity

The nearest utility corridor to Silurian Lake is Utility Corridor "D" (Boulder Corridor) which is 15.3 km (9.5 mi) to the south near Baker. It contains four overhead, high-voltage transmission lines that transport a major portion of the electrical power consumed in southern California. Other facilities within the Boulder Corridor consist of WorldCOMM fiberoptic cable and the Kern River Gas Transmission Pipeline. There are no fixed electrical power sources at Silurian Lake (BLM 1996).

Communications

No communications facilities exist at Silurian Lake.

Fuel

There is no existing fuel supply at Silurian Lake.

3.2.1.2 Hazardous Materials and Hazardous Waste

No hazardous materials are currently documented at Silurian Lake. In 1992, a Preliminary Assessment Screening was conducted in the Silurian Valley by Chambers Group, Inc., to determine the extent or potential for hazardous or toxic contamination. Results indicate that no areas of major environmental contamination or hazards exist; however, there are several areas where additional testing was recommended (Figure 3-12). These are almost exclusively mining areas that should be checked for mineral content in the tailings piles and/or subsurface soils for elevated heavy metal contaminant concentrations resulting from previous operations. No environmental contamination or hazards were noted for Silurian Lake or the immediate surrounding environs. Table 3-8 shows areas of potential environmental concern located in the Silurian Valley (BLM 1996).

3.2.1.3 Solid Waste

No landfills exist in the immediate area around Silurian Lake. The closest municipal landfill is approximately 3.2 km (2 mi) south of Baker, California (32 km (20 mi) south of Silurian Lake). It is a Class III landfill operated by the County of San Bernardino. The Tecopa landfill, operated by the County of Inyo, is located about 35 km (22 mi) north of Silurian Lake. Although there is an Army operated municipal landfill located near the cantonement area at Fort Irwin approximately 42 km (26 mi) to the east of Silurian Lake, over 161 km (100 mi) of road travel would be required to reach it.

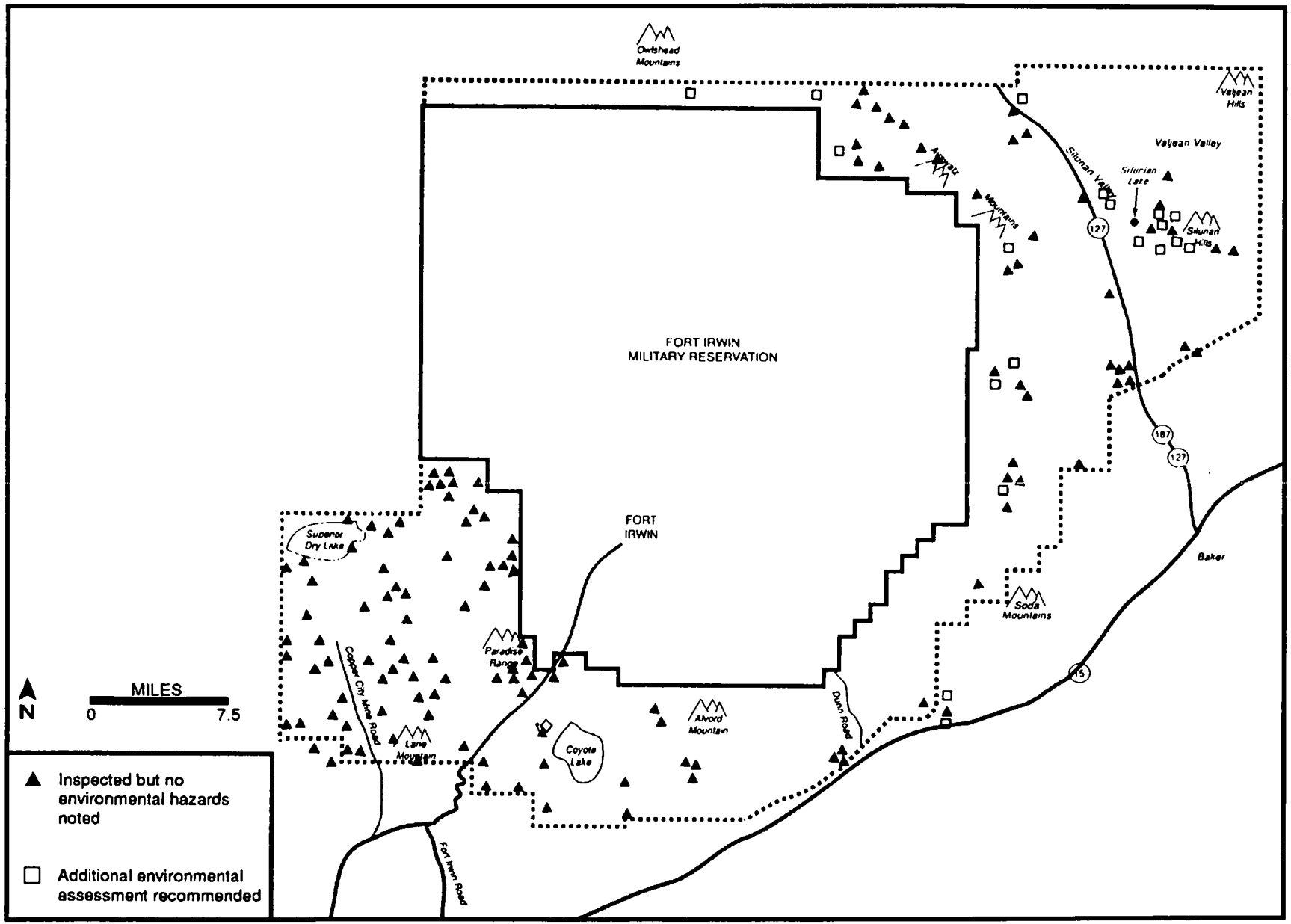


Figure 3-12. Areas of Potential Environmental Concern in the Silurian Valley.

Table 3-8. Areas of Potential Environmental Concern in the Silurian Valley Area.

Quadrangle Name	Nature of Area Studied and/or Potential Environmental Problems
Owl Lake	Owl Hole Springs - Manganese ore mill site, small oil spills in proximity to spring, distressed vegetation.
East of Owl Lake	No environmental concerns noted in area.
Old Ibex Pass	Large metal box located near prospect holes, unknown nature of materials (if any) in box.
	Boston Valley Claims - Rock salt deposits, no environmental hazards noted.
	King Claims - Rock salt deposits, no environmental hazards noted.
	Salt Basin Claims - Rock salt and gypsum deposits, no environmental hazards noted.
Saddle Peak Hills	Prospect holes, no environmental hazards noted.
	Ruins of old structure, no environmental hazards noted.
	Salt Spring Hills - Poisonous gases, potential cyanide or mercury contamination from gold separation techniques.
Dumont Dunes	No environmental concerns noted in area.
Valjean Hills	No environmental concerns noted in area.
Avawatz Pass	Denning Springs - Potential cyanide wash tank and smaller vessels containing white powder near old gold mine.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Salt Basin Mines - Mineshafts, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Cottonwood Spring - Old structure and mineshaft, no environmental hazards noted.
Sheep Creek Spring	Sheep Creek Mine - Talc deposits, no environmental hazards noted.
	Sheep Creek Spring - University of California research station, scattered refuse, no environmental hazards noted.
	Large Ore Stockpile - Uncharacterized stockpile, probably containing ore from Sheep Creek Mine.
	Prospect holes, no environmental hazards noted.
	Avawatz Crown Mine - Large operation, potential for leachates from lead, zinc, and silver ore.
	Prospect holes, no environmental hazards noted.
	Prospect holes, no environmental hazards noted.
	Old Mormon Springs Ruins - No environmental hazards noted.

3.2.1.4 Climate

The climate of the area surrounding Silurian Lake is characterized by hot summers, mild winters, infrequent rainfall, moderate afternoon breezes, and generally fair weather. Regional winds are typically from the southwest with an average annual speed of about 16 km/hr (10 mph). Winds blowing across State Highway 127 show dominant airflow to the east. A wind rose for Fort Irwin, located west of Silurian Lake, is shown in Figure 3-13. A wind rose from Silver Lake, located immediately south of the Silurian Valley, is presented in Figure 3-14. Local valley winds are generated by differential heating and cooling of the air in the complex mountain terrain. During the night and early morning, local winds are light, proceeding down the slopes of the ridges of local mountains. Stronger afternoon upslope/valley winds draw air through the local basin areas (BLM 1996).

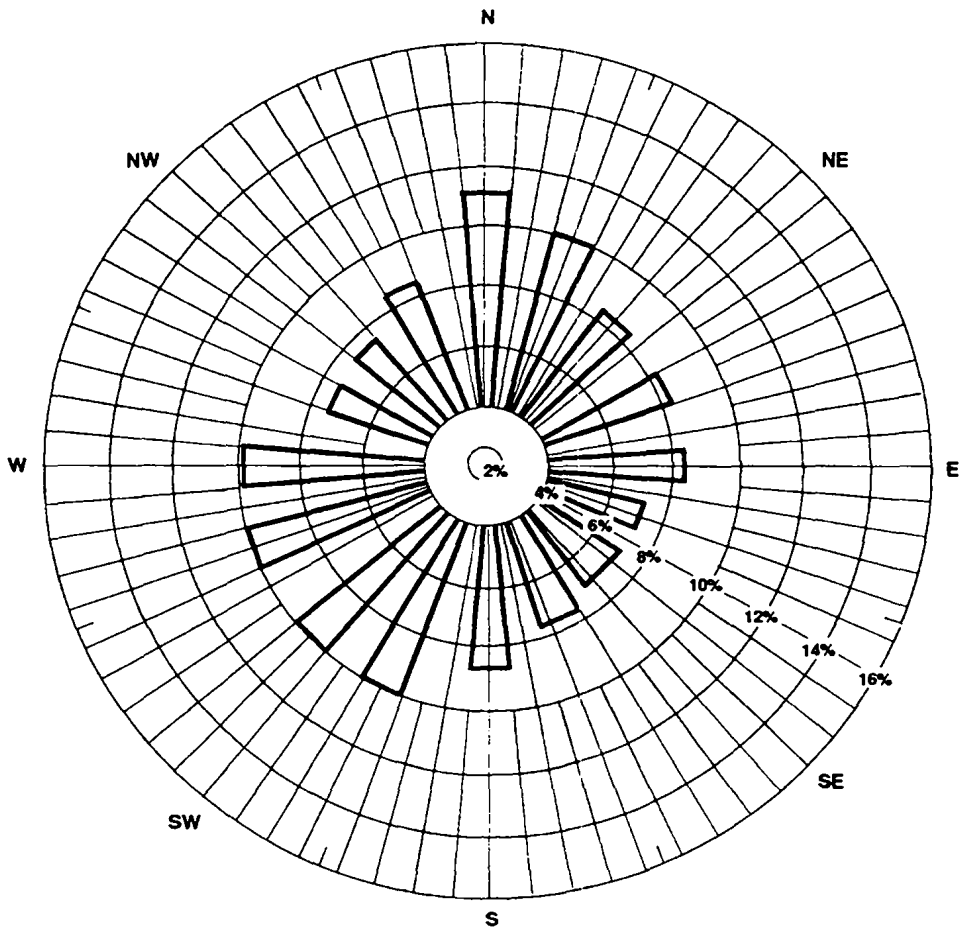


Figure 3-13. Wind Rose for Fort Irwin, Located West of Silurian Lake.

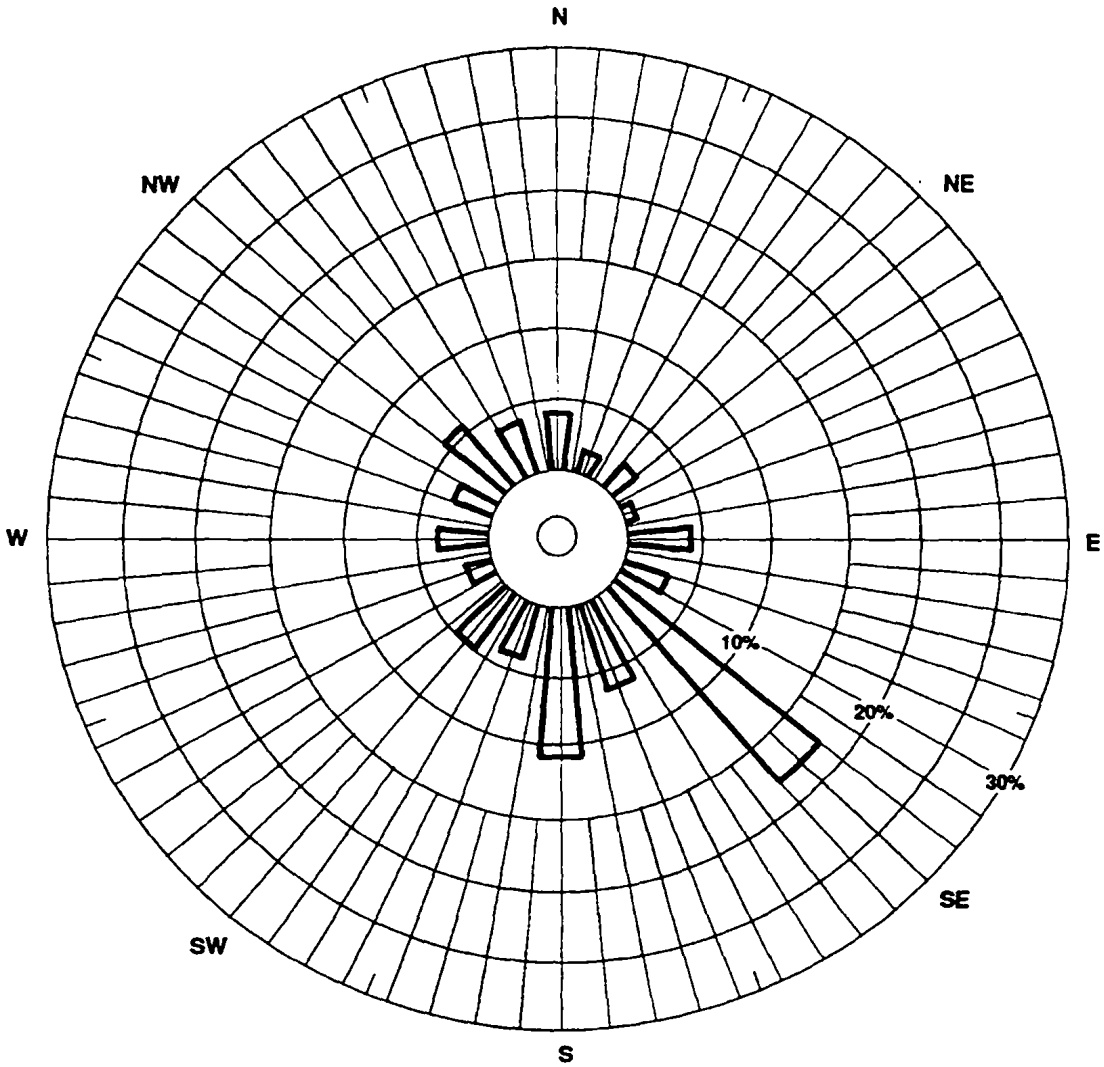


Figure 3-14. Wind Rose for Silver Lake, Located Immediately South of the Silurian Valley.

Monthly mean temperatures of the area as determined from long-term climatic data from the Barstow/Daggett Airport and Bicycle Lake Airport Aviation Support Facility range from 8.9 to 31.7° C (48 to 89° F) with a maximum mean of 40° C (104° F) and a minimum mean of 2.2° C (36° F) (see Table 3-9).

Table 3-9. Climate Averages of Fort Irwin NTC.

Month	Temperatures °C (°F)		Precipitation cm (in)		Wind m/s (knots)		Humidity/Clouds	
	Mean Max.	Mean Min.	Mean Total	24-Hour Max.	Mean	Peak Gust	Rel. Hum. (%)	Cloud Cover (%)
January	15.6 (60)	2.2 (36)	1.5 (0.6)	2.5 (1.0)	3.6 (7)	34.5 (67)	54	40
February	18.9 (66)	4.4 (40)	0.8 (0.3)	1.8 (0.7)	4.1 (8)	35.5 (69)	47	40
March	21.7 (71)	6.7 (44)	1.0 (0.4)	2.3 (0.9)	5.7 (11)	36.0 (70)	45	30
April	26.1 (79)	10.0 (50)	0.8 (0.3)	1.8 (0.7)	6.2 (12)	37.6 (73)	34	30
May	30.6 (87)	14.4 (58)	0.3 (0.1)	1.0 (0.4)	6.2 (12)	36.5 (71)	30	30
June	36.7 (98)	18.9 (66)	0.3 (0.1)	1.3 (0.5)	6.2 (12)	34.5 (67)	22	10
July	40.0 (104)	22.8 (73)	0.8 (0.3)	2.5 (1.0)	5.7 (11)	26.8 (52)	24	20
August	38.9 (102)	22.2 (72)	1.3 (0.5)	5.3 (2.1)	5.1 (10)	25.7 (50)	28	10
September	35.0 (95)	18.3 (65)	1.0 (0.4)	5.8 (2.3)	4.6 (9)	30.9 (60)	32	10
October	28.3 (83)	12.8 (55)	0.5 (0.2)	1.8 (0.7)	4.6 (9)	30.4 (59)	34	20
November	21.1 (70)	6.1 (43)	0.8 (0.3)	2.8 (1.1)	4.1 (8)	29.8 (58)	38	30
December	16.7 (62)	2.2 (36)	1.0 (0.4)	2.5 (1.0)	3.6 (7)	31.9 (62)	42	30
Annual	27.2 (81)	11.7 (53)	9.9 (3.9)	5.8 (2.3)	5.1 (10)	37.6 (73)	36	30

Period of Record: Barstow/Daggett Airport 1949-1981; Bicycle Lake AAF 1986-1990.
Source: Lance S. Jensen, Capt., USAF, NTC Staff Weather Officer as contained in MBA 1991.

Rainfall varies considerably with almost all of the annual rainfall coming from the fringes of mid-latitude storms from August to April. Summers are often completely dry except for occasional widely scattered thundershowers. Rainfall averages approximately 9.9 cm (3.9 in) per year. Relative humidity is typical of the high southeast Mojave Desert area and is low in the summer except during infrequent rain storms (BLM 1996).

3.2.1.5 Air Quality

There are no major sources of air pollution in the area. Air quality is affected by air pollution transported from the Los Angeles Basin, pollution generated by vehicles on the I-15 corridor, particulate matter from desert wind storms, and activities occurring on unpaved routes in the desert. Data from a Barstow air monitoring station show inland transport of air pollutants from the Los Angeles Basin area, particularly with respect to ozone (see Table 3-10).

Table 3-10. National Ambient Air Quality Standards (NAAQS) and 1995 Local Monitoring Data.

Pollutant	Averaging Time	NAAQS $\mu g/m^3$ (ppm)		Maximum Observed Concentrations by Monitoring Location $\mu g/m^3$ (ppm)			
				Silurian Lake			
		Primary	Secondary	(Barstow)	(Mojave)	(Lancaster)	(Trona)
SO_2	24 Hour 3 Hour annual	365 (0.14) None 80 (0.03)	None 1310 (0.5) None	nm nm nm	nm nm nm	nm nm nm	16 (0.006) nm 29(0.011)
NOx	annual	100 (0.05)	100 (0.05)	240 (0.12)	240 (0.12)	280 (0.14)	100 (0.05)
CO	8 Hour 1 Hour	10 (9) mg/m^3 40 (35) mg/m^3	None None	2.3 (1.98) mg/m^3 6.9 (6.1) mg/m^3	nm nm	nm nm	nm nm
PM_{10}	24 Hour annual	150 50	150 50	116 28.73	43 nm	61 nm	51 22.3
Lead	quarterly	1.5	1.5	nm	nm	nm	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	236 (0.12)	236 (0.12)	275 (0.14)	177 (0.09)

NAAQS are as listed in 40 CFR, Part 50.
1995 Monitoring Data presented.
nm = not monitored.

Photochemical smog levels (mainly ozone) at Barstow have exceeded the California Ambient Air Quality Standards' (CAAQS) 1-hour average of 177 micrograms per cubic meter ($\mu g/m^3$) (0.09 ppm) every year for the 5-year period from 1990 to 1994 with fairly steady levels since 1990. Carbon monoxide shows no exceedances over the 5-year period, with peak levels slightly decreasing in recent years. Nitrogen dioxide has shown one exceedance of the standard at the Trona monitoring station. The area is currently considered in attainment for Nox. The 24-hour average CAAQS for PM_{10} particulates was exceeded several times each year for the 5 years from 1990 to 1994 but shows a downward trend in the number of exceedances as indicated by the 1995 data. Airborne particulate exceedances were strongly correlated with desert wind storm frequencies and increased construction activities in the High Desert in the early 1990's. Total suspended particulates and PM_{10} are mainly the products of windblown dust and physical disturbance (BLM 1996).

The area is still listed as in nonattainment of the state and federal PM_{10} standard as of January 1997 due to the exceedances in 1990 to 1994.

The Silurian Valley is in attainment of the federal ozone standard, but not the state standard. The proposed project area is also in attainment of the California hydrogen sulfide standard (BLM 1996).

3.2.1.6 Airspace and Air Traffic

The nominal (planned) Silurian Lake flight track is approximately 129 km (80 mi) long. The flight path is located entirely within the R-2508 Complex described in Section 3.1.7. Airspace above the lake bed is part of the Shoshone MOA indicated as Complex 4A on Figure 3-5, and military flight operations do not involve surface to 61 m (200 ft) which is considered as uncontrolled, Class G airspace under the Federal Aviation Administration classification system. Silurian Lake is also located in the Los Angeles Air Route Traffic Control Center (ARTCC) Sector 16. Table 3-11 details the specific restricted sectors and MOAs included in the intervening airspace between Edwards and Silurian Lake. All coordination of X-33 flight between Edwards and Silurian Lake would be under the authority of the Air Force Flight Test Center.

Table 3-11. Control Authority and Airspace Restrictions of Nominal Flight Path from Edwards to Silurian Lake (NOAA 1997-A).

RESTRICTED SPACE	TIME USED	ALTITUDE RESTRICTION
R2502N	Continuous	Unlimited
R-2515	Continuous	Unlimited
R-2524	Continuous	Unlimited
R-2508	Continuous	6100 m (20,000 ft) -Unlimited
Panamint	Mon-Fri	61 m (200 ft) AGL to 5,500 m (18,000 ft)
Shoshone	Mon-Fri	61 m (200 ft) AGL to 5,500 m (18,000 ft)

3.2.1.7 Biological Resources

Vegetation

Silurian Lake lies within the Mojave Desert scrub biome (region) of California (BLM 1996). The area surrounding Silurian Lake can be classified as a Mojave creosote bush scrub, at the most simple and general level of community classification. The Mojave creosote bush scrub community is characterized by dominant creosote bush that forms an open shrub community 0.5 to 3.0 m (1.6 to 9.8 ft) tall with considerable bare ground between shrubs. These are usually found on well-drained soils, bajadas (alluvial fan), and low hills, but not in highly saline or alkaline soils. This habitat is not found in significant concentrations on the steepest and rockiest slopes, washes, saltbush flats, and dry lake beds. Additional community types in the Silurian Valley are Mojave Creosote Bush Scrub/Joshua Tree Woodland and Mojave Creosote Bush Scrub/Desert Saltbush.

Open playas or dry lake beds occur at the lowest elevations in closed basins where runoff temporarily collects after heavy rains. Waters that settle on the playas bring fine silts and clays

that are deposited along with salts and minerals. Therefore, playas are poorly drained and usually saline or highly alkaline. They are nearly flat and generally devoid of vegetation. Silurian Lake is largely unvegetated, except for a few small stands of chenopod scrub and salt cedar (*Tamarix* sp.) (BLM 1996).

Wetlands and Floodplains

Large-scale winter storms originating in the Pacific Ocean account for the majority of the precipitation in the Mojave Desert. High-intensity thunderstorms originating in the Gulfs of California or Mexico during the summer months are responsible for most of the remainder of the precipitation. Floods resulting from short duration, heavy rains account for a significant percentage of desert erosion. If concentrated in a canyon, the flood wave has great erosive and transportive power. If it is spread over an open slope or bajada, a slower moving and less destructive sheet flow occurs.

A significant portion of rainfall is lost to evaporation and plant transpiration soon after it falls. Some of the rainwater quickly infiltrates into the porous alluvium of the desert floor and eventually reaches the deeper underlying saturated sediments. The remainder flows into ephemeral streams and washes that carry it to lake beds and other sinks. Due to the rugged and diverse topography, a variety of surficial hydrologic features are found in the region, including springs, seeps, ephemeral streams, and playas (BLM 1996).

Due to the known ponding of water each year and the general characteristics of Silurian Lake, the U.S. Army Corps of Engineers (COE) was consulted on the jurisdictional wetlands or floodplains classification of the lake bed. Insufficient data exist on the lake bed to allow an expeditious determination of status. The COE advised that a prudent position would be to assume that Silurian Lake would meet the definition of a jurisdictional wetlands or floodplains and apply for a Section 404 permit under the Clean Water Act if one is required. NASA agrees with COE's advice (McCaleb 1996).

The closest riparian area is at Salt Creek, approximately 10 km (6 mi) northwest of Silurian Lake. BLM has designated this area, where year-round surface water supports riparian/wetland vegetation and wildlife, as an Area of Critical Environmental Concern (ACEC). The Salt Creek drainage carries stormwater flow northwesterly off the Silurian Lake playa and into the Salt Creek ACEC.

Wildlife

Silurian Lake is essentially devoid of vegetation and does not provide wildlife habitat when dry although some species migrate across the lake bed. Migratory birds and large mammals visit these areas on occasion after heavy rains (BLM 1996).

3.2.1.8 Threatened, Endangered, and Sensitive Species

Vegetation

No listed federal or state threatened or endangered species are known to occur in the Silurian Valley. Some potential exists for Federal Species of Concern (FSOC) and species considered rare or declining by California Native Plant Society (Appendix F, Table F-2). A rare plant survey conducted in the Silurian Valley in 1993 revealed six sensitive plant species. One small-flowered androstephium plant (*Androstephium breviflorum*, FSOC) was observed in the low hills on the southern border of Silurian Valley. Nine populations of sand linanthus (*Linanthus arenicola*, FSOC) were located in sandy washes on the bajadas of Silurian Valley and north of the Avawatz mountains. Areas of high, moderate, and low sensitivity with regard to plant species and habitat are delineated on a sensitivity potential map (Figure 3-15). Sensitivity areas are based on the presence of sensitive species, potentially suitable habitat, regional abundance of habitat or community type, and level of habitat disturbance. The area around Silurian Lake is considered moderately sensitive because no sensitive plants were observed and disturbance is low in the areas which contain considerable habitat suitable for sensitive species (BLM 1996).

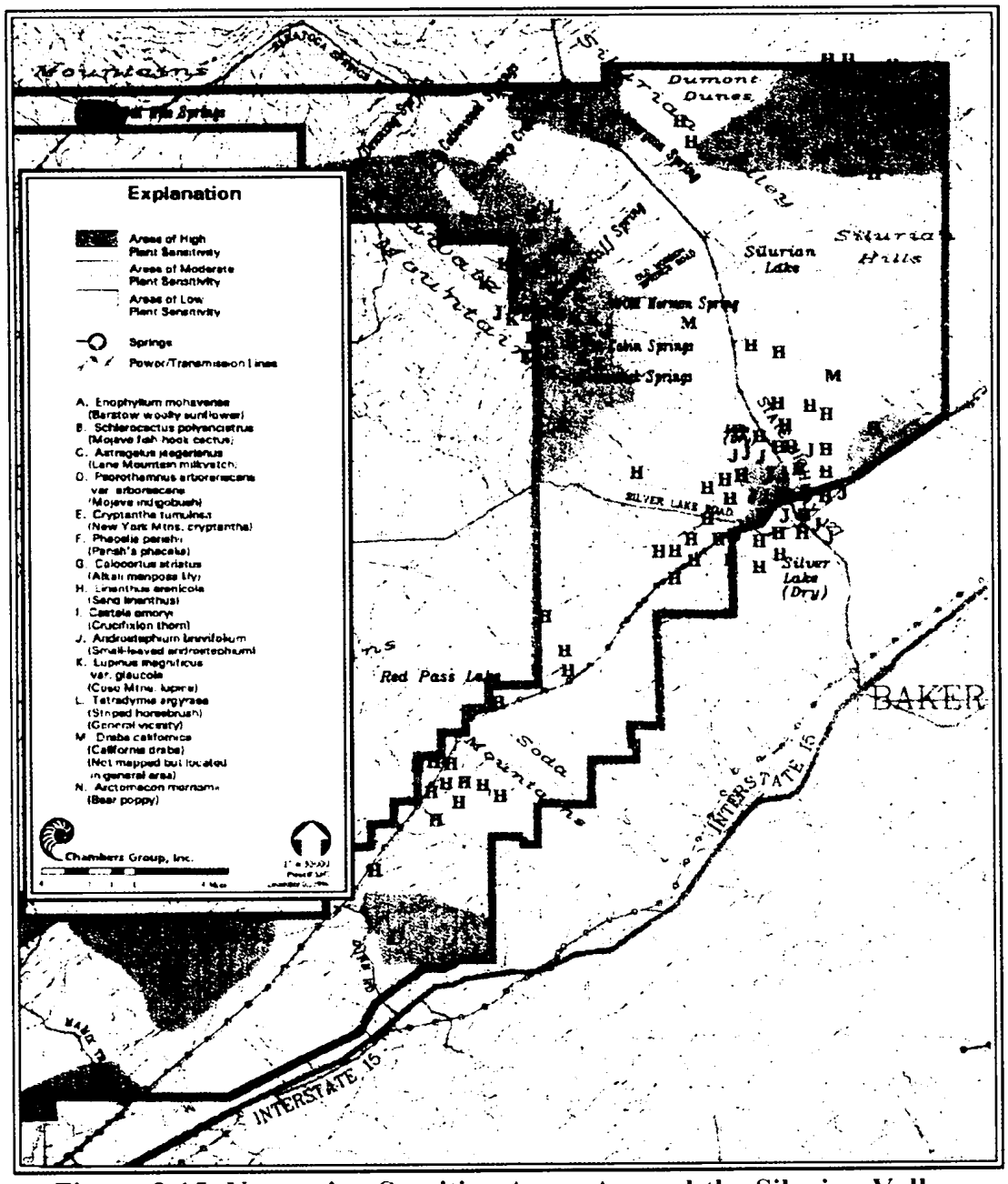


Figure 3-15. Vegetation Sensitive Areas Around the Silurian Valley.

Wildlife

The desert tortoise (*Gopherus agassizii*), a federal and state threatened species, is an herbivorous reptile found in portions of California, Arizona, Nevada, and Utah deserts. A 1992 survey conducted for the desert tortoise in the Silurian Valley showed very little occupied habitat. No tortoises, tortoise burrows, or other evidence of tortoises have been documented on immediately adjacent areas (Egan, pers. comm.). Therefore the area is not designated as a BLM Desert Tortoise Category nor is it designated critical habitat.

Low elevations and extremely rocky soils are likely important factors making the area unsuitable for tortoises. The only areas where any signs of tortoises were found are approximately 3 miles both north and south of the Silurian Hills. The total size of these occupied areas was approximately 60 sq km (23 sq mi) with the average tortoise density being 16.2 tortoises per sq km (26 tortoises per sq mi) (Figure 3-16). Twenty-six of the 60 sq km (10 of the 23 sq mi) had density estimates of less than 12.4 tortoises per sq km (20 tortoises per sq mi). These estimates are in contrast to the entire Silurian survey area with an average density of 1.2 tortoises per sq km (2 tortoises per sq mi). A list of federal and state species of concern is found in Table F-2 (BLM 1996).

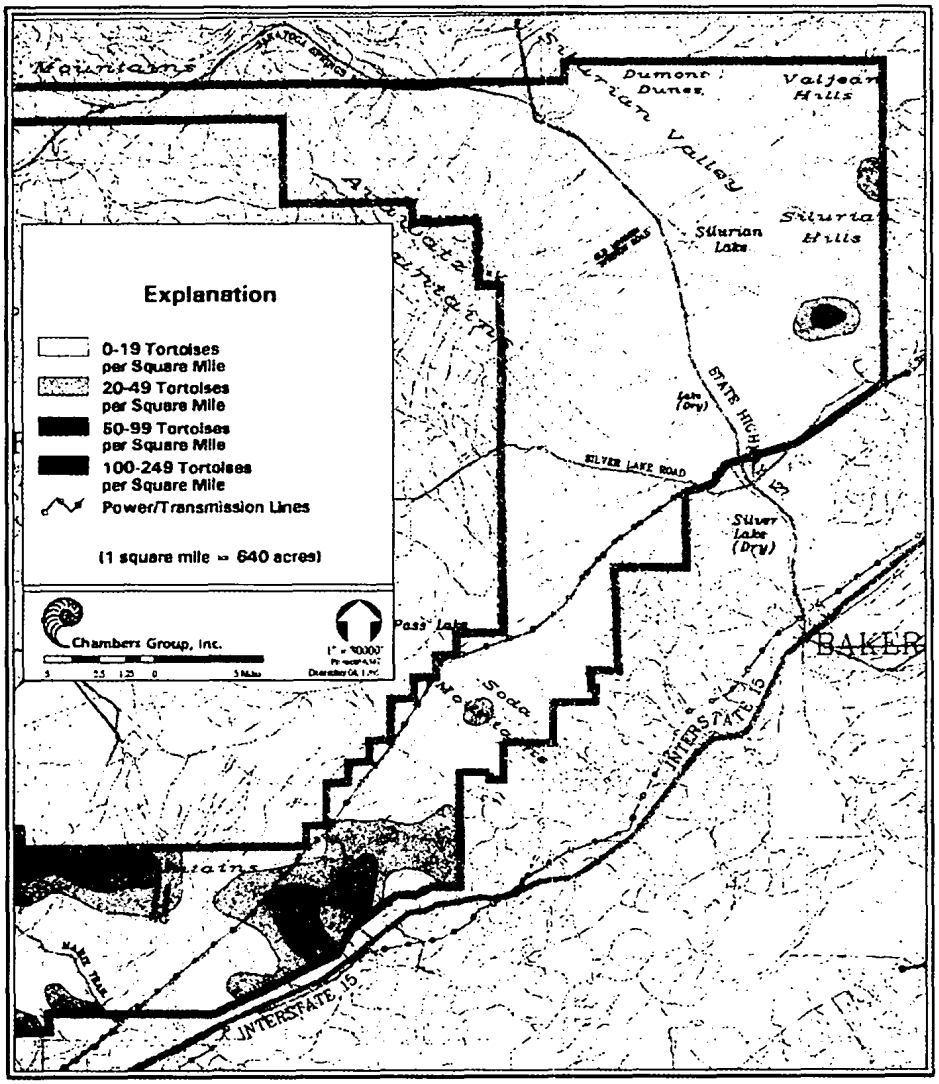


Figure 3-16. Desert Tortoise Densities Around the Silurian Valley

3.2.1.9 Cultural Resources

In 1995, a geomorpholgical study was conducted which included an archaeological investigation. This survey of approximately 5,140 ha (12,700 ac), resulted in the recording of 92 sites. These sites are comprised of 79 prehistoric sites, 9 historic sites, and 4 sites containing both prehistoric and historic components. None of these sites are on or adjacent to the lake bed, which has been proposed as an alternate landing site for the X-33. A survey of 1,740 ha (4,300 ac) was completed in late 1995, and a survey of an additional 16,188 ha (40,000 ac) began in January 1996 (BLM 1996). None of these sites are on or adjacent to the lake bed.

Cultural resource surveys were conducted in the Silurian Valley area from 1994 to 1996. The results of the surveys include a prehistoric lithic scatter measuring 12 m by 20 m (40 ft by 66 ft) is located along the eastern shoreline of the lake bed. This scatter differed from the other five scatters found during the surveys because it contained three types of material instead of two, and the only biface fragment recovered was from this site. Isolated flakes of prehistoric materials have also been documented from the north end of the lake bed.

A number of historic routes and trails traversed the study area. The Old Spanish Trail/Mormon Road was used by pack trains and trade caravans traveling between Sante Fe and California from 1830 until 1848. It skirted the western edge of Silurian Dry Lake. Two small dirt roads split from the main trail toward the Avawatz Mountains. Although no archaeological evidence was found along these routes, their placement near the lake bed is based on historic documents archived by the San Bernardino County Information Center. The Silurian Lake/Riggs Road is a 7 km (4.2 mi) dirt road extending from the historical railstop at Riggs to the Old Spanish Trail (Highway 127). Historical trash, including cans dated from 1910 to 1920, is scattered along the entire route. One 35 m by 125 m (115 ft by 412 ft) dump with many cans and amethyst glass fragments was found along the road (ASM Affiliates, Inc. 1997).

3.2.1.10 Water Resources

Groundwater

Groundwater is stored within the soils and rock strata. Recharge to underlying aquifers occurs through direct infiltration of precipitation, subsurface flow from adjoining valley groundwater basins, and runoff and subsequent infiltration of flash flood waters originating in the surrounding mountainous areas. There is limited data concerning depth to groundwater throughout the areas. Historically, groundwater was withdrawn from the southeastern end of Silurian Lake for use at the Riggs Mine. Inspection of the lake revealed the presence of groundwater at approximately 6 m (20 ft) below ground surface (BLM 1996).

Surface Water

The Silurian Valley is part of a large topographic trough that extends southward more than 81 km (50 mi) from the southern end of Death Valley. Salt Creek flows north and is a primary watercourse draining parts of the Silurian Valley. In general, the Silurian Valley trends in a north-south direction, with tributary washes extending far back into the mountains to the east and west. The drainage basin configuration is similar to an inverted "L." Runoff from the bordering mountains flows across coalescent alluvial fans (bajadas) toward the central valley floor (BLM 1996).

Playa lake beds such as Silurian Lake dry rapidly but contain surface water for 3 to 4 weeks following heavy rainfall. Impermeable clay deposits are formed by the continual deposition of fine suspended solids in runoff when ponded water evaporates or percolates into the ground. These impermeable clay layers result in diminished groundwater recharge to subsurface aquifers around playa lakes. Ambient evaporation rates tend to dry the lake surfaces rapidly. Playa lakes may accumulate up to 0.9 m (3.0 ft) of water (BLM 1996).

3.2.1.11 Geology and Soils

Playas in this area occur in very poorly drained areas of flats and closed basins at elevations from 518 to 975 m (1,700 to 3,200 ft) mean sea level. Playa soils are very poorly drained with very slow runoff and may pond for short periods at infrequent intervals. They are saline-alkaline and range in clay content and texture from silty clay to loamy sand. The incidence of soil blowing is very high when conditions are dry (BLM 1996).

3.2.1.12 Health and Safety

Silurian Lake is public land under the control of BLM and is not normally used for space vehicle landing activities. Silurian Lake is not a controlled access area, and there are presently no means to control public access. There is no dedicated safety and health organization with experience in this type of operation that has responsibility at Silurian. Wildfire protection is provided by BLM. Structural, vehicle, and other fires not involving land are responded to by the San Bernardino County fire station in Baker, California. Emergency medical response is provided by Baker Emergency Medical Services, Inc. from Baker, located 26 km (16 mi) to the south. The nearest hospital is located in Barstow, 121 km (75 mi) from Silurian Lake. Air ambulances are available for transporting serious injuries to larger hospitals near Victor Valley and the San Bernardino-Riverside area.

3.2.1.13 Noise

The ambient noise environment in the vicinity of Silurian Lake is determined primarily by military operations. Military training exercises at the National Training Center (NTC), Fort Irwin, whose east boundary is located approximately 13 km (8 mi) west of the Silurian Lake area, include ground maneuvers by army vehicles, artillery firing, air operations, air-to-ground gunner and firing, and transportation to, from, and within the NTC during and after maneuvers. Routine military aircraft operations in established airspace corridors also contribute to the existing noise environment. Secondary contributors to the noise environment include traffic along State Highway 127 and commercial and private aircraft that fly outside of NTC's existing boundaries (BLM 1996).

Noise monitoring was conducted in Silurian Valley in 1992. The survey revealed that noise within the area is characterized by the natural sound of the wind as well as the sound produced by aircraft overflights. Traffic noise predominated near State Highway 127 (BLM 1996).

3.2.1.14 Transportation

State Highway 127 is the closest roadway, located adjacent to Silurian Lake on the west side. This highway is a north-south route beginning in Baker at I-15 and extending north to Death Valley National Park, which is a major tourist and commercial route to points north in eastern Inyo County and agricultural communities in Nevada. Approximately 72 percent of the estimated 1.5 million annual visitors to Death Valley National Park use the State Highway 127 access. The daily average traffic usage at the junction of State Highway 127 and Saratoga Springs Road, north of Silurian Lake is 800 vehicles per day (based on 1995 traffic counts) (Busacca 1997A). It is a two-lane highway providing one lane in each direction. I-15 is the major route in the vicinity of Silurian Lake and is a four-lane highway linking San Bernardino, California, and Las Vegas, Nevada. There are also a few light-duty, unpaved roads in the area (Figure 3-17) (BLM 1996).

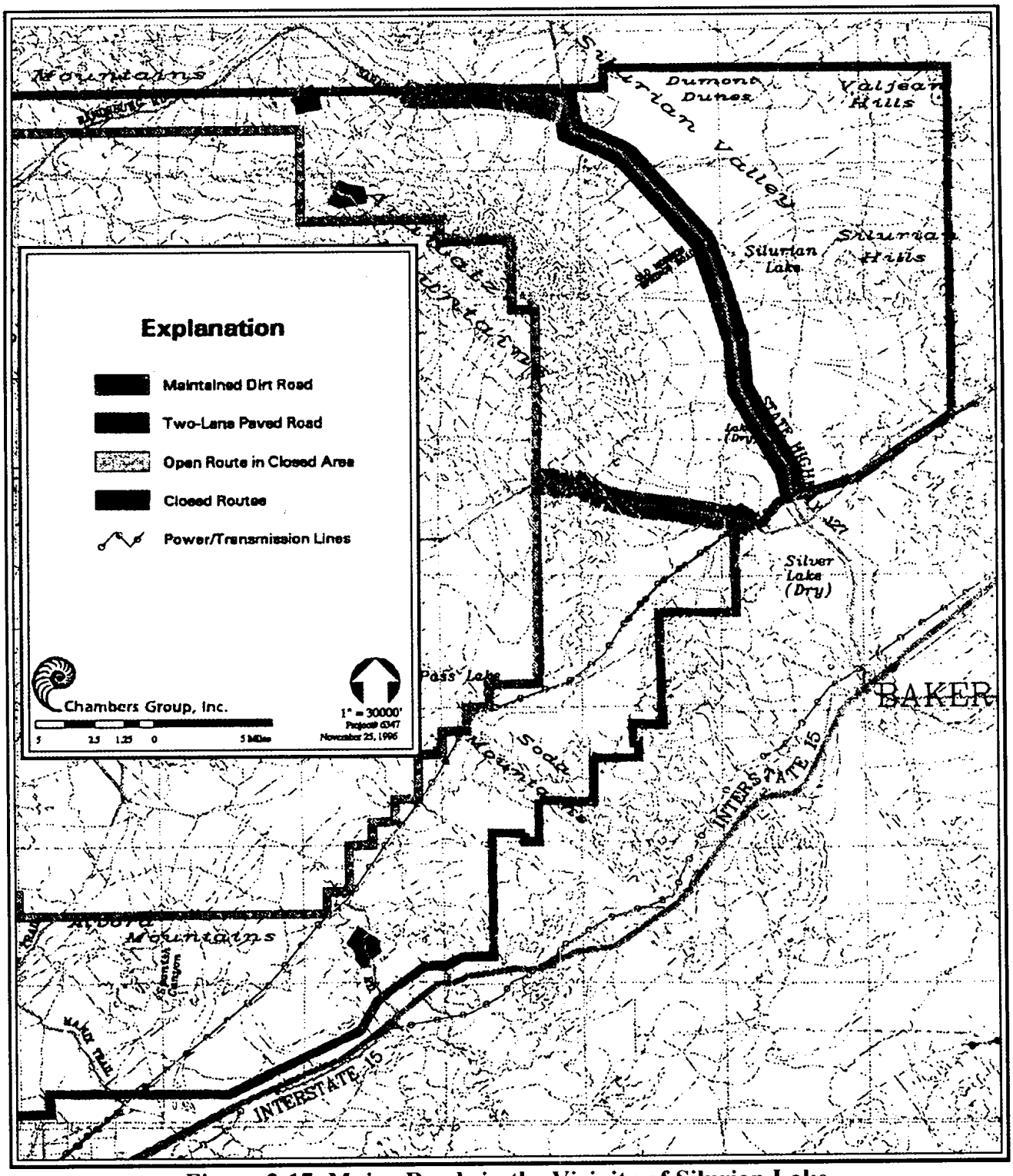


Figure 3-17. Major Roads in the Vicinity of Silurian Lake.

3.2.1.15 Population and Employment

Silurian Lake is surrounded by large acreages of vacant lands and low population densities. Employment opportunities are provided by small communities outside the proposed project area. Communities include towns along I-15 from Barstow to Baker to the south of Silurian Valley, Shoshone and Tecopa to the north, and the NTC at Fort Irwin. Most private and public land is vacant. Activities occurring in the vicinity that contribute measurably to employment and/or local economies include mining and grazing. Other activities bringing revenues to local communities include vehicular touring, hunting, camping, and other recreational activities (BLM 1996).

3.2.1.16 Land Use

The California Desert Conservation Area (CDCA) was established by Congress in 1976 with the passage of the Federal Land Policy and Management Act (FLPMA), Public Law 94-579. The Act required the BLM to complete a resource management plan for the CDCA to accomodate a variety of uses and to ensure continuing protection of the public lands and resources. The CDCA Plan was completed by BLM in 1980.

The CDCA Plan identifies the management of the public lands under four "multiple-use classification". The public lands at Silurian Lake (the lake bed surface) are designated as multiple-use class I (Intensive). Its purpose is to provide for concentrated use of lands and resources to meet human needs. Reasonable protection is provided for sensitive natural and cultural values. The areas surrounding the lake bed are designated as multiple-use classes M (Moderate) and L (Limited). Management of class M areas provides for a wide variety of present and future uses while conserving desert resources and applying adequate mitigation. Class L public lands are managed for the protection of sensitive natural, scenic, ecological and cultural resources by allowing only carefully controlled and limited land uses. The BLM CDCA Plan multiple use classes in and around Silurian Lake are shown in Figure 3-18.

In addition to the multiple-use class designations, the CDCA Plan also designates certain "Areas of Critical Environmental Concern" (ACEC) where special management attention is required to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes. The Salt Creek Hills ACEC (Figure 3-19) is located approximately 6.5 km (4.0 mi) north of Silurian Lake. The ACEC is set aside for the protection of the desert stream, riparian habitats and associated wildlife, and historic and prehistoric cultural resources. The BLM management plan for the Salt Creek Hills ACEC provides guidance for protection of these resources. The area also receives recreation use such as camping, dove hunting, rockhounding, sightseeing, hiking and horseback riding (BLM 1996).

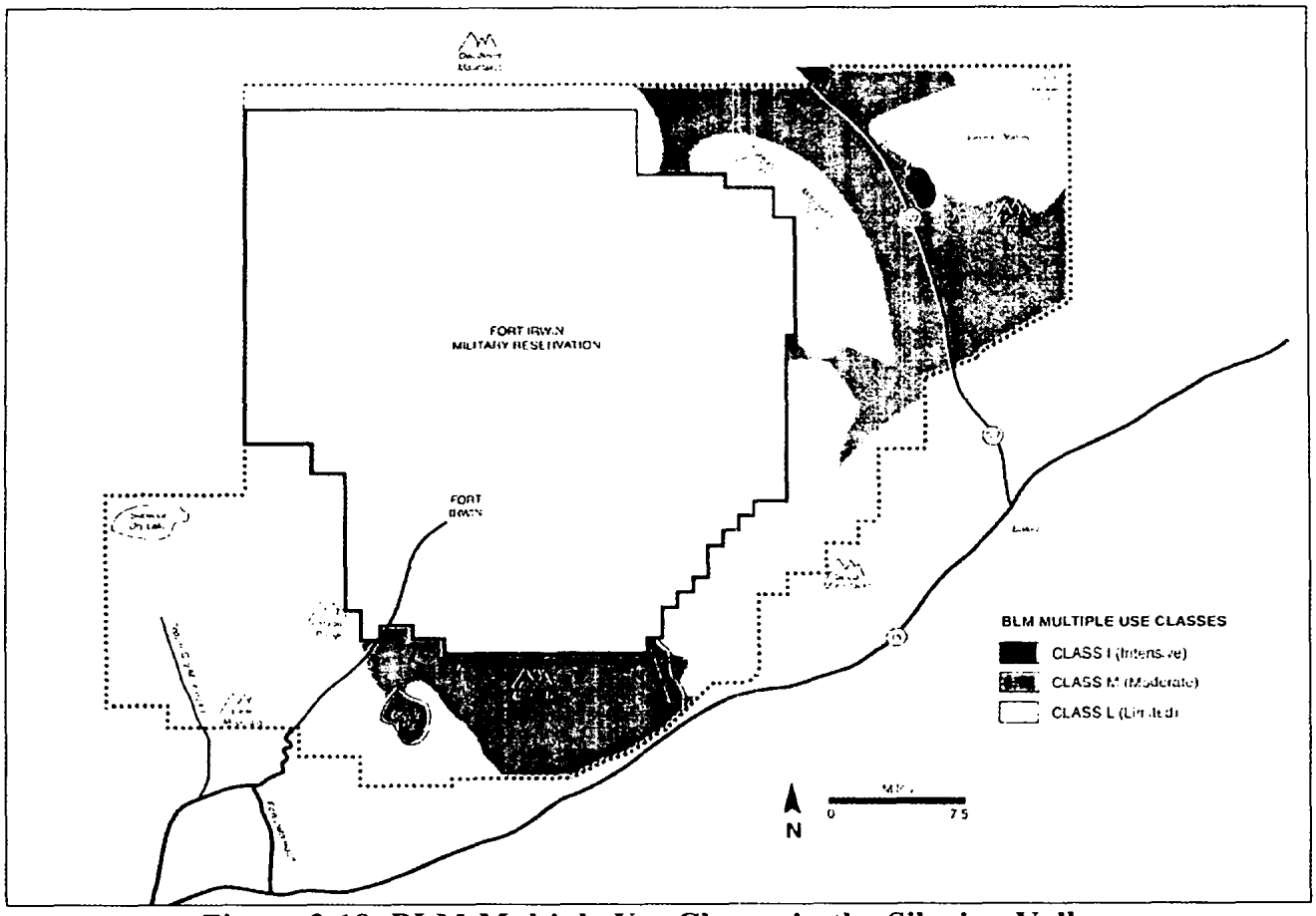


Figure 3-18. BLM Multiple Use Classes in the Silurian Valley.

The CDCA Plan also designated Wilderness Study Areas (WSA); public lands that meet the criteria for further consideration for potential recommendation and designation under the Wilderness Act of 1964. Upon passage of the California Desert Protection Act in 1994, five BLM WSAs in the Silurian Valley area became Congressionally designated as WSAs (Figure 3-20). The Kingston Mountains WSA boundary is located within 1.6 km (1 mi) of Silurian Lake. Any proposed action in a WSA must meet certain "non-impairment" criteria to ensure that the activity does not impair the area's future consideration for designation as wilderness. Those proposed activities not meeting these criteria are not allowed.

The main current uses of Silurian Lake and surrounding areas are commercial filming operations permitted by BLM, landsailing, mining, sightseeing, rockhounding, and vehicle touring. The California Statewide Motorized Trails Plan shows several routes that cross the Silurian Valley (BLM 1996).

Another recreational use of Silurian Lake is land sailing. BLM estimates that land sailing use is less than 50 visitor use days annually with fewer than 200 annual visits for all recreation purposes. Off-highway vehicle use is dispersed throughout the area. The California Statewide Motorized Trails Plan has several routes that cross the Silurian Valley (BLM 1996). BLM has also issued temporary use permits in the past for commercial movie filming in the vicinity of and on the lake bed.

The Silurian Lake area is included in the expansion of Ft. Irwin (BLM 1996). If the area is transfered to Ft. Irwin prior to flight testing, Ft. Irwin has indicated that commitments for use of the area for flight tests will not be affected.

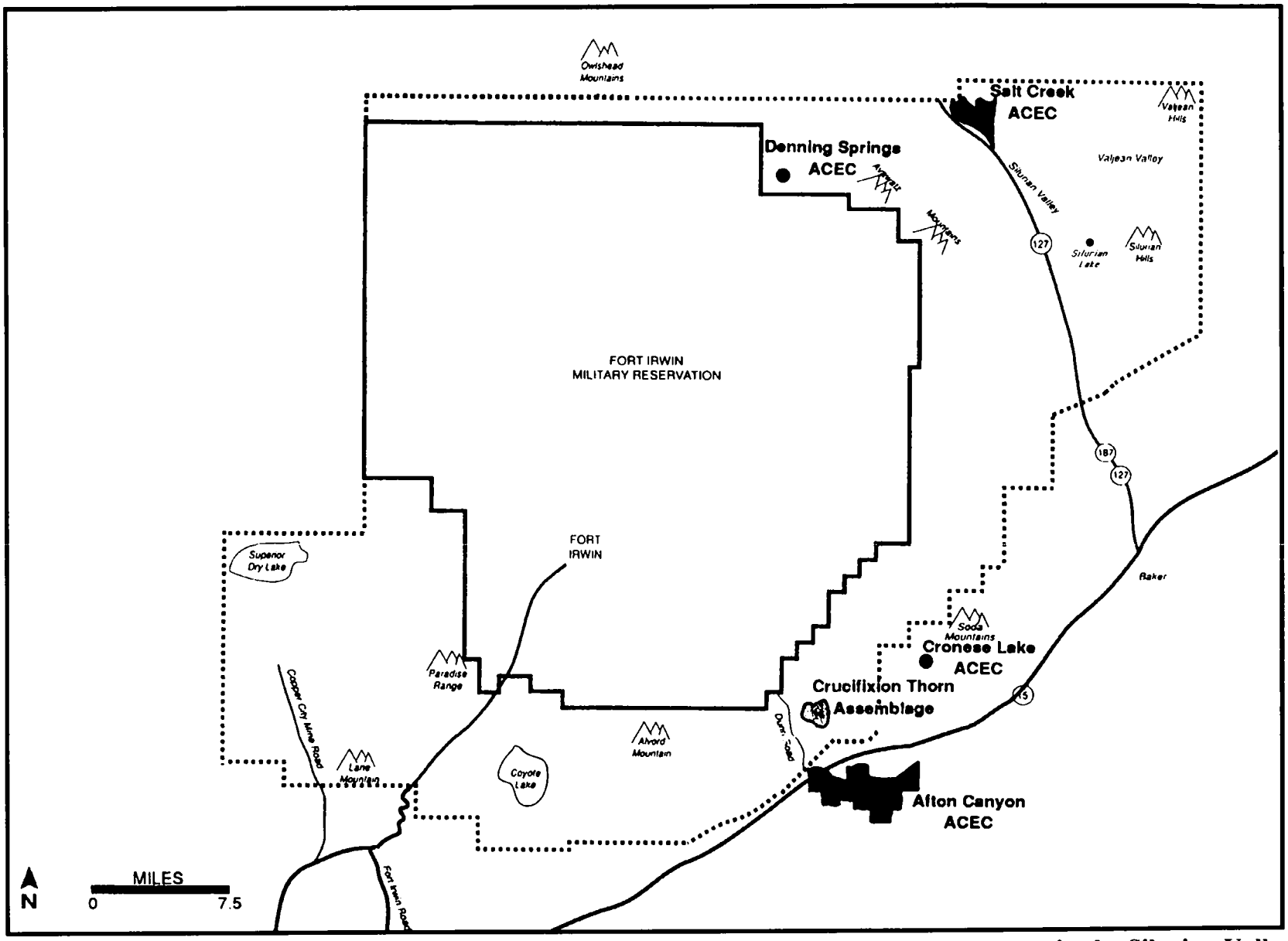


Figure 3-19. Areas of Critical Environmental Concern (ACEC) and Unusual Plant Assemblages in the Silurian Valley.

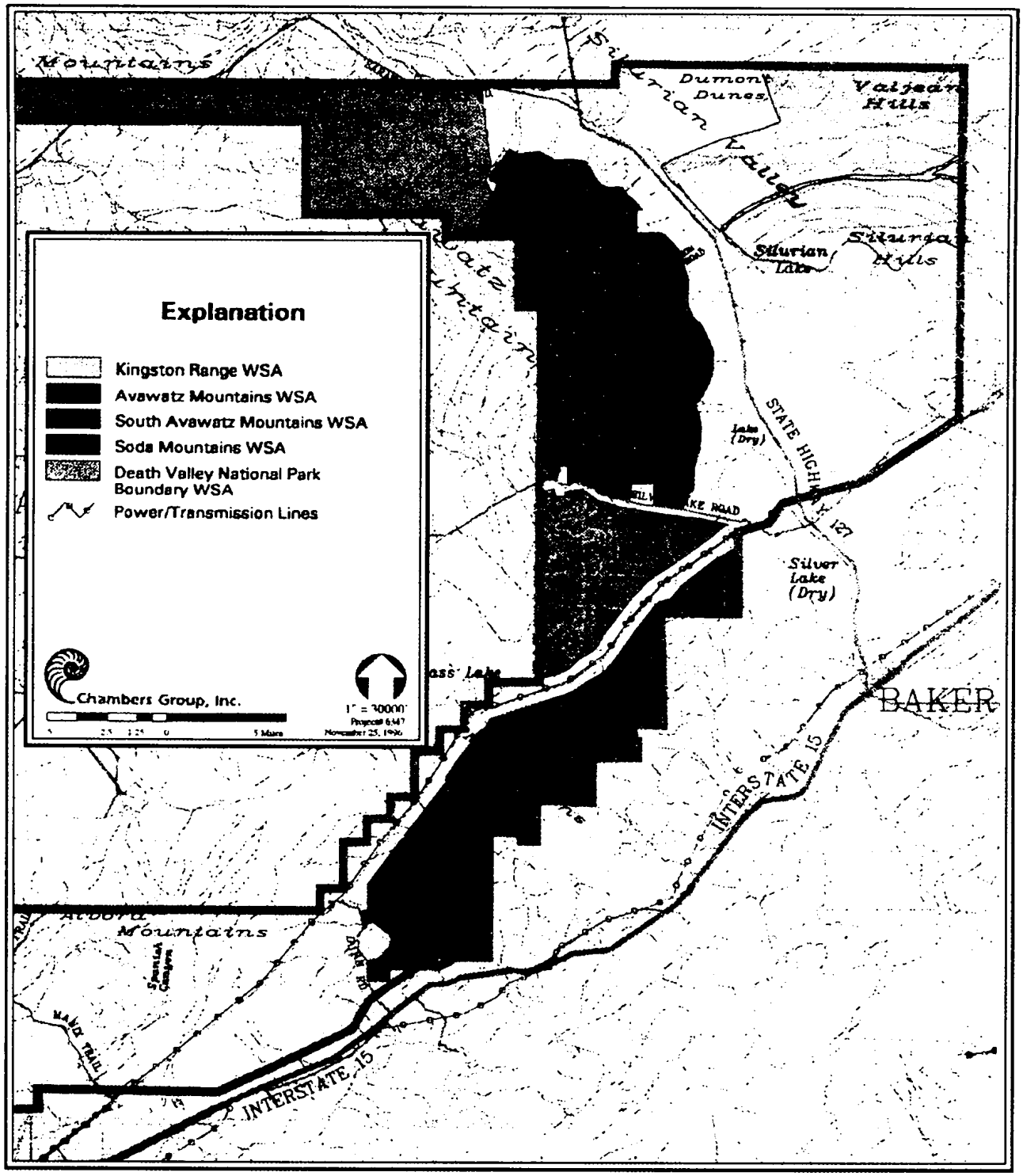


Figure 3-20. Wilderness Study Areas in the Silurian Valley.

3.2.1.17 Snow Conditions

During scoping, the potential for sonic booms to trigger snow avalanche was raised in Great Falls, Montana. Due to low frozen precipitation potential in southern California, this issue is not applicable to Silurian Lake.

3.2.2 China Lake Naval Air Weapons Station

3.2.2.1 Site Infrastructure

Runways

Armitage Airfield encompasses more than 4,452 ha (11,000 ac) of land approximately 4.8 km (3 mi) northwest of the Naval Air Weapons Station (NAWS) Headquarters Building. The airfield is geographically located at latitude 35' 41" north and longitude 117' 41" west at an elevation of 696 m (2,283 ft) above mean sea level. The runways form a triangular pattern which includes Runways 3-21, 14-32, and 8-26 (see Figure 2-12), and dimensions and use patterns are given in Tables 3-12 and 3-13. All runways are equipped with E-28 arresting gear systems and are accessible by airfield fire protection crash crews and equipment. Runway 3-21 was identified as meeting X-33 landing criteria since it is 3,048 m long by 61 m wide (10,000 by 200 ft). Runway 21 has an end turnoff width of 31 m (100 ft).

Table 3-12. Runways at China Lake Naval Air Weapons Station.

Runway	Width	Length	Remarks
3-21	200 LF	10,000 LF	Primary runway; drone aircraft launched and recovered on 21.
8-26	200 LF	7,700 LF	Used for back-taxi, emergency recoveries.
14-32	200 LF	9,000 LF	Instrument runway.

Sources: Air Operations Manual, 1985; Reece, 1987.
LF = linear feet

Table 3-13. Runway Utilization at China Lake Naval Air Weapons Station.

Runway	Departures	Patterns	Arrivals	Totals
21	17.1%	35.4%	16.9%	69.4%
3	0.2%	0.2%	0.2%	0.6%
14	3.7%	9.2%	3.6%	16.5%
32	1.8%	3.6%	1.8%	7.2%
26	1.4%	3.0%	1.5%	5.9%
8	0.1%	0.2%	0.1%	0.4%
Total				100.0%

Source: Harris Miller Miller & Hanson, 1986 (1984 Operations Data)

Aircraft parking space is limited since part of the hangar parking apron lies inside the Runway 14-32 primary surface. Aircraft now park inside the primary surface, which deviates from safety criteria. Transient aircraft are frequent at China Lake because visiting squadrons use the Weapons Station ranges and aircraft in transit between the Nevada test ranges and coast bases refuel at the Station.

Water Supply and Distribution

Water sources supplying the main population center at China Lake are deep wells in the Indian Wells Valley. The water transmission line is on a west-to-east axis, parallel to and north of State Highway 178 (Inyokern Road), with the westernmost source being two wells at the Harvey Field Pumping Plant, which is 13 km (8 mi) west of the Station's main gate. The water transmission system consists of six wells, deep well pumps, pumps to move water along the transmission line, 14 reservoirs, pressure reducers, and approximately 346 km (140 mi) of asbestos cement and cast iron piping. The water supply system is currently not used to capacity. Condition of the water distribution system ranges from poor to good since the majority of existing water transmission pipeline and distribution system was installed between 1945 and 1946.

Wastewater

The city of Ridgecrest owns and operates the on-Station sewage treatment plant and has the responsibility of maintaining and upgrading the plant as required to meet water quality standards and future loadings. The plant processes sewage from populated areas of the Station and Ridgecrest. Operation is under the jurisdiction of the Regional Water Quality Control Board.

The main site area and the city of Ridgecrest are served by separate sewer systems, which terminate in the single sewage treatment plant on Station. Effluent from these systems flows to the sewage treatment plant, where primary treatment consists of the removal of grit and primary sediment. Secondary treatment is provided by a series of seven oxidation ponds and four evaporation ponds on approximately 89 ha (220 ac). The plant has a rated design capacity of 16.7 MLD (4.4 MGD), and the average daily volume is around 8.7 MLD (2.3 MGD) (USN 1989). The sewer system at the Station is in fair to good condition, and maintenance is done on an as-needed basis.

Electricity

The Station receives its electrical power from Southern California Edison at 34,500 volts, 3 phase, 60 hertz. It is delivered from the Inyokern Substation, which also serves the city of Ridgecrest. The capacity of the substation is about 110 megavolt-amperes (MVA), of which 50 to 75 MVA are available to the Station through 3 overhead feeders. Local distribution, the 34,500-volt power, is fed over 6 lines to various substations which transform it to 4,800 volts. There are approximately 805 km (500 mi) of power lines at the two distribution voltages.

Fifty MVA are available to the Station from the Inyokern substation, with the largest annual peak demand being 25.2 MVA.

Communications

The Station Telecommunications System (CTS) is computer controlled, fully digitized integrated voice and data system and provides the following capabilities: voice, digital data, and communications. CTS includes universal wiring with modular telephone and data jacks and plugs. Also included are voice communications within the Station and access to off-Station voice networks.

CTS has the capability to provide digital data communications without the use of modems for terminals, computers, and interface units.

Fuel

The aircraft-ready fuel facility site occupies approximately 6.1 ha (15 ac). The facility includes primary storage for 1.5 million L (0.4 million gal) of JP-8 fuel in two-0.8 million L (0.2 million gal) aboveground steel storage tanks tied together through pipelines with multiple pumping systems, fuel truck delivery and refueler loading facilities, an aircraft fuel laboratory, a fuel truck staging area, and an oil/water separator (USN 1994). JP-4 fuel is stored at Buildings 4014 and 4015 with capacities of 93,110 L (24,597 gal) and 45,429 L (12,001 gal), respectively. Army aviation gas (30,280 L (7,999 gal)) is stored at Building 4017 with two aboveground defuel tanks (15,140 L (4,000 gal) each) with piping and a pumping system, and one underground product recovery tank (22,710 L (6,000 gal)) with piping and pump. The LOX/LN_2 facility has the ability to handle LOX/LN_2 for aircraft servicing only. The facility has the following equipment: Two 7,570 L (2,000 gal) LOX tanks with capability to pump liquid or gas; one 3,785 L (1,000 gal) LN_2 tank with capability to pump liquid or gas; and one nitrogen purification unit for servicing launcher cylinders (Gomez 1997).

3.2.2.2 Hazardous Materials and Hazardous Waste

Hazardous waste includes explosive and toxic waste (flammable, poison, reactive, etc.). Coordination for the disposal of explosive ordnance hazardous waste is the responsibility of generators who operate under the control of the Naval Air Weapons Station Staff. Other hazardous waste disposal is under control of the Supply Department and is accomplished through operation of the permitted Hazardous Waste Storage and Transfer Facility (HWSTF). Proper management (storage, labeling, and identification) of hazardous waste is also the responsibility of the waste generator. Off-site transportation and disposal of hazardous waste is accomplished through the HWSTF.

The Navy has initiated the Installation Restoration Program to identify adverse environmental impacts resulting from past use and disposal of industrial/military substances on Navy-controlled bases. The Initial Assessment Study identified 43 sites on Station lands as actual or suspected locations of hazardous material/waste disposals or spills. An additional site was added after the study was published. Two sites, Armitage Airfield Dry Wells and Aircraft Washdown Drainage Ditches, are undergoing remedial cleanup action (USN 1989). Remedial cleanup has also begun on Michelson Laboratory Ponds and Salt Wells Ponds. Active cleanup and remediation permits

include: Underground Storage Tanks 5, Resource Conservation Recovery Act, Part B, California-only Treatment 15, and Burro Canyon Interim Status Treatment.

3.2.2.3 Solid Waste

Nonhazardous solid waste is accumulated in dumpsters and rolloff boxes emptied or retrieved by a contracted waste collection and hauling company into a permitted landfill operated by Kern County. Solid waste is recycled under the Station's resource recovery programs. The Defense Reutilization and Marketing Office, which has the largest volume resource recovery program, receives specific materials and equipment. Some materials and equipment are sold at public auctions, some are reissued to various public agencies, and some materials are sold by contract. The Supply Department operates the recycling facility. An estimated 91 metric tons (100 tons) per year of high quality computer and xerographic papers are recovered and sold through this program.

3.2.2.4 Climate

The climate of the region is typical of the southern California high desert and characterized by hot summers, cool to cold winters, large daily temperature variations, low rainfall and humidity, and little cloudiness or visibility restriction (Table 3-14). The Sierra Nevada mountains present a barrier to passing storms and frontal systems resulting in a rain shadow. Rainfall averages 10 to 15 cm (4 to 6 in) a year. Measurable rainfall can be expected about 22 days and snowfall 3 days a year. Thunderstorms occur during August and September in conjunction with the southeast monsoon. Precipitation is at its maximum from November through March, with normal monthly rainfall averaging near 1.3 cm to a little over 1.9 cm (0.5 to 0.75 in).

Table 3-14. Climate for Main Site Planning Area and Ridgecrest Area.

Period	Temperatures ° C (° F)		Average ° C (° F)		Rain	Humidity	
	High	Low	Max	Min	cm (in)	Min	Max
January	23.3 (74)	-4.44 (24)	18.9 (66)	0 (32)	3.18 (1.25)	31%	81%
April	35.6 (96)	2.22 (36)	26.1 (79)	7.8 (46)	0.08 (0.03)	17%	46%
July	42.7 (109)	15.6 (60)	38.3 (101)	17.8 (64)	0.08 (0.03)	13%	49%
October	31.7 (89)	0.56 (33)	27.2 (81)	7.2 (45)	0.08 (0.03)	16%	45%

Summer is characterized by very warm, dry days with cool nights. Afternoon temperatures rise to 37.8° C (100° F) or higher about 67 days a year and drop below 20° C (68° F) at night. The maximum recorded temperature is 50° C (122° F) recorded in 1990, and the annual average monthly mean maximum is 26.7° C (80.1° F). Winters are cool with nighttime temperatures dropping to 0° C (32° F) or less about 77 days a year, then warming to between 12 and 15° C (54 and 59° F) during the day.

Relative humidity in the Coso area is typical of the high northeast Mojave Desert area: low in summer (except during infrequent thundershowers) and relatively low in winter (except during rainstorms). Mean monthly relative humidity at China Lake (1946 - 1976) ranged from a high of

53 percent in January to a low of 27 percent in July. Mean annual lake evaporation in the Coso region was estimated to range from 137 to 198 cm (54 to 78 in) per year.

The strongest surface winds occur from October through May cold fronts move rapidly through the area. Fronts can occasionally cause severe dust and sand storms. Strong surface winds, with a prevailing speed of 29 km/hr (17 mi/hr) or greater, can be expected 15 days a year. For approximately four of these windy days, prevailing visibility will be reduced to less than 11 km (7 mi) from blowing dust and alkali, with Owens Lake sometimes being a significant contributor. Owens Valley is located approximately 121 km (75 mi) north-northwest of the China Lake complex.

3.2.2.5 Air Quality

The proposed project site is located in an area designated non-attainment for both the California and Federal National Ambient Air Quality Standards (NAAQS) for ozone. The state designation "moderate" is based on an ozone concentration of 0.21 ppm measured at Barstow. The federal designation "serious" is based on inclusion of China Lake in the Metropolitan Statistical Area for the city of Bakersfield, some 193 km (120 mi) away. Table 3-15 shows the NAAQS and local monitoring data for the China Lake area.

Table 3-15. National Ambient Air Quality Standards (NAAQS) and Local Monitoring Data.

Pollutant	Averaging Time	NAAQS $\mu g/m^3$ (ppm)		Maximum Observed Concentrations by Monitoring Location $\mu g/m^3$ (ppm)			
				China Lake			
		Primary	Secondary	(Barstow)	(Mojave)	(Lancaster)	(Trona)
SO_2	24 Hour	365 (0.14)	None	nm	nm	nm	16 (0.006)
	3 Hour	None	1310 (0.5)	nm	nm	nm	nm
	annual	80 (0.03)	None	nm	nm	nm	29(0.011)
NO_X	annual	100 (0.05)	100 (0.05)	240 (0.12)	240 (0.12)	280 (0.14)	100 (0.05)
CO	8 Hour	10.3 (10) mg/m^3	None	2.3 (1.98) mg/m^3	nm	nm	nm
	1 Hour	40 (35) mg/m^3	None	6.9 (6.1) mg/m^3	nm	nm	nm
PM_{10}	24 Hour	150	150	116	43	61	51
	annual	350	50	28.7	nm	nm	22.3
Lead	quarterly	1.55	1.5	nm	nm	nm	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	235 (0.12)	235 (0.12)	275 (0.14)	177 (0.09)

NAAQS are as listed in 40 CFR, Part 50.
1995 Monitoring Data presented.
nm = not monitored.

China Lake is within the Searles Valley Planning Area, designated by Environmental Protection Agency as Group I for PM_{10}. The area was subsequently designated by operation of law as "moderate non-attainment" under the 1990 Clean Air Act Amendments, requiring that a State Implementation Plan be submitted by November 15, 1991, demonstrating attainment of the NAAQS by December 31, 1994. Since the Searles Valley Planning Area includes portions of Kern, Inyo, and San Bernardino counties, the State Implementation Plan developed jointly

affected three districts (Kern County Air Pollution Control District, Great Basin Unit Air Pollution Control District, and San Bernardino County Air Pollution Control District, now Mojave Desert Air Quality Management District, respectively). In the State Implementation Plan submittal, the Searles Valley Planning Area was divided into three "subplanning" areas ("China Lake," "Coso Junction," and "Trona") roughly following the districts' jurisdictional boundaries and identified by associated exceedance(s) being addressed.

The PM_{10} value for the China Lake subplanning area (166 $\mu g/m^3$) was measured on March 13, 1991, during a windy day. The value was only 11 percent over the NAAQS and by far the largest segment of the emissions inventory (46 percent) was from unpaved roads. The attainment strategy for Kern County was based on a 25 percent reduction from process fugitives and 15 percent reductions each from wind erosion and unpaved roads. To implement this strategy, the District adopted Rule 402 (Fugitive Dust) on November 29, 1993. This rule requires the application of Reasonably Available Control Measures to all sources of fugitive dust within the subplanning area as well as dust control plans for construction/ demolition projects and large sources. Kern County's strategy also includes enhanced new source review, variance, and enforcement measures. No additional control measures were found to be necessary to demonstrate attainment of the federal standard.

Visibility historically has been excellent in the high desert of the southwest. Natural dust storms and manmade activities such as mining and traffic on dirt roads are local factors occasionally contributing to a lessening of normal conditions of visibility. Visibility of the area is also reduced by pollutants transported from the San Joaquin Valley, particularly in the summer months. Visibility is an issue of critical concern to the Naval Air Weapons Station as good visibility is required to carry out the base mission. China Lake's historic data indicate that visibility is at the lowest level (60 km (37 mi)) during the months of July through September. Visibility improves steadily throughout the summer, fall, and winter months, dropping sharply during the spring, reflecting the dust storms from Owens Lake and increasing influence of smog from the San Joaquin Valley in late spring. Mid-winter readings show great variability, with periods of low visibility attributed to winter precipitation and fog (USN 1989).

3.2.2.6 Airspace and Air Traffic

The flight path from Edwards to Armitage Air Field within China Lake NAWS is approximately 81 km (50 mi) long and wholly within the R-2508 Complex. The airfield is specifically within the R-2505 restricted sector. The trajectory would exceed 18,300 m (60,000 ft) in altitude when flight of the X-33 is not in military restricted airspace. China Lake is also located in the Los Angeles Air Route Traffic Control Center Sector 16. Table 3-16 details the specific restricted sectors and MOA's included in the intervening airspace between Edwards and China Lake. All coordination of X-33 flight between Edwards and China Lake would be the responsibility of the Air Force Flight Test Center working with China Lake's Commander and Range Control authorities for approval of use and the R-2508 Complex Control Board for approval of shared-use airspace.

Table 3-16. Control Authority and Airspace Designations of Nominal Flight Path from Edwards to Armitage Air Field on China Lake Naval Air Weapons Station (NOAA 1997-A).

RESTRICTED AIRSPACE	TIME USED	ALTITUDE LEVELS
R-2515	Continuous	Unlimited
R-2524	Continuous	Unlimited
R-2508	Continuous	6100 m (20,000 ft) -Unlimited
R-2505	Continuous	Unlimited
Panamint	Mon-Fri	61 m (200 ft) AGL to 5500 m (18,000 ft)
Isabella	Mon-Fri	61 m (200 ft) AGL to but not including 5500 m (18,000 ft), excluding 915 m (3,000 ft) and below over Domeland Wilderness Areas
Owens	Mon-Fri	61 m (200 ft) AGL to but not including 5500 m (18,000 ft), excludes airspace below 915 m (3,000 ft) over Wilderness Areas, National Parks and Monuments

3.2.2.7 Biological Resources

Vegetation

The airfield is located in a Creosote Bush Scrub community, dominated by creosote bush (*Larrea tridentata*) and burro-bush (*Ambrosia dumosa*). Table F-3 in Appendix F lists vegetation species known or thought to occur in this area.

Wetlands and Floodplains

There are no wetland areas occurring in the immediate area of the runways. The nearest wetland areas are Lark Seep and G-1 Seep and the interconnecting drainage channels located approximately 4.5 km (2.8 mi) from the runway.

The main site area lies within the 100-year floodplain, but the Station is not protected. A number of flood control projects designed to control floodwaters at the 60- to 70-year flood event level were completed at the Station. A report prepared for the Station by the U.S. Army Corps of

Engineers in 1979 entitled, *Special Flood Hazard Information, U.S. Naval Weapons Center, China Lake, California*, projected that during a 100-year flood, the combined flow from Ridgecrest and part of El Paso mountains would cause major damage in Michelson Lab. The study projected that other areas within a 152 to 305 m (500 to 1,000 ft) corridor from Michelson Lab, areas along East Inyokern Road and North Hussey Road, and residential areas in the southern portion of the China Lake Complex would be flooded during a 100-year flood. Additional areas are considered to be in the 500-year floodplain (USN 1989).

Wildlife

At least 80 species of mammals, 225 species of birds, and over 30 species of reptiles and amphibians have been recorded on the Center (Appendix F, Table F-4). The wildlife habitat quality around the airfield is typical of desert scrub habitats throughout the northern Mojave region. No suitable raptor nesting habitat exists within or immediately adjacent to the airfield.

Common reptile species anticipated in this area include side-blotched lizards (*Uta stansburiana*), zebra-tailed lizards (*Callisaurus draconoides*), western whiptails (*Cnemidophorus tigris*), and western fence lizards (*Sceloporus occidentalis*). Common snake species include red racers (*Masticophis flagellum piceus*), gopher snakes (*Pituophis melanoleucus*), and sidewinders (*Crotalus cerastes*).

Common resident birds that may at times visit or use the site include the Northern mockingbird (*Mimus polyglottos*), LeConte's thrasher (*Toxostoma kecontei*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetas*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), mourning dove (*Zenaida aurita*), greater roadrunner (*Geococcyx californianus*), common barn owl (*Tyto alba*), great horned owl (*Bubo virginianus*), Say's phoebe (*Sayornis saya*), horned lark (*Eremophila alpestris*), common raven (*Corvus corax*), loggerhead shrike (*Lanius ludovicianus*), house finch (*Carpodacus mexicanus*), and black-throated sparrow (*Amphispiza bilineata*). Summer resident birds that may occur in the area during the spring and summer months include the common poorwill (*Phalaenoptilus nuttallii*), lesser nighthawk (*Chordeiles acutinpennis*), black-chinned hummingbird (*Archilochus alexandri*), Costa's hummingbird (*Calypte costae*), western kingbird (*Tyrannus verticalus*), ash-throated flycatcher (*Myiarchus cinerascens*), and black-chinned sparrow (*Spizella atrogularis*). Winter visitors include the sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperi*), ferruginous hawk (*Buteo regalis*), American robin (*Turdis migratorius*), hermit thrush (*Cathatus guttatus*), dark-eyed junco, white-crowned sparrow (*Zonotrichia leucophrys*), golden-crowned sparrow (*Zonotrichia atricapilla*), and song sparrow (*Melospiza melodia*).

Small mammal species known or thought to occur include the little pocket mouse (*Perognathus longimembris*), Merriam kangaroo rat (*Dipodomys merriami*), deer mouse (*Peromyscus maniculatus*), desert woodrat (*Neotoma lepida*), and antelope ground squirrel (*Ammospermophilus leucurus*). Larger mammal species include the Audubon cottontail (*Sylvilagus audubonii*) and jackrabbits (*Lepus californicus*). Desert kit foxes (*Vulpes macrotis*), coyotes (*Canis latrans*), and gray foxes (*Urocyon cinereoargenteus*) may, on occasion, visit the site.

3.2.2.8 Threatened, Endangered, and Sensitive Species

Vegetation

The Station currently has over 650 identified plant species, 13 of which are classified as sensitive species by the state. None of these sensitive species of plants are prevalent to Station lands. Two species of potential management concern on China Lake are the Mohave fishhook cactus (*Sclerocactus polyancistrus*) and Charlotte phacelia (*Phacelia nashiana*); however, neither of these are located near the airfield. Although not classified as sensitive species, the creosote bush (*Larrea tridentata*) forms large rings over time as new plants grow in a circular formation around the parent plant, which eventually dies out. The age of the clonal creosote rings has been estimated to be between 6,000 and 10,000 years. A stand of these ancient plants is located at the base of the Argus Mountain range, but none have been identified near the airfield.

Wildlife

The Station currently has documented 345 identified wildlife species. Eight species are listed by the U.S. Fish and Wildlife Service as federally endangered or threatened (Appendix F, Table F-5). The three species of most concern with regards to the X-33 project are the Mohave tui chub (*Gila bicolor mohavensis*) occurring at Lark Seep (Figure 3-21), the Inyo California towhee (*Pipilo crissalis eremophilus*) found along riparian areas in the Argus range, and the desert tortoise (*Gopherus agassizii*), a species currently listed as threatened. No evidence of current or past use of the airfield site by tortoises has been noted (Figure 3-22). The other six species are birds potentially occurring at China Lake are as follows: bald eagles (*Haliaeetus leucoccephalus*), American peregrine falcon *(Falco peregrinus anatus*), brown pelican (*Pelicanus occidentalis californicus*), willow flycatcher (*Empidonax trailii)*, southwestern willow flycatcher (*Empidonax trailii extimus*), and least Bell's vireo (*Vireo bellii pusillus*). These species occur very infrequently, have never been documented on base, or are migratory. The Mohave ground squirrel (*Spermophilus mohavensis*) occupies a variety of habitats within the region (Figure 3-23). Although the species has been proposed for delisting by the California Department of Fish and Game, its management future is still undecided.

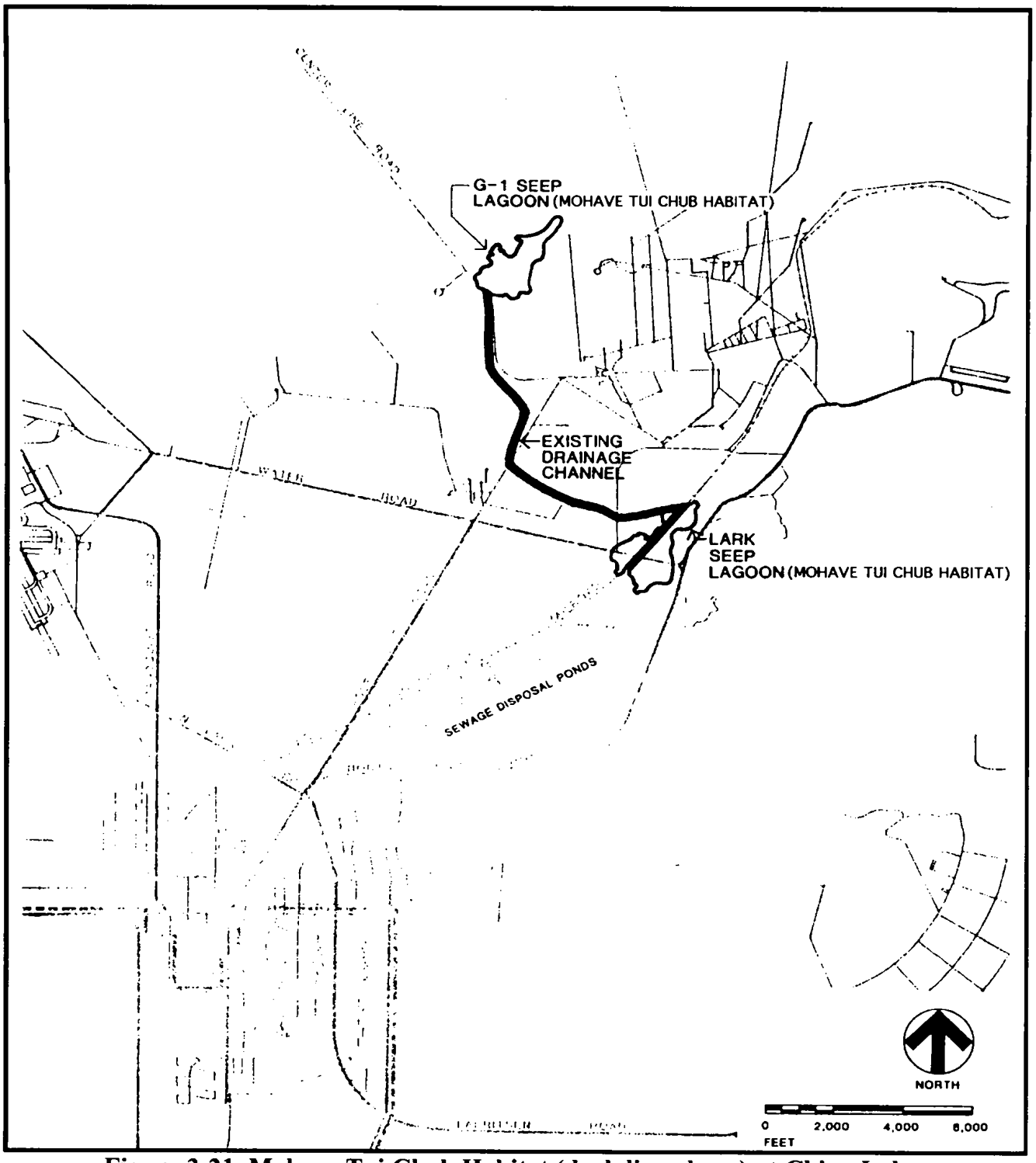


Figure 3-21. Mohave Tui Chub Habitat (dark line above) at China Lake.

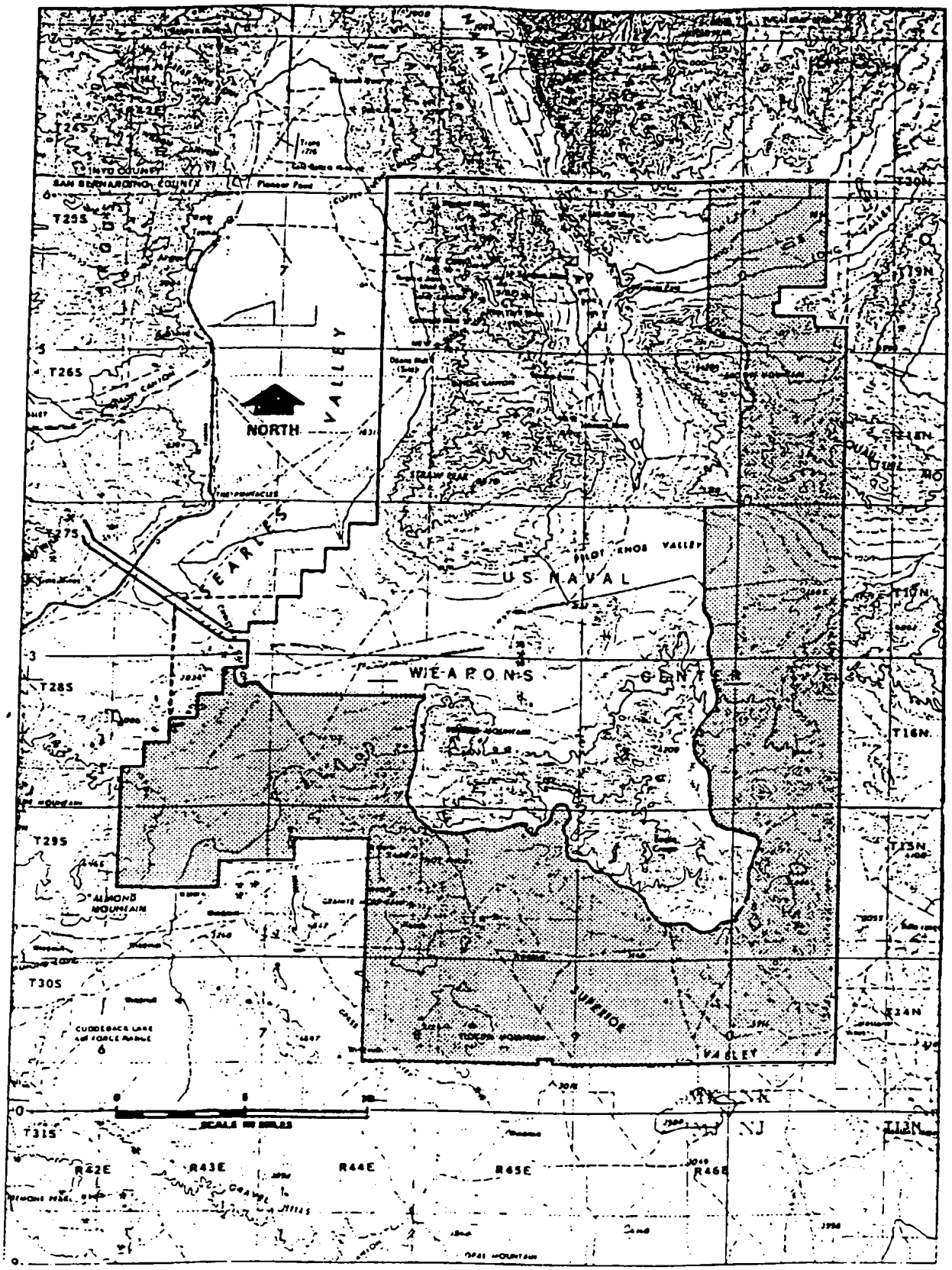


Figure 3-22. Desert Tortoise Critical Habitat (shaded areas above) at China Lake.

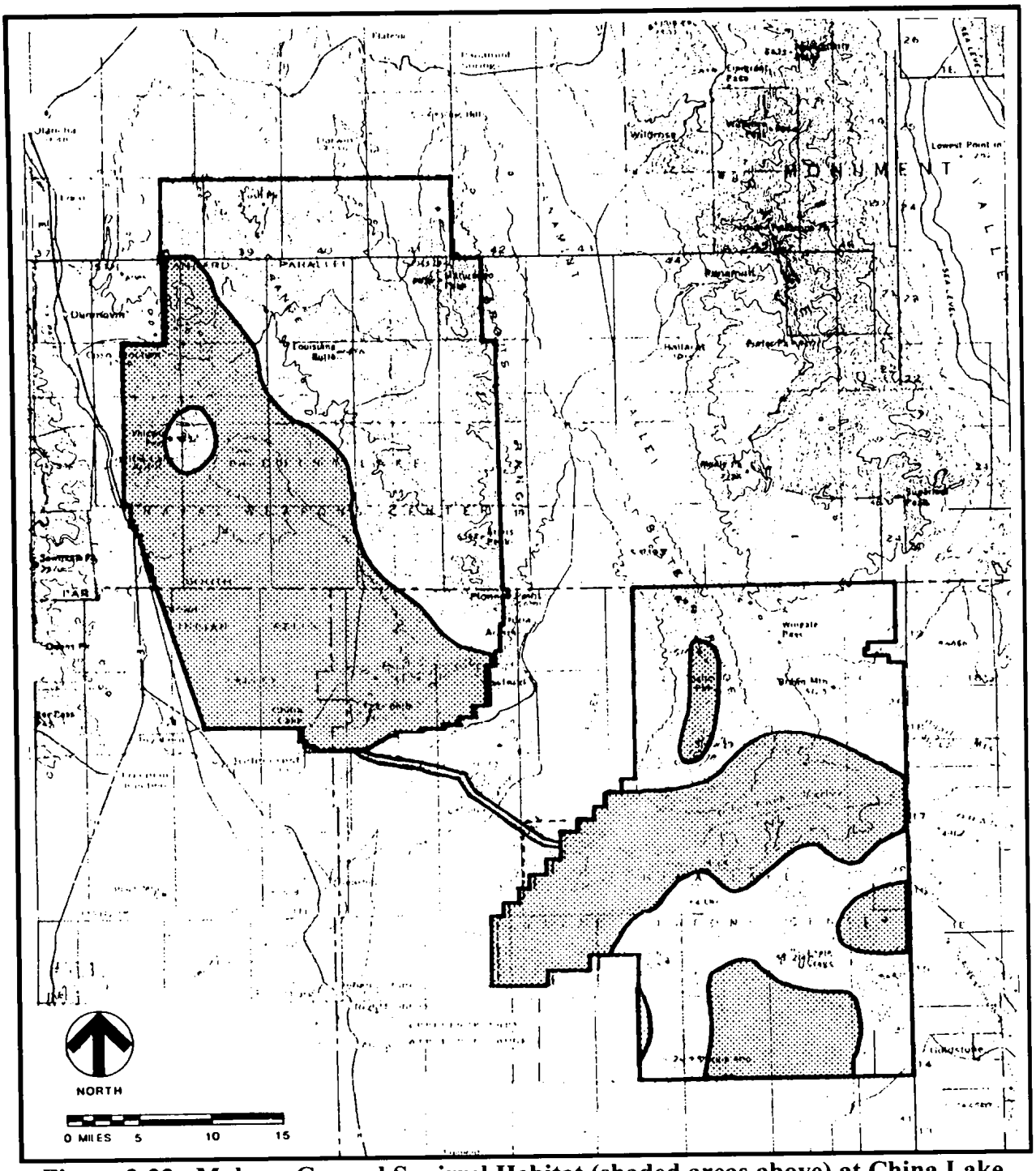


Figure 3-23. Mohave Ground Squirrel Habitat (shaded areas above) at China Lake.

3.2.2.9 Cultural Resources

The earliest occupation dates for the Station area have been debated among archaeologists. Some believe that occupation dates back to the Pleistocene period, 45,000 years BC, when the Pleistocene Lake China covered most of the area between the White Hills and the present southern boundary of the China Lake Complex. Indian artifacts and mineralized bone fragments from Rancholabrean animals have been found in the dry playa of the ancient lake (USN 1989).

Other archaeologists believe that the earliest cultural period in the Station area is the Lake Mojave period (10,000 BC to 5,000 BC). Diagnostic artifacts include large leaf-shaped and stemmed points, crescents, and a variety of knives, scrapers, and gravers. Groups were apparently small and highly mobile. The Pinto period (5,000 to 2,000 BC) was a time of sparse human occupation or perhaps abandonment of some areas. A hunting and gathering society rotated between permanent base camps, with storage facilities adjacent to rivers and springs. The Gypsum period (2,000 BC to AD 500) emphasized hunting, although seeds were also processed. The Saratoga Springs period (AD 500 to AD 1,200) saw the introduction of the bow and arrow. The Shoshonean period (AD 1,200 to the present) includes groups who occupied the area at the time of historic contact and had large winter villages in the Coso range. Diagnostic artifacts include projectile points and brownware pottery (USN 1989).

In historic times, the Station area was the province of three Numic peoples: the Koso, Kawailsu, and the Chemehuevi. Two of the villages were on what are now Station lands; one at Coso Hot Springs, and the other at an unidentified spring area, perhaps Coso (Cold) Springs, located approximately 8 km (5 mi) south of Darwin. The harsh desert environment permitted only sparse populations, and groups moved with the seasons and in response to the local water and food supply.

Two sites on the Station are on the National Register of Historic Places (NRHP): Big and Little Petroglyph Canyons and Coso Hot Springs. Big and Little Petroglyph Canyons National Historic Landmark, located 35 km (22 mi) from the airfield, was included on the list of historic places in 1966 with no boundaries included. Coso Hot Springs, located approximately 42 km (26 mi) from the airfield, has prehistoric and historic components. Within the Station boundaries, approximately 20 areas appear to be eligible for the NRHP. A few of these are Cactus Flats Village Site, Pothunter Spring Site, Wingate Pass monorail, Copper City site, and the Coso Village site.

3.2.2.10 Water Resources

Groundwater

The China Lake Complex depends on water primarily from the Indian Wells Valley aquifer and to a lesser extent from the Darwin Wash and Owens Valley aquifers. Approximately 49 springs and seeps have been identified in the China Lake Complex. The Indian Wells Valley receives water from surrounding mountains to the north, east, and west.

The groundwater basin characteristics of the Indian Wells Valley are not completely understood, and there is much debate regarding the potential water supply. Some experts believe that Indian Wells Valley is a closed basin with deep and shallow aquifers. They also believe that the basin holds 1.2 billion m^3 (1 million ac-ft) of water and has a recharge rate of 11.1 to 12.3 million m^3 (9,000 to 10,000 ac-ft) per year. Approximately 37 million m^3 (30,000 ac-ft) of water have been taken from the basin annually in recent years causing an overdraft. Serious water shortages could occur within a decade (USN 1989).

Other experts believe that Indian Wells Valley is an open basin with no evidence of a shallow aquifer. These experts also believe that the valley may be the wreckage of an old caldera, Little Dixie Wash may be a satellite caldera, with both having been filled in with debris over time, and beneath the surface are scattered clay lenses with very complex layers. Under this concept, the basin holds 24.7 trillion m^3 (20 million ac-ft) of water and has an annual recharge of 37 million m^3 (30,000 ac-ft). Therefore, no water shortages are anticipated under the open basin theory (USN 1989).

Surface Water

The Station is located in the South Lahontan basin, which lies generally south and east of the Sierra Nevada and the Mono drainage divide, west of the California/Nevada state line and north of the Providence, Granite, San Bernardino, and San Gabriel mountains. The Lahontan region has been characterized as arid to semiarid. Precipitation in the desert basins is low, although intense cloudbursts may result in occasional flooding. Surface runoff results from rainfall, melting of snowpacks on the nearby mountains, or springs (USN 1989).

All of the developed portions of the lowland areas of the China Lake Complex depend on Indian Wells Valley for water. Indian Wells Valley receives drainage, both underground and surface, from the Sierra Nevada mountains, the Coso and Argus ranges, and the El Paso mountains. The most significant surface flows originate in the El Paso range, southwest of Ridgecrest, and are conveyed to the China Lake, Mirror Lake, and Satellite Lake dry basins via Ridgecrest Wash, El Paso Wash, and other local ephemeral channels. These washes are typical of such desert channels, with small capacities and coalescing alignments (USN 1989).

3.2.2.11 Geology and Soils

Tectonic and volcanic activity during the last 2 to 3 million years has shaped and continues to shape much of the present physiographic and geologic character of the region. The interaction of the physiography, geology, and climate of the area present the Station with a variety of geologic hazards and interrelated engineering and environmental problems (USN 1989).

Soil substrates in the region consist of aeolian deposited sandy loam. Basin floor soils such as those found in and around Airport Lake are severely saline and void of vegetation. Soil textures are extremely variable, ranging from sand to clay. The soils in the main site area are coarse-textured material with cemented zones at depths from 1.5 to 5.5 m (5 to 18 ft) and are underlain by sand. Armitage Airfield soils are classified as silty sands, and except for the loose surface deposits, are dense and compact. Soils at the Range Operations Center near the China Lake playa are predominantly silts and clays. The area approximately 1.6 km (1 mi) southeast of Armitage Airfield contains predominately silty sands, sandy silts, and sands to a maximum depth of 12 m (40 ft) (USN 1989).

3.2.2.12 Health and Safety

The airfield at China Lake is currently an active military flightline with numerous landings and departures daily. A comprehensive occupational and flight safety program managed by the Naval Air Weapons Station is in place to ensure operations are conducted in a safe manner and risks are minimized. Fire protection and crash rescue capability at the airfield is provided by the China Lake Naval Air Weapons Station Fire Department, which has a station with crash rescue vehicles at the airfield. Medical treatment is provided by a Naval Medical Clinic on China Lake. Additional medical services, including a hospital providing inpatient treatment and most medical specialties, are available in the nearby city of Ridgecrest. There are no unusual proximity hazards to the runway.

3.2.2.13 Noise

An Air Installation Compatibility Use Zones (AICUZ) study for the Station was performed in 1977 and covered the southern portion of the China Lake Complex and the adjacent civilian community of Ridgecrest and its surrounding areas. It examined air operations at Armitage Airfield, as well as the low-level aircraft test operations, which run from south to north on three target ranges. Recommendations contained in the AICUZ study resulted in two sets of actions. These actions reduced the effect of noise on the adjacent community of Ridgecrest and potential for accidents due to inadvertent weapons drops by aircraft in the range approach corridors over the community.

Following the AICUZ study, the following guidelines were adopted: (1) flight paths are located to avoid populated areas wherever possible, and aircraft are instructed to approach east of the community; (2) only propeller type aircraft are allowed approach over the community; (3) the high-powered run-up area at the airfield is located away from the populated areas. Another result of this study was adoption of a straight-out departure path for Runway 21, which has been successfully used more than 90 percent of the time. This change was made to relocate the 65 dB Community Noise Equivalent Level (CNEL) contour 305 m (1,000 ft) to the west, away from Ridgecrest. For the purposes of this document, it can be assumed that the CNEL is functionally equivalent to the L_{dn} because the two measures typically do not differ by more than 1 or 2 dBA.

The AICUZ study also recommended nonresidential uses for most areas of San Bernardino County lying under the "G" range approach corridor and Kern County beneath the approaches to the "B" and "C" ranges. Residential uses were judged to be conditionally acceptable in areas located between the 65 and 70 CNEL noise exposure contour. In areas beyond the 65 CNEL noise contour but still within the Drop Potential Zone (areas of potential accidental equipment drops, including ordnance, guided missiles, and flares), low density residential use (one home per acre) was recommended (Figure 3-24).

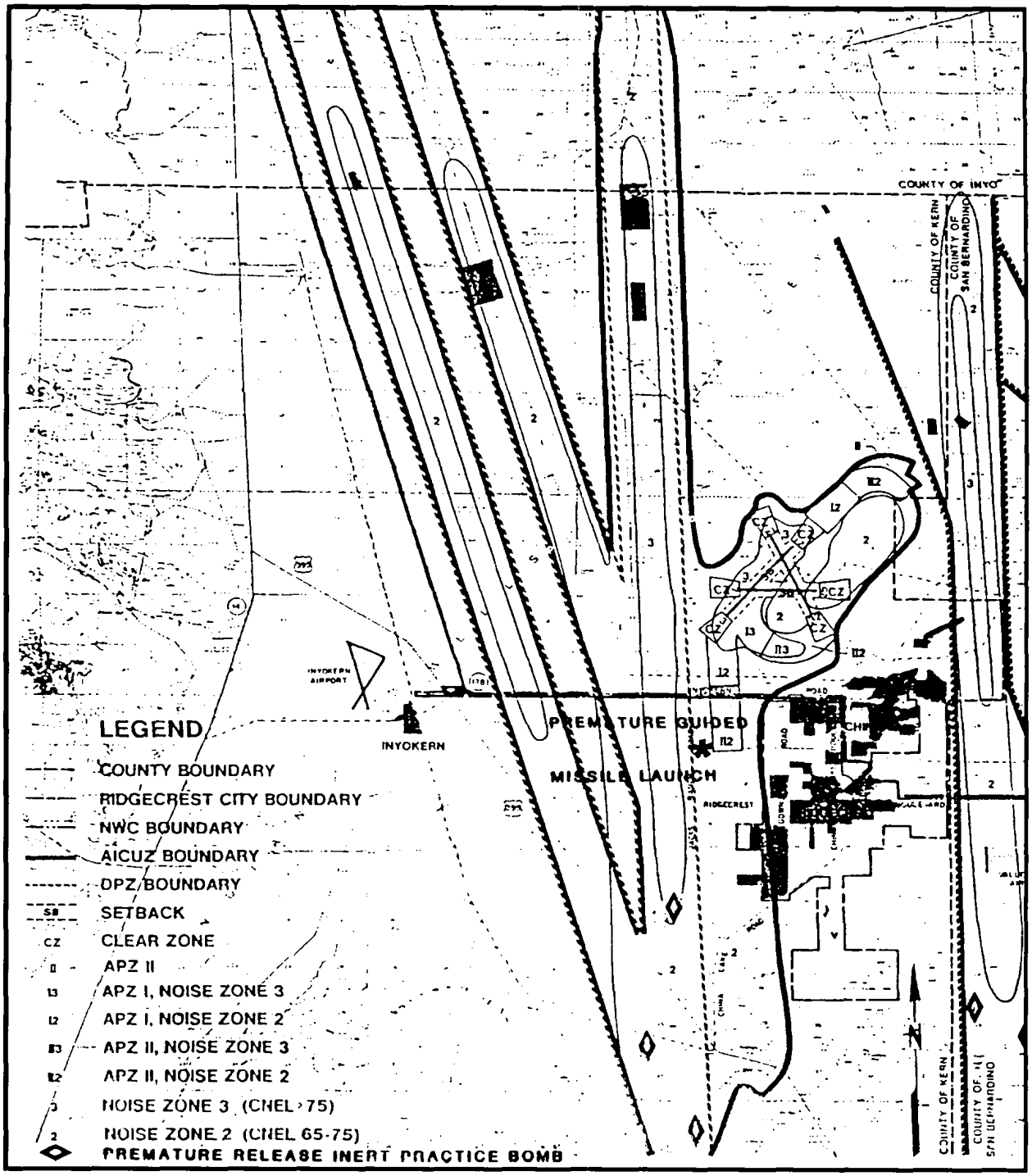


Figure 3-24. AICUZ - Noise/Accident Potential/Drop Potential Zones.

China Lake Naval Air Weapons Station is currently updating the noise study component of its AICUZ study and will be updating the AICUZ study as part of the command's Land Use Management Plan.

3.2.2.14 Transportation

Major roads in the vicinity of the Station are as follows. California State Highway 14 provides access southwest to the Los Angeles area. U.S. Highway 395 provides access south to San Bernardino and Riverside and north to the eastern Sierra resorts and Reno, Nevada. State Highway 178 provides direct access west to Bakersfield, the Kern County seat. It is sometimes impassable during winter storms. State Highway 14 connects with State Highway 58 in Mojave to provide a less direct route to Bakersfield; this route is used more than Route 178.

3.2.2.15 Population and Employment

The upper Mojave desert is still predominantly an open and undeveloped landscape, where the Department of the Interior and DOD own and manage most of the land. Antelope Valley, including Palmdale and Lancaster, is a center for aircraft development and testing at Edwards, which is located north of the population center of Lancaster. Barstow, to the southeast, is a railroad and highway junction point where transportation and distribution activities are major factors in the local economy. Small, surrounding communities include Lake Isabella, Inyokern, Trona, Lone Pine, Independence, and Bishop. They provide limited employment opportunities in tourism and agriculture.

The adjacent town of Ridgecrest had a population of 27,752 during the 1990 census. Its civilian facilities support the base and associated commercial and light industrial activities. Including the outlying areas, the population of the Indian Wells Valley approaches 40,000.

The Naval Air Warfare Center Weapons Division (NAWCWPNS) continues to be the major source of employment for Ridgecrest residents and depends increasingly upon Ridgecrest for support services. The same locational characteristics that initially attracted NAWCWPNS to this area (vast uninhabited space, clean air, good water, highway accessibility, and proximity to Los Angeles and Bakersfield) continue to provide the potential to attract other companies to the area. The NAWCWPNS in China Lake employed approximately 4,000 civilian personnel and 1,000 active military personnel with an annual gross payroll of $260 million in 1996. Contractors providing services to China Lake add approximately 1,700 employees.

The second major employer is the North American Chemical Corporation, which employed approximately 1,000 people and had an annual gross payroll of $38 million in 1994. Other companies present include: Texas Instruments, General Dynamics, Raytheon, Honeywell, IBM, Comarco Engineering, Sverdrup, Hughes Aircraft Company, Martin Marietta Data Systems, Ford Aerospace, Computer Technology Associates, Day & Zimmerman, Boeing Information Systems Group, and California Energy.

3.2.2.16 Land Use

China Lake Naval Air Weapons Station's mission is to be the principal Navy research, development, testing, and evaluation center for air warfare and missile weapons systems; and the national range/facility for parachute test and evaluation. Capabilities include testing of tactical aircraft systems, including flight tests of aircraft avionics and defense suppression systems; propulsion testing for the development of solid, air-breathing, and liquid propulsion units, including static tests of rocket motors; and special purpose testing for warhead, fuze, motor, airframe, and other components (USN 1989).

The surrounding terrain includes dry, flat lakebeds, large dry washes , alluvial fans, open desert and pine-covered mountains. The land is used for test and evaluation of weapons systems or as a buffer between sensitive or hazardous tests and the surrounding public lands.

3.2.2.17 Snow Conditions

During scoping, the potential for sonic booms to trigger snow avalanche was raised in Great Falls, Montana. Due to low frozen precipitation potential in southern California, this issue is not applicable to China Lake.

3.2.3 Michael Army Airfield Within Dugway Proving Ground, Utah

3.2.3.1 Site Infrastructure

Runway

Michael Army Airfield is 4,000 m (13,124 ft) long and 61 m (200 ft) wide and is suitable for landing very large aircraft, including the Boeing 747 and the Space Shuttle (DPG Home Page 1996) (see Figure 2-13). The surface is asphalt with unstable shoulders, and there are no obstructions around the runway. Available facilities include a 680 sq m (7,317 sq ft) office building with phone and fax, a 230 sq m (2,475 sq ft) AF hangar, and a 1,860 sq m (20,014 sq ft) Army hangar. Additional existing resources are a helicopter pad, radar tracking, emergency medical technicians and equipment within 1.6 km (1.0 mi), fire/crash rescue on the airfield, and security and public affairs personnel on base.

Water Supply and Distribution

Potable and nonpotable water is supplied from wells on Dugway Proving Ground. However drinking water in the Carr, Baker and Ditto test areas is trucked in as bottled water. Raw water is within standards of the National Interim Primary Drinking Water Regulation (NIPDWR) for all applicable constituents. Well No. 3 has exceeded regulation standards in the National Secondary Drinking Water Regulation (NSDWR) for chlorides, iron, and manganese. There are no NIPDWR standards for these constituents, and no other well is available to serve Ditto Technical Center and Baker Laboratory. Therefore, Well Number 3 will continue to be used. All wells exceeded the NSDWR standards for total suspended solids, while organic chemicals are below detection limits. NSDWR standards, promulgated by the Environmental Protection Agency (EPA), are based on aesthetic and operational considerations and are enforceable at the state's discretion. The state of Utah recognizes that no better water supply is realistically available for Dugway (U.S. Army 1982).

Wastewater

Four major individual sewage and disposal systems serve Dugway: the English Village/Fries Park wastewater treatment system, the Ditto/Avery Technical Center wastewater treatment system, the Baker wastewater treatment system, and the Carr Facility wastewater treatment system. These systems are designed to handle nonhazardous domestic wastewater. The operations and treatment methodologies are covered in U.S. Army Technical Manual 5-665. Operations of wastewater treatment facilities are established under U.S. Army Dugway Proving Ground Standard Operating Procedure 2-010. Each facility is operated by a wastewater treatment plant operator under direct supervision of the Base Operations Contractor. The standard operating procedure specifies proper and reliable sampling and reporting requirements, and outlines training and licensing requirements for operators to maintain their certification. The standard operating procedure also describes required operations and maintenance schedules and procedures. The English Village/Fries Park and the Ditto/Avery wastewater treatment facilities are both three-cell aerated lagoon systems with chlorination procedures to disinfect the effluent. The Baker Area and the Carr Facility wastewater treatment facilities are both lagoons designed to fully contain all

flows and releases of water by evaporation and percolation. The Lagoons are permitted by the Utah Department of Environmental Quality. Excess capacity exists, but an exact quantification of additional burden that the systems could accommodate was unavailable (U.S. Army 1982).

Electricity

Electrical power for Dugway 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). Dugway consumes less than one percent of Utah's power and light annual production (U.S. Army 1982).

Communications

Dugway Proving Ground telephone system is owned and operated by the Division of Information Management, Dugway, and connects with U.S. West Communications (U.S. Army 1982). 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.

Dugway is connected to the Automatic Digital Network (AUTODIN). Narrative message traffic is routed through the Dugway Communications Center to the Pentagon, Washington, DC, and then to other AUTODIN systems.

Fuel

Heat is primarily supplied 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.

Aviation gasoline and JP-8 fuel facilities are available and currently in use at Dugway. There are no facilities available to transfer or store liquid hydrogen or liquid oxygen (U.S. Army 1982).

3.2.3.2 Hazardous Materials and Hazardous Waste

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 L (1.1 million 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 (U.S. Army 1982).

Other hazardous materials at Dugway 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 65 ha (161 ac) 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 (U.S. Army 1982).

Dugway is classified as a large quantity hazardous waste generator (more than 1,000 kg/mo (2,200 lb/mo)) under the provision of the Utah Waste Management Rules. Management of hazardous wastes generated at Dugway is administered by the Directorate of Environmental Programs (FDEP) under the direct supervision of the installation commander. All hazardous waste generated or managed by activities on Dugway 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 administrated by the U.S. Environmental Protection Agency, the State of Utah Department of Environmental Quality 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 of 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 (Safety) Office (U.S. Army 1982).

Dugway 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 1 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 Department of Environmental Quality on March 15, 1994, once permit modification applications are approved (U.S. Army 1982).

3.2.3.3 Solid Waste

Most of the nonhazardous solid waste produced on Dugway is deposited on base in a 20 ha (49 ac) state of Utah-approved sanitary landfill. The landfill was built in 1968 and designed to handle solid waste disposal needs until 2000. Construction debris is deposited in an area adjacent to the landfill. Five pit dumps located around Dugway have been filled, graded flat with the surrounding terrain, and covered with soil. One was used for construction debris and the other four contain incinerator ashes, animal cage bedding material, uncontaminated waste material, and empty pesticide containers (U.S. Army 1982).

3.2.3.4 Climate

Dugway lies in a mid-latitude steppe region, which can generally be described as arid year-round (Table 3-17). Summer is particularly dry and hot, but the variable terrain can cause some areas to receive much greater than average amounts of rain. Daily temperature fluctuations are extreme because of the dry air and ground, sparse vegetation, and light winds. Spring and fall are cool and winter is moderately cold (U.S. Army 1982). Winter weather is affected by the continental winter storm track, but the continental divide east of the Great Salt Lake Basin usually protects the area from arctic air blasts that are common in other parts of the central U.S.

Table 3-17. Climatic Data (1950-1993) for Dugway Proving Ground.

Month	Temperature ° C (° F)			Precipitation cm (in)		
	Avg daily max	Avg daily min	Avg	Average	30% chance will have less than	30% chance will have more than
January	2.9 (37.2)	-9.2 (15.4)	-3.2 (26.3)	1.32 (0.52)	0.76 (0.30)	1.70 (0.67)
February	7.1 (44.7)	-5.2 (22.7)	0.9 (33.7)	1.45 (0.57)	0.58 (0.23)	1.80 (0.71)
March	11.7 (53.1)	-1.9 (28.6)	4.9 (40.8)	1.93 (0.76)	0.89 (0.35)	2.41 (0.95)
April	17.2 (63.0)	2.1 (35.8)	9.7 (49.4)	1.85 (0.73)	0.89 (0.35)	2.26 (0.89)
May	22.9 (73.3)	6.9 (44.5)	14.9 (58.9)	2.46 (0.97)	1.22 (0.48)	3.10 (1.22)
June	29.3 (84.7)	11.9 (53.4)	20.6 (69.0)	1.24 (0.49)	0.53 (0.21)	1.75 (0.69)
July	34.6 (94.3)	16.5 (61.7)	25.6 (78.0)	1.37 (0.54)	0.46 (0.18)	1.73 (0.68)
August	33.1 (91.5)	15.4 (59.7)	24.2 (75.6)	1.45 (0.57)	0.58 (0.23)	1.88 (0.74)
September	27.1 (80.8)	9.1 (48.4)	18.1 (64.6)	1.47 (0.58)	0.69 (0.27)	2.06 (0.81)
October	19.4 (66.9)	2.4 (36.4)	10.9 (51.7)	1.85 (0.73)	1.12 (0.44)	2.41 (0.95)
November	10.1 (50.2)	-3.3 (26.0)	3.4 (38.1)	1.35 (0.53)	0.71 (0.28)	1.70 (0.67)
December	3.8 (38.8)	-7.8 (17.9)	-2.0 (28.4)	1.47 (0.58)	0.69 (0.27)	1.91 (0.75)
Annual:						
Average	18.3 (64.9)	3.1 (37.6)	10.7 (51.2)			
Extreme	42.8 (109)	-33.9 (-29)				
Total				19.20 (7.56)	14.40 (5.67)	21.18 (8.34)

Average annual precipitation is between 35 and 55 cm (13.8 and 21.7 in), mostly as snow in the winter. There is very little rainfall during the summer.

Winds are generally light, northwesterly during the day and southerly at night (Figure 3-25). Topographical features such as mountains and large expanses of valley floors greatly affect local conditions (U.S. Army 1982).

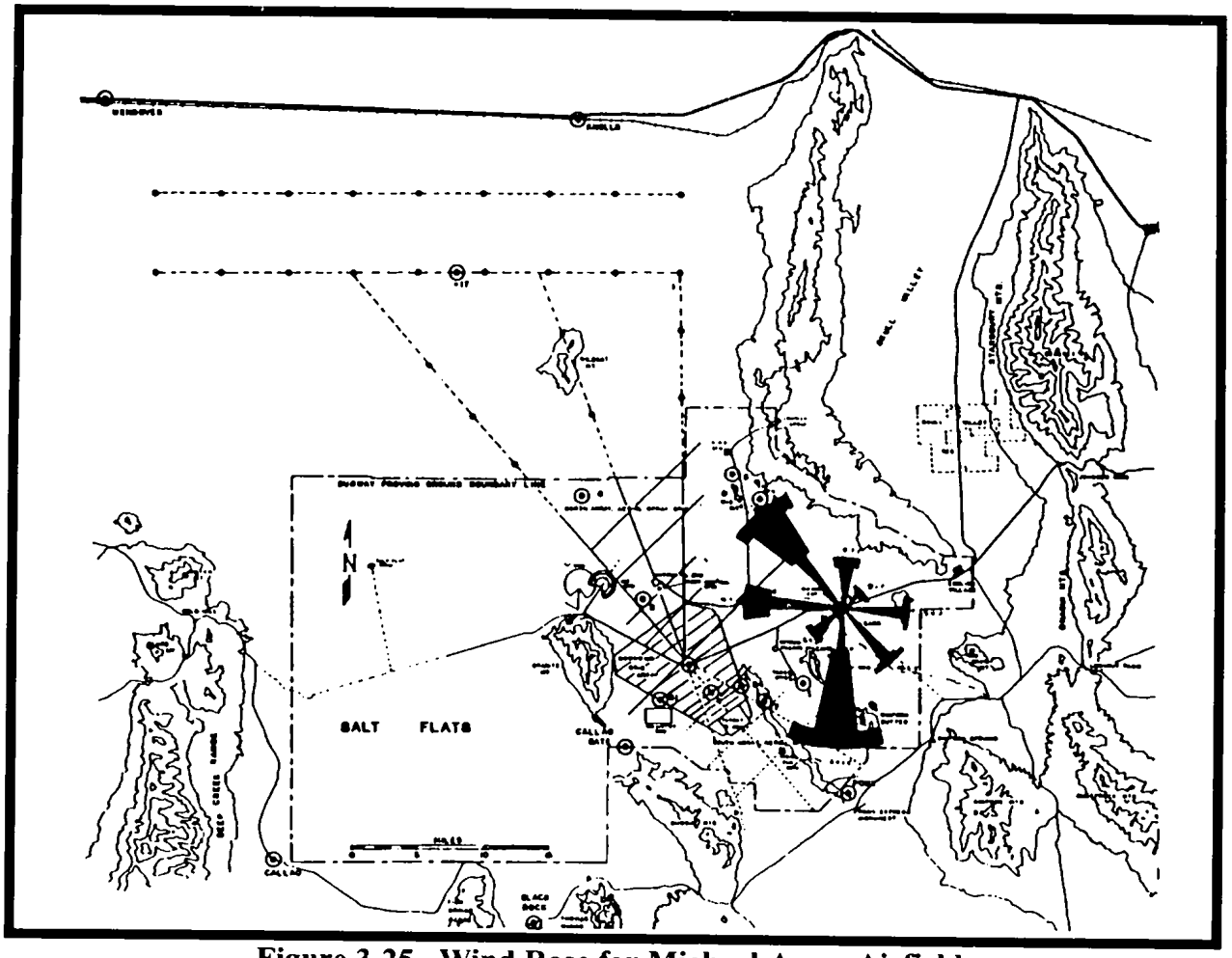


Figure 3-25. Wind Rose for Michael Army Airfield.

3.2.3.5 Air Quality

Dugway is located in the Wasatch Front Intrastate Air Quality Control Region (AQCR). There are no air monitoring stations on Dugway, but eight are located near Tooele Army Depot and two are at the base of the Stansbury mountains. Ambient air quality data from Grantsville can be found in Table 3-18.

Table 3-18. National Ambient Air Quality Standards (NAAQS) and Local Monitoring Data.

Pollutant	Averaging Time	NAAQS $\mu g/m^3$ (ppm)		Maximum Observed Concentrations by Monitoring Location $\mu g/m^3$ (ppm)
		Primary	Secondary	Dugway Proving Ground (Grantsville)
SO2	24 Hour	365 (0.14)	None	nm
	3 Hour	None	1310 (0.5)	63 (0.024)
	annual	80 (0.03)	None	nm
NOX	annual	100 (0.05)	100 (0.05)	nm
CO	8 Hour	10 (9) mg/m^3	None	nm
	1 Hour	40 (35) mg/m^3	None	nm
PM10	24 Hour	150	150	55
	annual	50	50	22.7
Lead	quarterly	1.5	1.5	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	nm

NAAQS are as listed in 40 CFR, Part 50.
1995 Monitoring Data presented.
nm = not monitored.

Dugway is an attainment area for the following air pollutants: particulates, sulfur oxides, nitrogen dioxide, carbon monoxide, ozone, hydrocarbons, and lead. Nonattainment areas for some pollutants exist elsewhere in the Wasatch Front Intrastate Air Quality Control Region, especially the Salt Lake City area. Prevailing high altitude winds are westerly and three mountain ranges separate the western portion of Dugway from the major pollution sources in the Salt Lake Valley. Several mountain ranges also separate Dugway from high pollution in Ely and Elko, Nevada (U. S. Army 1982).

Air pollution, including visible pollutants from Salt Lake City, frequently enters Tooele Valley during periods of air stagnation but rarely reaches Dugway. Visibility in the area is generally excellent because the climate is dry and extensive air pollution sources are downwind or distant. Snow, rain, blowing dust, haze and fog may all contribute to reduced visibility. Test vehicles traversing particular areas generate dust. The problem has been reduced by surfacing and graveling some roads, and confining travel along poorly maintained roads. Tests involving extensive off-road use of vehicles require environmental analysis and mitigation, and are avoided in order to reduce testing costs.

3.2.3.6 Airspace and Air Traffic

The Michael Army Air Field, Dugway Proving Ground flight track would originate at Edwards and extend northeast for approximately 570 km (450 mi). Landing would occur within the range airspace authority of the Utah Test and Training Range (UTTR) shown in Figure 3-25. All flight coordination between ranges would be the responsibility of the Air Force Flight Test Center (AFFTC) (U.S. Army 1982).

UTTR which includes airspace above and surrounding Michael Army Airfield is under the Commander, AFFTC, Edwards Air Force Base. Operation and control is effected through the 412th Test Wing, 545th Test Group and the 501st Range Squadron at Hill Air Force Base, Ogden, Utah. The 501st Range Squadron specifically provides operational control and exercises management responsibility for the UTTR. These responsibilities include airspace management, scheduling use of all range assets and operating and maintaining range facilities and equipment. Michael is within restricted airspace R-6402A defined as surface to 17,700 m (58,000 ft). Airspace above 17,000 m (58,000 ft) in R-6402A is under jurisdiction of the Continental Air Defense Command. As denoted on aviation maps, military restricted airspace prohibits overflight by civilian pilots except by permission of the controlling authority. A complete listing of UTTR airspace restrictions is provided in Table 3-19 (U.S. Army 1982). Approximately 4 to 50 flights per week occur within the UTTR.

Table 3-19. UTTR and Nellis Air Range Restricted Airspace Sectors and MOA's (NOAA 1997-A).

RESTRICTED AIRSPACE	TIME USED	ALTITUDE RESTRICTION
UTTR		
R-6404A	Continuous	AGL to 17,700 m (58,000 ft)
R-6404B	Continuous	AGL to 4,000 m (13,000 ft) Mean Sea Level (MSL)
R-6404C	Continuous	30.5 m (100 ft) AGL to 8,500 m (28,000 ft)
R-6404D	Continuous	From but not including 4,000 m (13,000 ft) MSL to 7,600 m (250,000 ft)
R-6405	Continuous	30.5 m (100 ft) AGL to 17,700 m (58,000 ft)
R-6406A	Continuous	Surface to 17,700 m (58,000 ft)
R-6406A	Continuous	Surface to 17,700 m (58,000 ft)
R-6406B	Continuous	30.5 m (100 ft) AGL to 17,700 m (58,000 ft)
R-6407	Continuous	Surface to 17,700 m (58,000 ft)
R-6402A	Continuous	Surface to 17,700 m (58,000 ft)
R-6402B	Continuous	30.5 m (100 ft) AGL to 17,700 m (58,000 ft)
Lucin A	Mon-Sat 1200 through 0300 z	30.5 m (100 ft) AGL to 2,700 m (9,000 ft) MSL
Lucin B	Mon-Sat 1200 through 0300 z	30.5 m (100 ft) AGL to 2,300 m (7,500 ft) MSL
Lucin C	Mon-Sat 1200 through 0300 z	30.5 m (100 ft) AGL to 2,000 m (6,500 ft) MSL
Sevier A	Mon-Sat 1200 to 0300 z	30.5 m (100 ft) to 4,400 m (14,500 ft) MSL
Sevier B	Mon-Sat 1200 to 0300 z	30.5 m (100 ft) AGL to 2,900 m (9,500 ft) MSL
Sevier C	Mon-Sat 1200 to 0300 z	4400 m (14,500 ft) to, but not including 5,500 m (18,000 ft)
Sevier D	by NOTAM	2900 m (9500 ft) MSL to, but not including 5,500 m (18,000 ft)
Gandy	Mon-Sat 1200 to 0300 z	30.5 m (100 ft) AGL to, but not including 5,500 m (18,000 ft)
Nellis Air Range		
R-4808 N	Continuous	Unlimited
R-4806 W	Continuous	Unlimited
R-4807 A	Mon 1400z to Fri 0300z	Unlimited
R-4809	Continuous	Unlimited
R-4816 S	Continuous	152 m (500 ft) above ground level (AGL) to but not including 5,500 m (18,000 ft)
R 4816 N	Continuous	458 m (1,500 ft) AGL to but not including 5,500 m (18,000 ft)

Note: All times noted on the individual tabulations are in "Zulu" (z), or Coordinated Universal Time. To arrive at local time, subtract the following from the indicated times:

Los Angeles Center	-8 hours
Oakland	-8 hours
Seattle	-0 hours (already presented in local time)
Salt Lake City	-7 hours

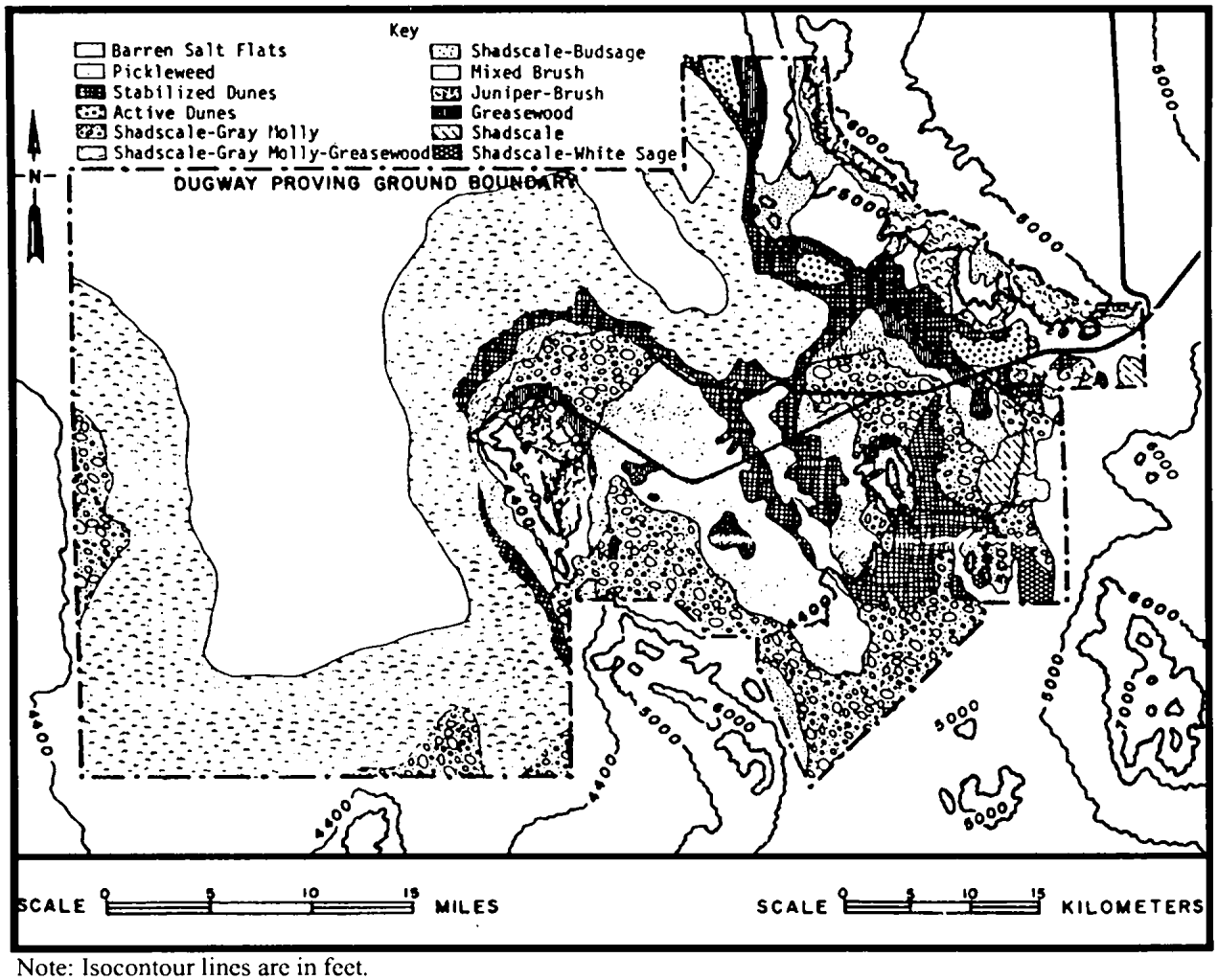
This path flies above Class A airspace controlled by the Los Angeles and Salt Lake City Air Route Traffic Control Center (ARTCC) and is used as three generalized flight corridors before terminating within UTTR. Other flight sectors involved are Los Angeles ARTCC Sector 16 and Salt Lake City ARTCC Sectors 47, 45, and 28 under the Federal Aviation Administration (FAA) authority. The X-33 nominal flight path would remain above 18,000 m (60,000 ft) when over FAA-controlled airspace. Flight zones in this region are classified as Class E, general control for classified activities by NASA, etc., requiring NOTAM's prior to flight.

The flight path to Michael would also cross the Nellis Air Range in Nevada under control and authority of Nellis Air Force Base near Las Vegas, Nevada. Nellis Air Range, consisting of the restricted sectors of R-4806W, R-4806E, R-4807A, R-4807B, R-4808N, R-4809, and R-4808S is controlled by Nellis Air Force Base continuously from surface to unlimited altitude.

3.2.3.7 Biological Resources

Vegetation

Dugway lies within the Bonneville Basin ecoregion (USDA 1995) formed by the recession of ancient Lake Bonneville. A total of 333 plant species or varieties are documented as occurring on Dugway; voucher specimens are housed at Colorado State University, Brigham Young University, or the Dugway herbarium. Nine distinct communities are recognized (Vest 1962) (Figure 3-26):



Note: Isocontour lines are in feet.

Figure 3-26. Plant Communities of Dugway Proving Ground.

1. Barren salt flats occur on the valley floor at the lowest elevations where runoff water pools until it evaporates. Mineral salts tend to accumulate and form a thin white crust on the ground (Vest 1962). Most of the salt flats are actually barren of vascular plants and wildlife.

2. The pickleweed community is found adjacent to salt flats on mounds of windblown sand called hummocks. These communities occur from 1 to 20 m (3 to 66 ft) apart, are oblong or elliptical, and oriented parallel to the prevailing wind. Hummocks are up to 9.9 cm (3.9 in) tall and the clay loam soil is heavily encrusted with salt. Vegetation on the hummocks is scattered and 94 percent pickleweed (*Allenrolfea occidentalis*) (Vest 1962).

3. The vegetated dune community has the greatest diversity of plants found on Dugway. Dunes consist of two portions: (1) higher areas of sandy soil supporting larger shrubs interspersed with bare sand, and (2) a hummock-like area at the base of the dune where soils are a combination of sand from the dune and clay from the adjacent salt flats. Dominant vegetation includes small shrubs and grasses (Vest 1962).

4. The shadscale-gray molly community occurs on flat plains of the Dugway valley. Soil in this community is clay loam with salt content between 0.3 and 0.8 percent. Except during rain events, the soil is dry, and the water table is far below the surface. Vegetation consists primarily of two species of low growing shrubs; shadscale (*Atriplex confertifolia*), which makes up 60 - 75 percent of the total; and gray molly (*Kochia vestita*). Both feed on surface water and have wide-spreading, shallow roots (Vest 1962).

5. The shadscale-gray molly-greasewood community is also present on the valley floor but is considered a broad ecotone between the shadscale-gray molly and greasewood communities. Dominant plants are gray molly (60 percent) and shadscale, but the horizon is dotted with dark green greasewood shrubs that grow to be 1 m (3 ft) tall (Vest 1962).

6. The greasewood community is scattered throughout the Dugway valley but occurs particularly at bases of mountains. Greasewood shrubs average 1.5 to 2.0 m (4.9 to 6.6 ft) tall with a varying amount of bare ground between plants. One other small shrub, inkwood (*Suaeda torreyanna*), is common in this community, often grouped at the base of greasewood plants. Monoculture stands of greasewood develop where water pools, as between mountains and dunes, and at the base of canyons (Vest 1962).

7. The shadscale-budsage community occurs on the sloped terrain between mountains and plains. The dominant shadscale bushes grow larger, have more foliage, and produce more seeds than the communities previously described in this section. Interspersed among the shadscale is budsage (*Artemisia spinescens*), a low growing bush with thick spreading branches (Vest 1962).

8. The mixed brush community is highly variable in topography, soils, and vegetation. Found on the bases of mountains, it extends up the steeper slopes of low mountains and occurs on several slope exposures and in ravines and gullies. Big sagebrush (*Artemisia tridentata*), hopsage (*Grayia spinosa*), budsage, shadscale, cheat grass (*Bromus tectorum*), and rice grass (*Oryzopsis hymenoides*) are the most common species (Vest 1962). Brush/shrub community types are severely degraded or threatened because of the invasion of an exotic Mediterranean plant, cheat grass (*Bromus tectorum*). Accidentally introduced during the early 1900's in association with livestock, it was described as "abundant" in 1912 (Utah Academy 1965). Cheat grass is a weedy colonizer that takes advantage of disruptions to the life cycles of native plants. It germinates and drops its seeds in the winter while most other plants are dormant, and completes its annual growth phase by early spring. When a shrubby habitat is damaged by fire or grazing, cheat grass quickly moves into the newly available area and usurps the resources. Once established, cheat grass is almost impossible to eliminate and its presence makes it easier for adjacent areas to burn and become invaded. Fifty percent of fires on Dugway are human-caused, and 50 percent are caused by lightning. Approximately 18,500 ha (45,714 ac) of native habitat on Dugway have been displaced by cheat grass, and it is the dominant species of vegetation over an even larger area. In order to slow the invasion or reduce the amount of cheat grass, legal grazing has been eliminated, but these efforts have thus far been unsuccessful (DPG 1996A).

9. The juniper-brush community dominates the foothills and mountain uplands, and occurs in two distinct associations. At higher elevations, juniper trees (*Juniperus osteosperma*) grow in thick monoculture stands called pygmy forests. At lower elevations, widely scattered, large junipers grow on sand dunes covered with a variety of shrubs (Vest 1962).

Wetlands and Floodplains

A survey of water bodies on Dugway was conducted in 1994 by the U.S. Army Corps of Engineers (COE) to identify and classify protected wetlands (COE 1994). Thirteen deep water springs comprising 989 ha (2,444 ac) were identified as jurisdictional wetlands (U.S. Army 1982). The water is fresh and plant cover approaches 100 percent (COE 1994). These springs are extremely important resources for wildlife and support plant species found nowhere else on base (U.S. Army 1982). Standing waters that accumulate on the hard playas from sporadic rain events and mountain runoff were designated "waters of the U.S." by the COE. These areas comprise approximately 17,046 ha (42,121 ac) (COE 1994); some playas are located approximately 1.6 km (1.0 mi) from the airfield. The water is extremely saline and plant cover is sparse and dominated by pickleweed. The Michael Army Airfield is not within the 100-year floodplain.

Wildlife

Studies of invertebrate and vertebrate wildlife began in 1951 with establishment of the Wildlife Survey Branch of the Medical Division at Dugway. Major groups of invertebrates were investigated and species documented included 1 protozoan, 20 flatworms, 79 roundworms, 4 spiny-headed worms, 36 snails and slugs, 1 clam, 6 crustaceans, 150 arachnids, and 1,300 insects. This list represents a small fraction of the true number of invertebrates likely occurring on base (U.S. Army 1982).

There are no fish on Dugway and only one native amphibian, the Great Basin spadefoot toad (*Scaphiopus intermontanus*). There are six species of lizards and one skink. Two species, the sagebrush lizard (*Sceloporus graciosus*) and the short-horned lizard (*Phrymosoma douglasii*), were documented before 1955, but have not been seen in recent years. Three species of nonpoisonous and two species of poisonous snakes are present. One of the poisonous species, the sidewinder rattlesnake (*Crotalus cerastes*), may be a non-native introduction (DPG 1996B).

Forty-one species of birds are year-round residents on Dugway (DPG 1996C). Forty-five species are summer-only residents and 18 occur in winter. There are confirmed breeding observations for 58 species. Eighty-one species regularly pass through the area during migration seasons. An additional 28 species were documented but are considered "accidentals" because Dugway is outside their range or there is not appropriate habitat on base. A total of 213 different bird species were documented (DPG 1996C).

Thirty-nine species of mammals representing 14 families were documented since 1993 (DPG 1996D). There are 11 species of bats, 4 mustelids, 2 foxes, 1 squirrel, 2 chipmunks, 5 mice, and 4 rats. Other mammals include raccoon (*Procyon lotor*), coyote (*Canis latrans*), mountain lion (*Felis concolor*), bobcat (*Lynx rufus*), yellowbelly marmot (*Marmota flaviventer*), porcupine (*Erethizon dorsatum*), blacktail jackrabbit (*Lepus californicus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and feral horse (*Equis cabellus*).

3.2.3.8 Threatened, Endangered, and Sensitive Species

Vegetation

One plant species, Ute ladies-tresses (*Spiranthes diluvialis*), is federally listed as threatened. This orchid was observed in 1994 along the southern boundary of Dugway. Survey efforts in this vicinity are hampered by illegal cattle grazing, but Ute ladies-tresses could easily occur on the property. Four other plants are classified as federal species at risk, and *Frasera gypsicola* (no common name) is listed by the state of Utah as a species of special concern.

Wildlife

Two federally protected raptors, the endangered American peregrine falcon (*Falco peregrinus anatum*) and the threatened bald eagle (*Haliaeetus leucocephalus*), occur during different times of the year. Peregrines are occasionally seen in fall and spring, usually following groups of migrating shorebirds. Peregrines are documented as nesting on nearby BLM land. Wintering bald eagles are fairly common and have been observed foraging and roosting. One candidate species for federal protection, the mountain plover (*Charadrius montanus*), was observed feeding on the property in 1994. One plant, two snails, three birds, three pocket gophers, and four bats are federally listed as species at risk. Fifty to 60 feral horses are federally protected and roam freely on the base (DPG 1996A).

The ferruginous hawk (*Buteo regalis*) is protected as a threatened species by the Utah Division of Wildlife Resources and is a confirmed year-round resident in upland habitats; nesting has been observed. In addition, the northern goshawk, burrowing owl, sage grouse, and kit fox are listed as Utah's species of special concern; all except the sage grouse are confirmed breeders.

3.2.3.9 Cultural Resources

Dugway and its vicinity are rich with archaeological and historical sites. Four Native American cultures, the oldest dating back to 11,000 years BC, left a variety of artifacts including tools, jewelry, pottery, and weapons. There are several Native American village sites in the Tooele Valley and approximately 200 campsites from the dune areas on Dugway. One of these dune sites is registered with the Utah State Antiquities Section. A cave north of Wig mountain is also registered with the state. Native American artifacts are protected by several federal, state, and local policies and acts (U.S. Army 1982).

From 1860 to 1867, the Pony Express route ran immediately south of what is now Dugway. A cemetery and the remnants of five station houses still exist (U.S. Army 1982).

Five sites near or on Dugway are listed by the National Register of Historic Places: Bonneville Salt Flats Raceway which has been used for land speed racing since 1925; Iosepa Cemetery which belonged to a colony of Polynesian people in the early 1900's; Soldier Creek kilns near Stockton; Lincoln Highway bridge (ca. 1919) which is all that remains in the area of the first coast-to-coast highway; and German Village, a launch site and block house where captured V-1 and V-2 German rockets were tested after World War II (U.S. Army 1982).

The Utah State Register of Historical Sites lists five sites in the area: Bonneville Salt Flats Raceway; David E. Davis home in Clover; the first Tooele County Courthouse (ca. 1867); Ophir Town Hall and Fire Station (ca. 1870); and John Sharp Home in Vernon (U.S. Army 1982).

Several major historic trails, roads, and foundations occur on Dugway. Disturbance to these areas is avoided. Locations and other information are available through the Environmental and Life Sciences Division on Dugway.

3.2.3.10 Water Resources

Groundwater

The Great Salt Lake Desert lies above an extensive deep aquifer system. In most areas, water from the surface down to 11 m (35 ft) is saline and separated from potable water by an impervious layer of clay. The top of the potable water lies between 5 and 45 m (17 and 148 ft) below surface, and the base extends to more than 760 m (2,494 ft). Below the potable layer, water again becomes very high in mineral content. Recharge of the potable groundwater is by percolation of runoff from surrounding mountains. The down gradient of the surface of deeper aquifers is generally west-northwest within the well fields in the English Valley and Dugway Valley areas (U.S. Army 1982).

Surface Water

Dugway is characterized by an overall lack of precipitation. Annual rainfall averages less than 18 cm (7 in), most of which comes in the spring. There is very little rainfall in the summer, and most of that occurs as violent thunderstorms over the mountains which can cause soil erosion and flooding. Precipitation in the winter months is usually snow. Arid conditions at Dugway hinder the formation of permanent surface waters. A few small, spring-fed streams and ponds are in the area, but the nearest large permanent stream is 110 km (68 mi) away. During heavy rainfall events, the clay surface of the lake bed causes water to pool and large, saline ponds form. These ponds quickly evaporate, causing upward leaching of high mineral content water from just below the surface. In areas north and west of Granite mountain, the water table is at or near the surface and the clay surface supports mud flats for 9 months of the year (U.S. Army 1982).

3.2.3.11 Geology and Soils

During the lower Cambrian period, most of Dugway and the surrounding area was under the sea. Mountain formation began in the Cretaceous period and faulting still continues. During the Pleistocene, a huge freshwater lake, Lake Bonneville, covered the area. The depth of Lake Bonneville fluctuated over time, and several well defined relict shorelines occur between 1,300 and 1,600 m (4,265 and 5,250 ft) elevation. The closest shorelines are located approximately 6 km (4 mi) from the airfield. As the lake receded, deep sedimentary deposits were left behind, and the area once supported an extensive mining industry. Several inactive mines and fossil/gemstone localities occur on Dugway, as well as one hot springs with a surface temperature greater than 50° C (122° F).

There are 23 soil types present on Dugway. Eleven of these types predominate and can be classified into three groups based on soil color and location. The first group occurs as dark-colored soils in desert mountains above the level of depositional soils of Lake Bonneville. Soils in the second group are light colored and found in desert mountains, valleys, terraces, and fans. This group includes shoreline and lake bed deposits of Lake Bonneville. The third group consists of Sodic-saline soils on valley bottoms and floodplains.

3.2.3.12 Health and Safety

Michael Army Airfield is currently an active military flightline with numerous landings and departures daily. A comprehensive occupational and flight safety program managed by Dugway is in place to ensure operations are conducted in a safe manner and risks are minimized. Hill Air Force Base near Salt Lake City controls the airspace and is responsible for range safety on the Utah Test and Training Range (see Section 3.2.3.6). 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 Air Force Base 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.

The only proximity hazard to vehicle operations is the Carr Facility, a chemical research laboratory located 1.0 km (0.6 mi) south southeast from the runway. This lab is designated a no flyover area.

3.2.3.13 Noise

Noise sources on Dugway include vehicle usage, military exercises, aircraft overflights, and related support activities (USAF 1990). The most significant source is aircraft which, depending on the type of aircraft and mission, can generate a wide range of noise levels (i.e., wide range of frequencies and/or levels (loudness); sonic booms). Sonic booms at Dugway are generated by supersonic flights (flights with maximum speeds of Mach 1 to 5).

Overpressures on the ground are between 0.02 and 0.10 kPa (0.5 and 2.0 psf), with occasional focus booms between 0.19 and 0.29 kPa (4.0 and 6.0 psf). At those higher pressures, damage to windows of conventional buildings might be expected, but not damage to walls. The nearest residential community, English Village on Dugway, is 16 km (10 mi) east of the 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 Environmental Protection Agency (EPA) noise level exposure guidelines. EPA has not promulgated noise guidelines for sonic booms.

3.2.3.14 Transportation

Two hard-surfaced roads, Highway 199 and Skull Valley Road, lead to Dugway from several Utah state routes (U.S. Army 1982). Traffic flow on these roads is classified as light.

3.2.3.15 Population and Employment

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 rest work for local or state Governments or are self-employed. There are 443 children between 3 and 17 years old enrolled in schools on the base (DPG Census Data 1990).

Dugway is located in Tooele County. The total resident population for the county in 1995 was 29,263, which is 2,600 people higher than the 1990 and 1980 census figures. 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 (DPG/Tooele County Census Data 1996).

3.2.3.16 Land Use

Dugway consists of a total of 325,000 ha (803,000 ac), 121 ha (300 ac) of which are improved land, 217 ha (536 ac) 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; and flame, incendiary, and smoke obscurant systems. Dugway is also used extensively for a wide variety of training programs. Michael Army Airfield 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 and the Space Shuttle must return (U.S. Army 1982).

3.2.3.17 Snow Conditions

During scoping, the potential for sonic booms to trigger snow avalanche was raised in Great Falls, Montana. Precipitation in the regional area of Dugway is mostly in the form of snow in the winter (see Section 3.2.3.4).

However, no snow avalanche-prone areas have been identified in the vicinity of either proposed launch site or trajectories. Therefore, no impact is expected. A discussion of snow avalanche is provided is section 3.2.5.17.

3.2.4 Malmstrom Air Force Base

3.2.4.1 Site Infrastructure

Runway

The airfield at Malmstrom was constructed as a Class B airfield consisting of a single 3,500 by 61 m (11,500 by 200 ft) runway with a 61 m by 3650 m (200 ft by 12,000 ft) runway safety area, a 380 m (1,250 ft) blast pad distance, a parallel taxiway, adjoining aircraft parking areas, and six interconnecting taxiways. The runway orientation is 03/21, with most aircraft using 21. The highest elevator is 1,075 m (3,526 ft). Due to the base realignment and closure study, the flying mission has been relocated, and the runway was closed to fixed-wing operations the end of calendar year 1996. Since closure of the airfield, the USAF has no plans or budget to operate the runway. There is no control tower, no instrument landing system, no visual aids for visual approach, no slope indicator lights, no airfield weather support and no on-going maintenance of the runway. No military restricted airspace exists at Malmstrom. Reopening of the airfield through permission of the USAF and/or Congressional authorization would be required to land the X-33 at this facility even on a limited, temporary basis.

The Accident Potential Zone (APZ) is divided into three different areas around the runway. The Clear Zone (CZ) is 915 m (3,000 ft) wide by 915 m (3,000 ft) long and is limited to utility lines, roadways, and agricultural uses. The APZ I is a 915 m (3,000 ft) wide by 1,524 m (5,000 ft) long area immediately beyond the CZ that allows for limited industrial and retail activities, outdoor recreation, and limited agricultural activities. The APZ II is a continuation of APZ I and is 915 m (3,000 ft) wide and 2135 m (7,000 ft) long and excludes facilities for public gatherings. There has been no encroachment into the CZ or the APZ's by on- or off-base activities.

Water Supply and Distribution

Water is supplied to the base by the city of Great Falls through two 31 cm (12 in) mains and two ground level storage tanks with a collective capacity of 6.4 million L (1.7 million gal) capacity. It is distributed through 71 km (44 mi) of 20, 25, and 31 cm (8, 10, and 12 in) cast iron, asbestos cement, and polyvinyl chloride looped mains, 9.5 million L (2.5 million gal) of storage, and a pump station (MAFB 1996B).

Wastewater

The original wastewater system at Malmstrom was constructed in the 1940's and expanded in the 1950's and 1960's to accommodate housing. Malmstrom wastewater is transferred to the Great Falls treatment plant. The single lift station has a capacity of 5.7 MLD (1.5 MGD). It was constructed in 1982 and is in "good" to "excellent" condition. The city's treatment plant is an activated sludge facility owned by Great Falls and operated through service contract by a private sewage treatment management firm. The plant operates at approximately 50 percent capacity, with the base's discharge constituting less than 10 percent of the effluent.

Electricity

Malmstrom receives electrical power from the Montana Power Company. Service enters from the north on one 100-kV transmission line and proceeds to a 15 MVA substation (Building 81120) which consists of two 7.5 MW distribution transformers. The electrical distribution system has 44.2 percent excess capacity based upon a 3-month peak average (9.4 MW) compared to total system capacity (16.84 MW). Critical facilities are equipped with backup generators. Utilities were replaced in 1990 and are in "excellent" condition (MAFB 1996B).

Communications

The telephone system (private carrier and long-distance) is Government-owned and contractor-maintained by U.S. West Communications. The Dial Central Office switch, which currently operates at 33 percent capacity, can accommodate significant growth. The cable plant and switches have a capacity for a 21 percent increase (MAFB 1996B).

Seven individual Local Area Networks (LAN's) are currently operated independently (e.g., the Standard Base Supply System and the Energy Monitoring Control System). A fiberoptic cable network has been designed to link the separate LAN's, and initial phases were funded to begin work in Fiscal Year 1996. A Base Network Control Center was established and is connected to the individual building networks via 56K modems and routers.

The Defense Integrated Switched Network provides a dedicated high-speed information system to support command and control communication requirements of Air Force Major Command centers. A terrestrially-based network, the Defense Integrated Switched Network integrates voice, data, and video. There is also an Automatic Digital Network using 4.8 to 9.6 kilobytes per second and a Defense Data Network to provide interpretability, survivability, and reliability for data communications. The long distance communications systems for Malmstrom are adequate for current missions and capable of accommodating moderate growth.

The Malmstrom Land Mobile Radio network is a conventional non-trunked, very high frequency radio communication system consisting of 21 radio nets with 1,600 users sharing the frequencies (MAFB 1996B).

Fuel

The airfield is equipped with a jet fuel hydrant refueling system that was completed in 1993. The system consists of one truck fill stand with eight offloading headers for bulk fuel delivery, 10.1 million L (2.7 million gal) storage, an inactive 21-hydrant distribution system, and 1.6 million L (0.4 million gal) in operating storage tanks. There is significant excess capacity based upon the number of aircraft that had been previously assigned (21 KC-135's), but the system is not capable of further expansion. There is currently no capability to transfer or store liquid hydrogen or liquid oxygen.

3.2.4.2 Hazardous Materials and Hazardous Waste

Hazardous materials are used throughout the installation, and residues from these materials must be collected and controlled for proper management and disposal. Collection begins at a satellite accumulation point (SAP) to a maximum of 208 L (55 gal). Wastes are then transferred from the SAP to the 90-day hazardous waste storage area (adjacent to Building 411) where materials are analyzed, identified, and prepared for shipment. Upon completion of processing, materials are moved to the permitted hazardous waste storage facility (Building 1535) to await final disposition. Disposition is handled by outside contractors to a number of permitted hazardous waste facilities around the nation. Malmstrom prepared a Waste Minimization Plan in delineating strategies for reducing toxicity or volume of each waste stream. A Hazardous Materials Pharmacy (centralized hazardous materials distribution center) is in place for inventory control, and there is a scheme to substitute nonhazardous products for hazardous materials.

Twenty-one locations on base are designated as Installation Restoration Program because of suspected past contamination, but Malmstrom is not on the National Priorities List (commonly referred to as "Superfund List"). These sites are under investigation and characterization, risk assessment, cleanup procedure selection, or remediation and closure. All sites are scheduled for closure by the end of Fiscal Year 2001. Investigations and closures/actions at 18 of the contaminated sites are being performed under the provisions of the Resource Conservation and Recovery Act (RCRA). Six of these sites are in the general proximity of the airfield.

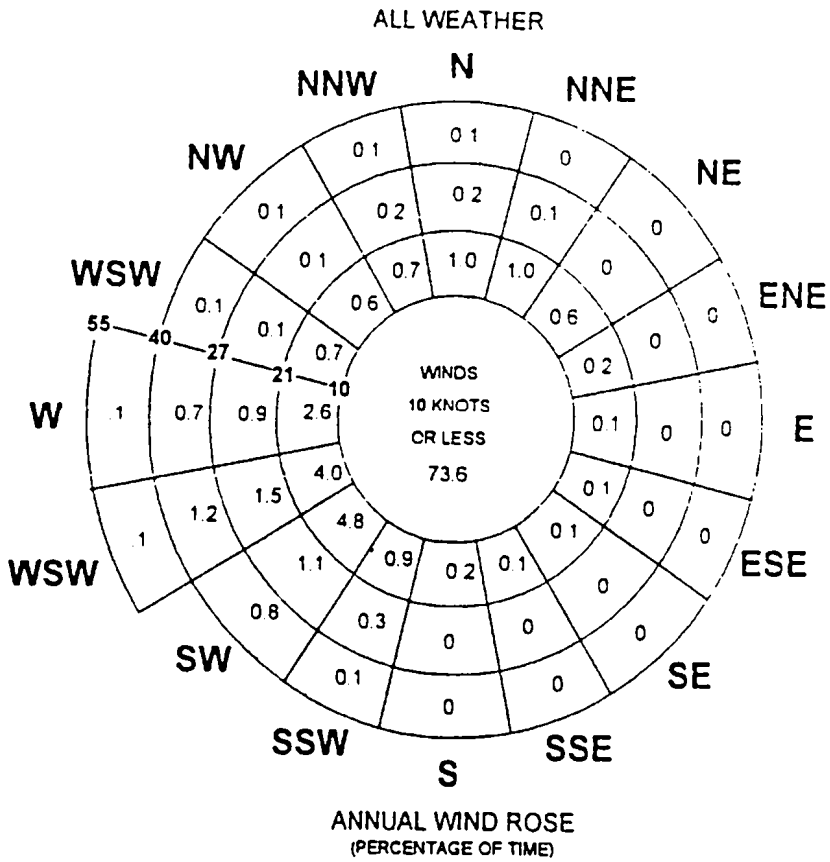
3.2.4.3 Solid Waste

Solid waste is accumulated in dumpsters and rolloff boxes that are periodically emptied or retrieved by a contracted waste collection and hauling company and emptied into a commercial landfill operated by the same contractor. The current solid waste disposal requirement for the installation is approximately 9,070 to 13,605 kg per day (kgd) (10 to 15 tons per day (tpd)), compared to approximately 317,450 kgd (350 tpd) for Great Falls and the surrounding area. The estimated operating life of the landfill is until Calendar Year 2036, and Great Falls has another property for additional disposal capacity. Malmstrom has a recycling program for white, computer, and mixed papers; newspaper, cardboard, clear glass, aluminum, plastics, steel, and used petroleum products.

3.2.4.4 Climate

The climate is characteristic of a semi-arid continental climate, as moderated by the presence of the Rocky Mountains to the west and Big and Little Belt ranges to the south. Summertime is generally pleasant, with cool nights, moderately warm and sunny days, and very little hot, humid weather. Winters are milder than would be expected of a continental location at this latitude because of the frequent occurrence of warm downslope winds (Chinooks) that produce temperature changes of 4.4° C (40° F) or more in 24 hours. July is generally the warmest month, with a mean high temperature of 28° C (82° F). January is usually the coldest month, with a mean low temperature of -12° C (11° F). The growing season averages 135 days per year (MAFB 1996A).

Humidity and precipitation are usually low, with associated large fluctuations in daily and seasonal temperatures. Average annual precipitation is 39 cm (15 in). Most of the precipitation during the late fall, winter, and early spring falls as snow, but the Chinook winds prevent large accumulations. The prevailing winds are from the southwest year round and are generally moderate with speeds exceeding 11 meters per second (m/s) (25 mph) only 2 percent of the time (Figure 3-27). Based on the average annual precipitation, the area would normally be classified as semi-arid, but about 70 percent of the annual rainfall typically occurs during the April to September growing season, so the climate is favorable for dry land farming. Table 3-20 presents average monthly temperature, precipitation, humidity, and wind speed data from the nearest National Weather Service station in Great Falls, Montana.



Notes: Concentric circles indicate wind speed in knots

1 knot = 1.1 miles per hour

Percentages rounded to the nearest tenth of a point

Source: *Airfield Pavement Evaluation, MAFB, MT*, May 1995

Figure 3-27. Malmstrom Wind Rose.

Table 3-20. Mean Climatic Conditions in Great Falls.

Month	Temperature		Precipitation		Relative Humidity[1]	Wind	
	Mean Daily Max °C (°F)	Mean Daily Min °C (°F)	Mean Total cm (in)	Mean Snow cm (in)	Mean (%)	Mean Speed m/s (mph)	Prevailing Direction
January	-0.5 (31.1)	-10.8 (12.5)	2.06 (0.81)	25.1 (9.9)	62	6.8 (15.3)	SW
February	2.3 (36.2)	-8.7 (16.3)	1.70 (0.67)	21.6 (8.5)	59	6.4 (14.3)	SW
March	5.8 (42.5)	-5.5 (22.1)	2.56 (1.01)	26.4 (10.4)	55	5.8 (13.0)	SW
April	12.9 (55.2)	0.2 (32.4)	3.15 (1.24)	18.5 (7.3)	47	5.1 (12.9)	SW
May	18.4 (65.1)	5.3 (41.4)	6.25 (2.46)	4.6 (1.8)	46	5.0 (11.4)	SW
June	22.9 (73.3)	9.5 (49.1)	6.75 (2.66)	0.8 (0.3)	44	4.5 (11.2)	SW
July	28.7 (83.6)	12.7 (54.9)	3.23 (1.27)	Trace	37	4.6 (10.1)	SW
August	27.6 (81.6)	11.9 (53.4)	3.40 (1.34)	Trace	39	5.1 (10.2)	SW
September	21 (69.8)	7.1 (44.7)	3.15 (1.24)	4.1 (1.6)	46	5.9 (11.3)	SW
October	15.1 (59.2)	2.6 (36.7)	1.96 (0.77)	7.9 (3.1)	46	6.5 (13.2)	SW
November	6.4 (43.6)	-3.7 (25.3)	1.82 (0.72)	19.1 (7.5)	54	7.0 (14.6)	SW
December	1.7 (35.0)	-8.2 (17.3)	1.85 (0.73)	22.6 (8.9)	60	7.4 (15.6)	SW
Annual	13.6 (56.4)	0.99 (33.8)	37.90 (14.9)	150.6 (59.3)	50	5.7 (12.8)	SW

[1]Relative humidity measured at 11:00 a.m.
[2] Wind speed based on 1941-90 period; prevailing direction through 1963.

Source: Bair (1992).

3.2.4.5 Air Quality

The city of Great Falls has an area "2 blocks by 13 blocks" located along 10th Avenue South, classified as nonattainment for carbon monoxide (CO). The area surrounding Malmstrom is classified as attainment for CO. According to the Montana Department of Environmental Quality, there are no nonattainment areas at Malmstrom, and based upon the 1990 Clean Air Act Amendments, Great Falls was categorized as "unclassified" in reference to CO. Ambient air quality data for Great Falls, Montana, can be found in Table 3-21.

The state has an existing federally enforceable State Implementation Plan prepared by the Montana Air Quality Bureau which was designed to bring federally designated nonattainment areas into compliance with the National Ambient Air Quality Standards. Air quality in the nonattainment area has improved sufficiently for the area to be redesignated as an attainment area. The Environmental Protection Agency, however, has not redesignated the area to date.

Table 3-21. National Ambient Air Quality Standards (NAAQS) and Local Monitoring Data.

Pollutant	Averaging Time	NAAQS µg/m³ (ppm)		Maximum Observed Concentrations by Monitoring Location µg/m³ (ppm) Malmstrom Air Force Base (Great Falls)
		Primary	Secondary	
SO2	24 Hour	365 (0.14)	None	63 (0.024)
	3 Hour	None	1310 (0.5)	223 (0.085)
	annual	80 (0.03)	None	10.5 (0.004)
NOx	annual	100 (0.05)	100 (0.05)	nm
CO	8 Hour	10 (9) mg/m³	None	9.0 (7.9) mg/m³
	1 Hour	40 (35) mg/m³	None	15.9 (13.9) mg/m³
PM-10	24 Hour	150	150	52
	annual	50	50	18
Lead	quarterly	1.5	1.5	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	nm

NAAQS are as listed in 40 CFR, Part 50.
1995 Monitoring Data presented.
nm = not monitored.

3.2.4.6 Airspace and Air Traffic

The Malmstrom Air Force Base flight track would originate at Edwards and extend northeast for approximately 1,530 km (950 mi). This flight path overflies 10 flight corridors under the control of the Los Angeles and Salt Lake City ARTCC, and terminates at Malmstrom Air Force Base. Flight sectors involved are Los Angeles Air Route Traffic Control Center (ARTCC) Sector 16 and Salt Lake City ARTCC Sectors 47, 45, 43, 42, 28, 40, 7, 18, 30, 31, 41, 8, 6, 19, and 20. The nominal flight track would also cross through the R-2508 Complex and Nellis Air Range. Restrictions of flight sectors within these military controlled airspace sectors have been previously described in Section 3.1.7.

Intervening flight areas would be over Class A Federal Aviation Administration (FAA)-controlled airspace requiring NOTAMs prior to launch. In addition, the immediate airspace through which the X-33 would descend in the vicinity of Malmstrom is under FAA control and is classified as Class B (terminal control) and Class A (positive control due to the large number of commercial air flights). Use of Classes A and B FAA-controlled airspace would require a sterile airspace, void of aircraft, from the FAA for imposing restrictions on civil, commercial, and military aircraft licensed within the U.S., when required.

3.2.4.7 Biological Resources

Vegetation

Most indigenous vegetation within the Malmstrom boundaries were removed by developmental activities and the introduction of exotic grasses, but the area was invaded by weedy forbs and some native species have recolonized portions of the base. In Appendix F, Table F-6 contains a list of the climax native perennial vegetation that is being encouraged (MAFB 1996B).

Wetlands and Floodplains

Approximately 15 ha (36 ac) of wetlands were identified on Malmstrom by the U.S. Army Corps of Engineers (USACOE) and range from standing water (Pow Wow Park) to stream beds that flow only after heavy precipitation (Figure 3-28). Wetland habitat reference material for Figure 3-28 are provided in Table 3-22. Any activities in these areas must be permitted by the USACOE (33 CFR 330.1).

Malmstrom is located on a high plateau south of the Missouri River and is approximately 30.5 m (100 ft) above the 100-year floodplain of the river.

Table 3-22. Wetland habitats identified on Malmstrom AFB (MAFB 1996A).

CLASSIFICATION	SIZE	DESCRIPTION
PEM1A(d)	20.0 ac (8.1 ha)	Palustrine, Persistent Emergent, Temporarily Flooded, (d) Partially Drained/Ditched. Common vegetation: Timothy (*Phleum pratense*).
PEM1Ax	1.0 ac (0.4 ha)	Palustrine, Persistent Emergent, Temporarily Flooded, Excavated.
PEM1C	10.4 ac (4.2 ha)	Palustrine, Persistent Emergent, Seasonally Flooded. Common vegetation: common cattail (*Typha latifolia*), red fescue (*Festuca rubra*), curley dock (*Rumex crispus*).
PEM1Cx	0.1 ac (0.04 ha)	Palustrine, Persistent Emergent, Seasonally Flooded, Excavated.
PEM1Fh	0.2 ac (0.08 ha)	Palustrine, Persistent Emergent, Semi-permanently Flooded, Impounded. Common vegetation: common cattail (*Typha latifolia*), hardstem bullrush (*Scirpus acutus*).
PFO1A	1.2 ac (0.49 ha)	Palustrine, Forested Broad-Leaved Deciduous, Scrub-Shrub Broad-Leaved Deciduous, Temporarily Flooded. Common vegetation: eastern cottonwood (*Populus deltoides*), black willow (*Salix nigra*).
PSS1/EM1Cx	0.1 ac (0.49 ha)	Palustrine, Broad-Leaved Deciduous Scrub-Shrub, Persistent Emergent, Seasonally Flooded, Excavated. Common vegetation: common cattail (*Typha latifolia*), reed canary grass (*Phalaris arundinacea*).
PSS1A	0.3 ac (0.12 ha)	Palustrine, Broad-Leaved Deciduous Scrub-Shrub, Temporarily Flooded. Common vegetation: black willow (*Salix nigra*).
PUBHh	1.9 ac (0.77 ha)	Palustrine, Unconsolidated Bottom, Permanently Flooded, Impounded. Open water created by a restriction in water flow.
PUBHhx	0.6 ac (0.24 ha)	Palustrine, Unconsolidated Bottom, Permanently Flooded, Impounded, Excavated.
R4SBAx	1.30 mi (2.6 km)	Riverine, Intermittent, Streambed, Temporarily Flooded, Excavated.
RASBC	0.25 mi (0.4 km)	Riverine, Intermittent, Streambed, Seasonally Flooded.
R4SBCx	2.25 mi (3.6 km)	Riverine, Intermittent, Streambed, Seasonally Flooded, Excavated.
R4SBFx	0.20 mi (0.3 km)	Riverine, Intermittent, Streambed, Semi-permanently Flooded, Excavated.

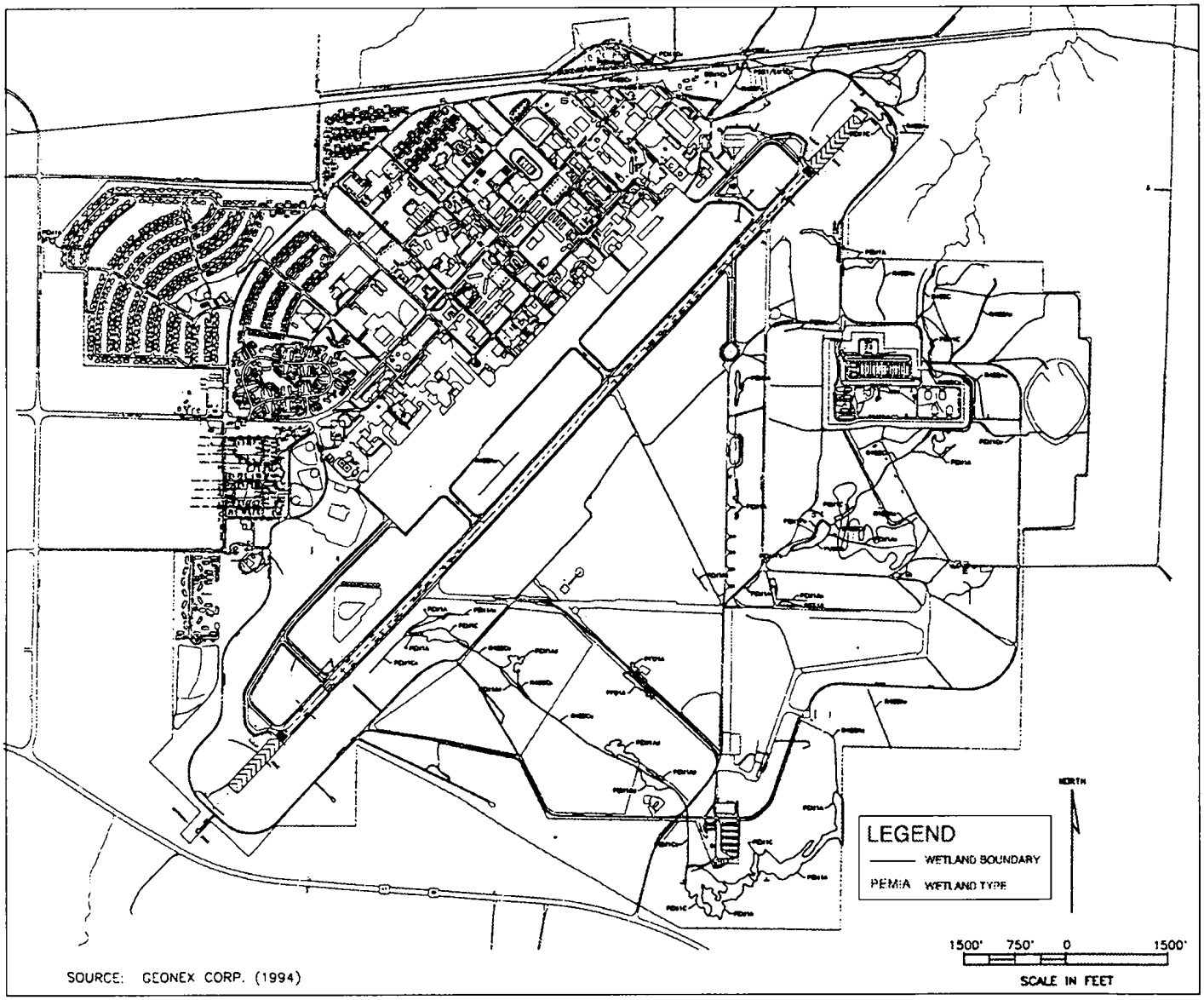


Figure 3-28. Wetlands at Malmstrom. Description of wetland designation can be found in Table 3-22 (MAFB 1996A).

Wildlife

Benton Lake National Wildlife Refuge is located about 23 km (14 mi) north of the base and is one of the major waterfowl production areas in the U.S. The Charles M. Russell National Wildlife Refuge, located 105 km (65 mi) from Malmstrom, is the beginning of the 240 km (149 mi) stretch of the Upper Missouri River System that is part of the National Wild and Scenic River System. The Giant Springs Heritage State Park and Fish Hatchery is a part of the Missouri River System. The Willow Creek and Pishkun National Wildlife Refuges occur about 97 km (60 mi) to the west of the base (Figure 3-29). Freezeout Lake Wildlife Management area, 64 km (40 mi) to the northwest, is home to shore birds, waterfowl, tundra swans, and tens of thousands of snow geese at certain times of the year. The Sun River Canyon, 113 km (70 mi) west of Great Falls, is home to the largest native herd of bighorn sheep in the U.S. This area also has Golden eagles (*Aquila chrysaetas*), prairie falcons, woodpeckers, and beavers.

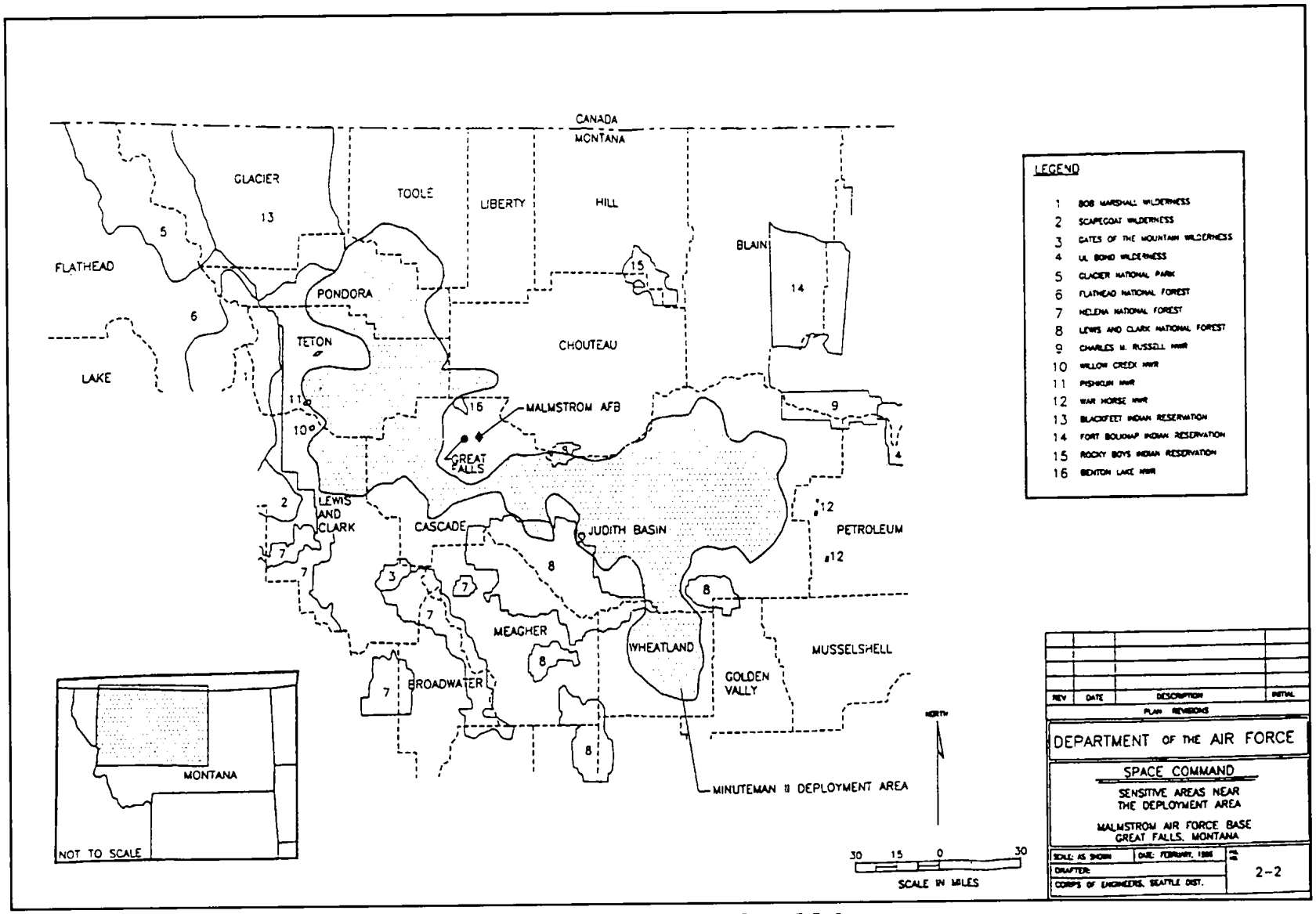


Figure 3-29. Sensitive Areas Near Malmstrom.

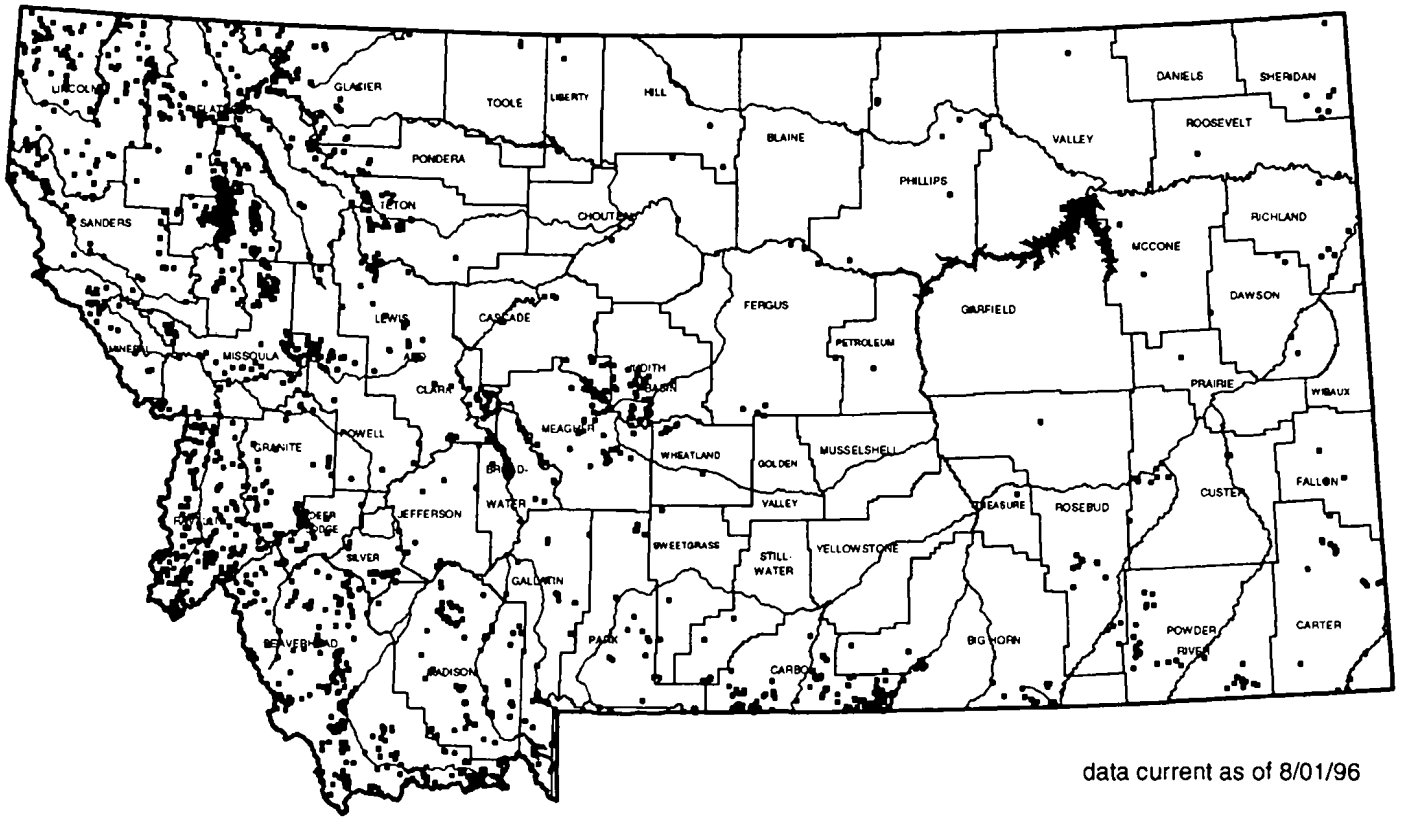
Wildlife in the area formerly included bison, wapiti, pronghorn, mule deer, white-tailed deer, black bear, and various small mammals. The Malmstrom Fish and Wildlife Management Plan contains a complete listing of birds, mammals, amphibians, reptiles, and fishes observed within a 32 km (20 mi) radius of the installation (Appendix F, Table F-7).

3.2.4.8 Threatened, Endangered, and Sensitive Species

Vegetation

An inventory of threatened and endangered plant species was completed in 1994, and none were identified. However, the report recommended an ecological management strategy that would keep native plant communities intact and preserve features that are an integral part of wildlife habitats. The Montana Natural Heritage Program has not identified any locations of plant species of special concern on Malmstrom (Figure 3-30).

Montana Natural Heritage Program
Plant Species of Special Concern



data current as of 8/01/96

Figure 3-30. Montana Natural Heritage Program Plant Species of Special Concern.

Wildlife

An endangered and threatened species inventory was completed for the base and the missile launch sites. Threatened or endangered species (e.g., bald eagles) have been observed in the area surrounding the base. The base is a potential habitat for candidate (ferruginous hawk and loggerhead shrike) and former candidate (long-billed curlew) species. Although no specific protective measures are required, consideration should be given to forestall disruption of their habitat. Barn swallows, though not protected, may not be disturbed while nesting. Threatened or endangered wildlife species do not currently impose a constraint to development on Malmstrom (MAFB 1996A). The Montana Natural Heritage Program map for animal species of special concern does not show any occurring at Malmstrom (Figure 3-31).

Montana Natural Heritage Program
Animal Species of Special Concern

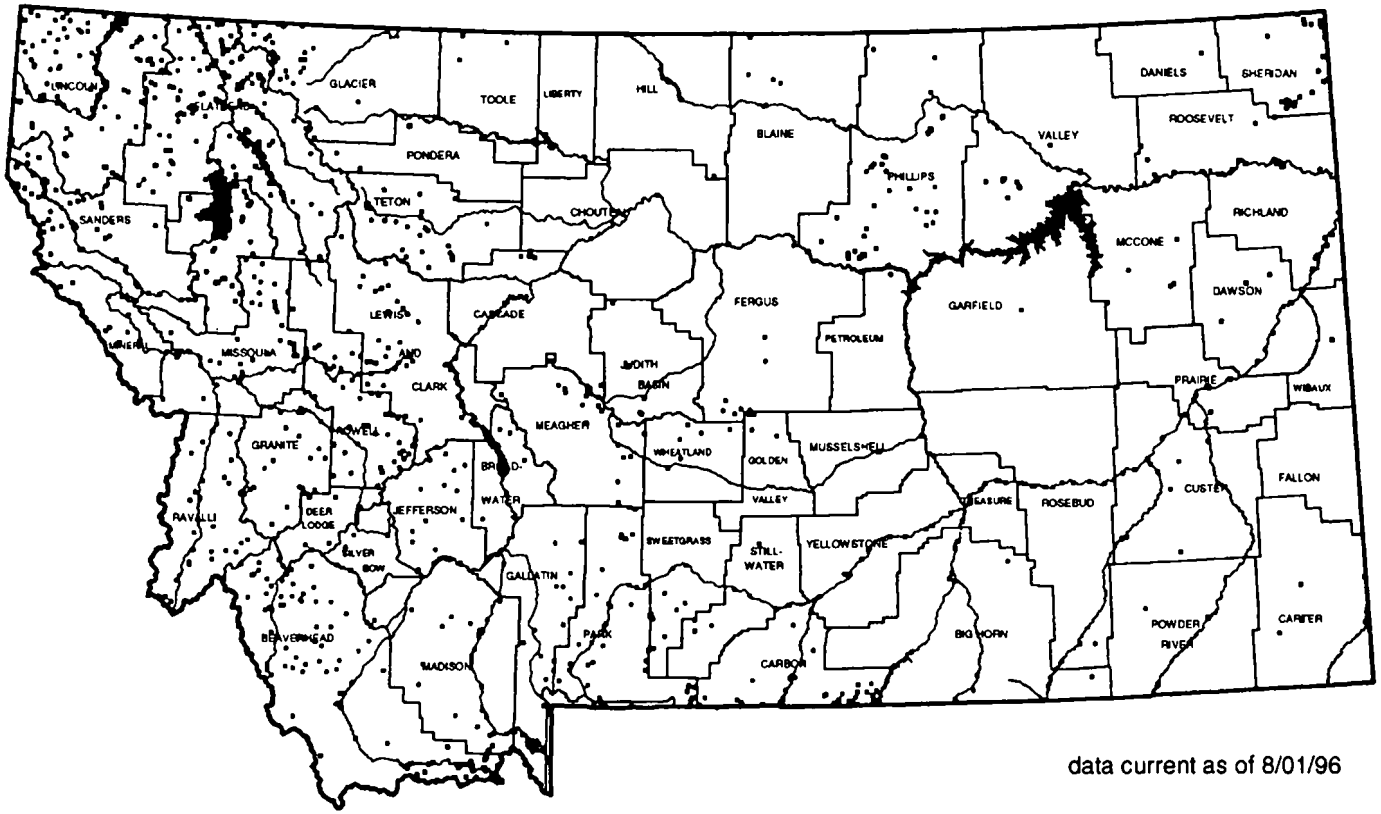


Figure 3-31. Montana Natural Heritage Program Animal Species of Special Concern.

3.2.4.9 Cultural Resources

Preliminary historical and archaeological surveys were conducted on the installation in August 1994. Two structures were identified as potentially eligible for the National Register of Historic Places. The Malstrom Command Center (Building 500) was originally a Semi-Automatic Ground Environment facility, which served as an alternate North American Air Defense Command Center during the Cold War. A segment of the Chicago, Milwaukee, St. Paul, and Pacific Railroad (now Burlington Northern) located along the northern perimeter of the installation may be eligible based on its role in the Euro-American settlement of the region.

The 1994 Archaeological Survey Report indicates that one prehistoric site (small lithic scatter) is located in a pasture south of the base's stables. Most of the artifacts were collected and are found at the Montana State University's Museum of the Rockies in Bozeman, Montana. Two prehistoric sites consisting of fire-cracked rock and lithic scatters were located off base in the surrounding lands and are considered surficial. A national landmark covering 3116 ha (7,700 ac) of noncontiguous lands was established to recognize the portage route of the 1804 Lewis and Clark expedition. The route allegedly extends across the base but no validating archaeological evidence has been discovered; therefore, none of the base's property was recommended for addition to that landmark.

A number of Native American groups occupied or passed through the region surrounding Malmstrom, but consultation with Native American groups concluded that there are no significant Native American cultural resources on Malmstrom (MAFB 1994).

Significant paleontological resources occur in Montana, mostly in surface to near-surface bedrock. Malmstrom is underlain by 9 to 31 m (30 to 100 ft) of glacial sediments, which do not tend to produce paleontological finds, and none have been found on Malmstrom (MAFB 1991 and MAFB 1994).

3.2.4.10 Water Resources

Groundwater

Shallow groundwater (less than 8 m (25 ft) below ground surface) was encountered as locally noncontiguous perched zones. Water was adversely impacted at some of the Installation Restoration Program sites. Due to the limited supply of water and discontinuous nature of this shallow aquifer, it is unlikely to be used as a water source in the future. Several regional aquifers underlie the installation at a depth greater than 31 m (100 ft). The Madison Swift aquifer feeds Giant Springs, 3 km (2 mi) northwest of Malmstrom, one of the largest springs in the world (MAFB 1991).

Surface Water

Stormwater discharged from Malmstrom drains into the Missouri River and, at the confluence, the river is recognized as a Class B-3 river by the state of Montana. This classification identifies it as a source of water suitable for drinking, culinary and food processing purposes, agricultural, domestic, industrial, and recreational uses, as well as an integral part of the wildlife habitat.

Nine primary surface water drainage basins were identified on Malmstrom, which consist of a system of swales, open trenches, and some covered pipes. Six basins have point discharges and five of them are monitored and sampled in compliance with the stormwater permit (MAFB 1996B). A monitoring program was initiated, and to date there are no compliance problems with the discharge limits. The state of Montana requires that the permit or the Stormwater Pollution Prevention Plan (SWPPP) be modified if changes in activities have a significant effect on the potential discharges of pollutants or if the SWPPP is ineffective in protecting state waters.

3.2.4.11 Geology and Soils

The Sweetgrass Arch is the dominant bedrock structural feature throughout Montana. It extends northwest between the Little Belt mountains, 39 km (24 mi) south, past the base on the southwestern side and into Alberta, Canada. Stratigraphic units important to the framework of the region surrounding Malmstrom range in age from the Madison Limestone of the Mississippian era (360 million years) to the Eolian Sand of the Holocene (10,000 years). These units include sedimentary bedrock formations, unconsolidated glacial deposits, and windblown deposits.

The predominant soil series is alluvium, consisting of silty clays and sandy loam, covering approximately 75 percent of the base. The majority of the remaining area is covered with a silty clay loam formed by glacial till and glaciolacustrine materials. The permeability of these soils is high, ranging from 0.2 to 15 cm (0.06 to 6.0 in) per hour. In conjunction with the level nature of the surface (average slope of 0.5°), runoff is slow and surface erosion due to water is slight. The sand dunes of the northwest portion of the base are more susceptible to erosion due to wind action (MAFB 1996B).

3.2.4.12 Health and Safety

The airfield at Malmstrom was, until the end of 1996, an active military flightline with numerous landings and departures daily. The runway was closed on December 31, 1996, for aircraft operations; however, helicopter operations in support of the base's missile mission will continue. A comprehensive occupational and flight safety program managed by the 341st Missile Wing Safety Office is in place to ensure operations are conducted in a safe manner and risks are minimized. Malmstrom has a fully operational fire department, but aircraft crash rescue vehicles

have been eliminated due to the runway closure; however, some limited crash coverage is available. Future aircraft operations may require bringing in specialized fire protection equipment and crews to handle possible contingencies. Medical treatment is provided by the 341st Missile Wing Medical Group which operates a fully staffed and equipped base clinic. This clinic includes an outpatient surgery center. Inpatient care is provided by civilian hospitals in two locations in the Great Falls area.

The primary existing hazard of the flight vehicles involves the close proximity of the runway to the city of Great Falls, as well as several high risk military facilities including the Weapons Storage Area, a missile booster storage site, two bulk fuel storage sites, and several base housing units.

3.2.4.13 Noise

An Air Installation Compatibility Use Zones (AICUZ) study for Malmstrom Air Force Base was performed. Noise zones and contours were developed using the NOISEMAP modeling program. The most significant area affected by noise on Malmstrom is the off-base Wherry military housing area, which is partially situated between the 60 and 70 L_{dn} contours.

3.2.4.14 Transportation

The city of Great Falls is the transportation hub of the region for highway and bus transportation. Great Falls is located at the intersection of Interstate Highway 15 and U.S. Highways 87 and 89. Interstate 15 is the primary north-south route, running north to the Canadian border and south to Helena and Butte. At Butte, approximately 161 km (100 mi) southwest of Great Falls, Interstate 90 intersects Interstate 15 providing an east-west route across the southern half of the state. Regional bus service is available in Great Falls to connect to major cities.

Traffic enters the base through two gates. The main gate is located on 2nd Avenue North, which becomes the base's main thoroughfare (Goddard Avenue), and the commercial gate enters from 10th Avenue North, becoming 72nd Street North, which intersects Goddard. Both entrance roads connect through city streets to Highways 87/89 and 10th Avenue South, the primary Great Falls thoroughfare. City bus service extends through the city to the main gate of Malmstrom. There is adequate parking at Malmstrom.

3.2.4.15 Population and Employment

Great Falls is one of the largest cities in Montana. It contains approximately 59,500 of Cascade County's 81,200 residents and serves as the county seat and civic and commerce center of the area. The closest communities to the north, east, and south are: Carter (39 km/ 24 mi), Belt (26 km/16 mi), and Tracy (8 km/5 mi), respectively.

Cascade County is considered the socioeconomic region of influence (ROI) for Malmstrom. In 1994, total employment in the ROI was estimated at 35,036 with the majority of workers employed in services or retail industries. The unemployment rate for Cascade County was 4.9 percent in 1994. Malmstrom currently employs 4,151 military and civilian employees, directly accounting for more than 13 percent of employment in the ROI, and contributes approximately $273 million annually to the area's economy (MAFB 1996B).

The 43rd Air Refueling Group consisting of 12 KC-135R aircraft was transferred to MacDill Air Force Base as a result of the Base Realignment and Closure Commission decision. This action included closure of the runway and removal of emergency fire/rescue crews at Malmstrom. After December 31, 1996, the total workforce was 4,151, with 477 civilians and 3,674 military (officers and enlisted). However, the RED HORSE heavy construction mobility force will be stationed at Malmstrom beginning in Fiscal Year 1998. They will use the Great Falls International Airport for takeoffs and landings. The squadron manning will be approximately 404 personnel. Of this total, 284 will be active duty Air Force personnel and 120 will be Montana Air National Guard.

3.2.4.16 Land Use

The base encompasses approximately 1,279 ha (3,159 ac) of Government-owned land. An additional 182 ha (449 ac) of restrictive easements are held on adjacent lands. Associated with the base is the 341st Missile Wing missile complex, which includes 4 missile squadrons with 20 missile alert facilities, and 200 launch facilities distributed throughout a 60,865 sq km (23,500 sq mi) area in north-central Montana. The missile complex is known as the Malmstrom deployment area.

Land use inside the base boundaries includes a military airfield, operational, industrial and administrative facilities to support the base, the airfield and the various missile sites under the control of Malmstrom and military housing areas. The airfield and flight operations facilities are no longer operational and are not being maintained (MAFB 1996B).

The city of Great Falls is located approximately 0.6 km (0.4 mi) to the west of the base. The land surrounding Malmstrom is all privately owned. The base is currently bordered on the north, east, and south sides by agricultural lands, with mixed commercial, industrial, residential, and open land uses to the west/northwest. Agricultural areas adjacent to Malmstrom are currently used for growing grain, predominantly wheat. With the exception of land already developed, the area is not specifically zoned. Due to the lack of development demand and the economic benefits of maintaining the land in agricultural production, this use is expected to continue.

3.2.4.17 Snow Conditions

In winter months, snow accumulates in high mountain areas, providing conditions suitable for alpine skiing and similar winter sports. An issue was raised during scoping in Great Falls, Montana, about the potential for sonic booms to trigger snow avalanche, especially in areas of high use. A discussion of snow avalanche is provided in Section 3.2.5.17

3.2.5 Grant County Airport, Moses Lake, Washington

3.2.5.1 Site Infrastructure

Runways

Runways at the Grant County Airport accommodate a wide variety of aircraft. Runways 14L-32R and 3-21 are designed for large aircraft, and 18-36 and 14R-32L are available exclusively for smaller aircraft. Runway 14L-32R is designated as the main runway and 3-21 is the cross-wind runway. Runway 14L-32R is 46 m (150 ft) in width and 4,115 m (13,500 ft) in length and can accommodate all aircraft currently in either the civilian or military fleets. Runway 3-21 is 31 m (100 ft) wide and 3,048 m (10,000 ft) long. It accommodates all design group III aircraft and a limited number of design IV aircraft operations. Runway 18-36, 23 m (75 ft) in width and 1,006 m (3,300 ft) in length, is primarily used by smaller aircraft and Big Bend Community College's flight training program (Tables 3-23 and 3-24). The existing layout of the Grant County Airport is shown in Figure 2-15 (Black and Veatch 1993).

Table 3-23. Grant County Airport Runway Characteristics.

Runway	14L-32R	3-21	18-36	14R-32L
Length(ft)	13,500	10,000	3,300	3,000
Width (ft)	150 (1)	100	75	75
Runway Safety Area (ft)	500 x 15,500	150 x 10,600	150 x 3,900	150 x 3,600
Approach Surfaces (ft)	34:1/50:1	34:1/34:1	20:1/20:1	20:1/20:1
Blast Pad Distance (ft)	1,000 (2)	1,000 (2)	Taxiway C	None
Highest Elevation (ft)	1,172	1,185	1,185	1,165
Lowest Elevation (ft)	1,163	1,150	1,175	1,165
Surfacing Type (ft)				
-Asphalt	8,000	5,600	3,285	N/A
-Concrete	5,502	4,398	N/A	3,025
Stabilized Shoulder (ft)	100 (3)	200 (4)	50	50
Allowable Gross Weights (5)				
-Single Wheel Gear	100	100	100	100
-Double Wheel Gear	200	200	200	200
-Dual Tandem Gear	400	400	400	350
-Double Dual Tandem Gear	500	N/A	N/A	400

(1) Full strength pavement = 300 feet, marked to 150 feet.
(2) Structurally inadequate as a stopway.
(3) No shoulder for first 3,000 feet of Runway 14L.
(4) 150 feet adjacent to Taxiway J.
(5) In thousands of pounds.

Table 3-24. Grant County Airport Runway Lighting and Navigational Aids.

Runway	14L-32R	3-21	18-36	14R-32L
Lighting:				
-Runway Edge Light Intensity	High	Medium	Medium	Medium
-In-Pavement Centerline Lights	No	No	No	No
Navigational Aids:				
-REIL	Yes - No	No - No	Yes - No	No - No
-RAIL	No - MALSR	No - No	No - No	No - No
-VASI	Yes 2 - No	Yes 4 - Yes-4	No - No	No - No
-PAPI	No - Yes	No - No	No - No	No - No
-VOR/DME	Yes - Yes	Yes - Yes	No - No	No - No
-NDB	No - Yes	No - No	No - No	No - No
Instrument Runway	Non-Precision/ Precision	Non-Precision/ Precision	No	No

Water Supply and Distribution

The city currently operates the Grant County Airport water system, although it is not connected to the rest of the municipal system. The Grant County Airport water system includes five wells. Treatment consists of chlorination at the wells. Grant County Airport elevated storage tanks provide a collective capacity of 2.8 million L (750,000 gal). Storage capacity was greatly enhanced in 1992 by a new 9.1 million L (2.4 million gal) tank installed in the residential area south of the airport. The pumping capacity of the five wells is 33 MLD (8.7 MGD).
Table 3-25 indicates excess capacity; however, according to projections in the 1992 Comprehensive Water Plan, the airport and city demands will exceed capacity by the year 2002 (Black and Veatch 1993).

Table 3-25. Potable Water Supply, Existing and Projected.

	1992	1997	2002
Larson Pressure Zone			
Supply (gpm)*	6,050	6,050	6,050
Demand (gpm)	3,770	4,888	6,682
Available Capacity (gpm)	2,280	1,162	-632
Whole City System			
Supply (gpm)*	21,390	21,390	21,390
Demand (gpm)	10,725	17,342	23,530
Available Capacity (gpm)	10,665	4,048	-2,140
*Assumes no expansion of existing system and reinstatement of out-of-service wells to prior capacity.			

Source: Interim Findings of ***Moses Lake Comprehensive Water Plan****, CH2M Hill.*

Wastewater

The city of Moses Lake provides wastewater collection and treatment services outside corporate limits to industries who enter into an agreement with the city for an extraterritorial extension of sewerage services. The city owns and operates two independent wastewater collection, treatment, and disposal systems which are the city/Sand Dunes System (Sand Dunes) and the Grant County Airport System. The treatment plants in each system currently dispose of treated wastewater through infiltration basins (Grant County 1996).

Domestic sanitary sewage at Grant County Airport is collected from the developed areas and treated at the base sewage treatment plant. The plant, now operated by the city, is located at the intersection of Tyndall and Randolph Roads. Current loading of the plant is about 1.3 MLD (0.35 MGD), and it is designed to handle an inflow of 2.3 MLD (0.6 MGD). However, a 1990 engineering study indicated it could probably not treat municipal waste flows at the design volume to today's standards. The plant is not meeting secondary treatment standards at certain times of the year. Upgrade and expansion of the plant for permit renewal may be necessary in the near future (Black and Veatch 1993).

Electricity

Electrical power is supplied by the Grant County Public Utility District (PUD). Service is from a PUD substation a half mile east of the airport on Stratford Road. The distribution system is underground in airport operational areas and aboveground elsewhere (Black and Veatch 1993).

The PUD supplies power from the Wanapum and Priest Rapids dams. However, the PUD has reached production capacity from it hydroelectric facilities. Electricity for any additional electrical load must be purchased on the open market where the cost is eight times the cost of power produced by PUD's electrical system. The Grant County PUD is promoting "field switching" or switching from one power supply to another. PUD will pay customers to change their power supply from electricity to natural gas. The electrical capacity that becomes available can be used for other customers and will maintain a low cost for their electricity. There is some concern that this will not be enough to provide for all growth needs of the area. Existing industries will continue to grow and increase their electrical needs even when they "field switch" some components of their operation (i.e., boilers). If "field switching" does not provide sufficient electrical capacity within the PUD system, the PUD will need to build a substation for the electricity generated outside the PUD system. An interruption of the present electric transmission system would result in curtailment of power. A transmission line is needed to provide system reliability. The planned Rocky Ford Project involves tapping into the Bonneville Power Administration transmission line near Rocky Ford Creek on SR 17 and constructing a transmission line to the Larson/Wheeler Corridor (Grant County 1996).

Communications

Telephone service for the Moses Lake area, including the Grant County Airport, is provided by U.S. West Communications. Services are considered adequate with no constraints to meet future growth (Grant County 1996; Black and Veatch 1993).

Fuel

Aircraft fuel is delivered via a 15 cm (6 in) pipeline from the Yellowstone Pipeline Company terminal located 0.8 km (0.5 mi) east of the airport on Stratford Road. Two branches of the pipeline enter the airport property. The pipeline near the intersection of Randolph and Graham Roads serves a former Larson Air Force Base (LAFB) fuel storage area on Boeing property and is no longer in use. The second pipeline enters airport property near the end of Runway 32R and serves a former LAFB fuel storage area located at the south end of the airport, at Randolph Road

and 21st Avenue. Pipeline capacity is 400 to 450 barrels per hour for jet fuel, 500 barrels per hour for gasoline, and 420 barrels per hour for diesel. All underground storage tanks have been removed.

3.2.5.2 Hazardous Materials and Hazardous Waste

This site manages both hazardous materials and hazardous wastes that are produced from its various operations. Hazardous materials include such things as aviation fuels, fuels such as gasoline and diesel for ground vehicles, and oils and lubricants. These materials are usually stored in bulk quantities and are transported around the facility using tankers and similar means. Other materials stored in smaller amounts include cleaning fluids and de-icing fluids. The facility has existing systems in place to manage and control these materials to ensure impacts to the environment are minimized.

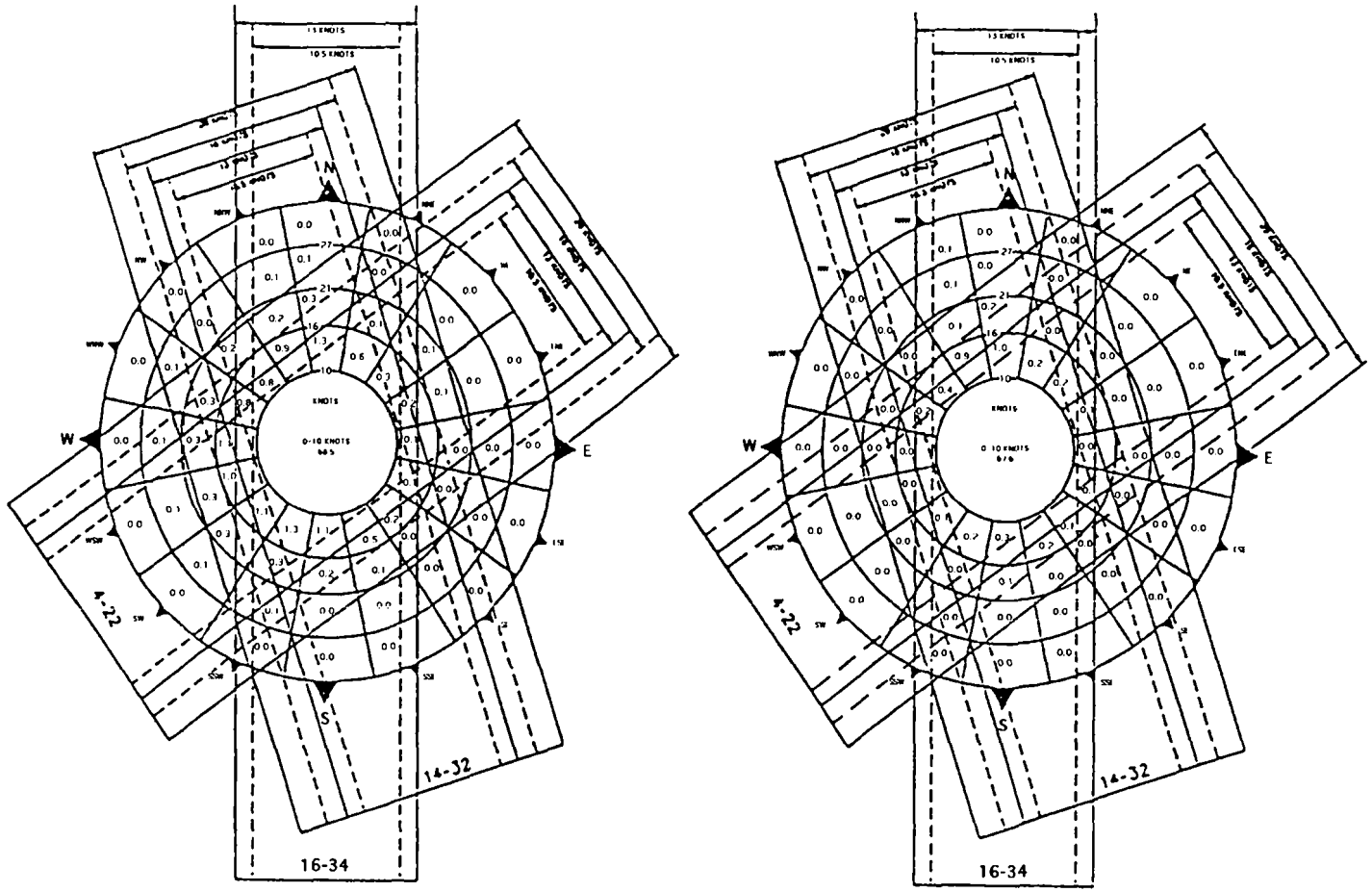
Various activities at the facility produce wastes which are classified as hazardous under RCRA. These include waste oils, waste fuels, spent solvents, and the like. Under RCRA, such materials must be removed from the site within 90 days of their production or be stored in a permitted storage facility. The facility has existing systems in place to properly dispose of these wastes in a timely manner. Temporary staging of these wastes may be done at various 90-day staging areas around the facility.

3.2.5.3 Solid Waste

Solid waste is removed by Consolidated Disposal Service. Consolidated collects solid waste for disposal at the Grant County landfill in Ephrata. Solid waste collection service is provided to approximately 5,000 customers in the unincorporated areas of Grant County and portions of Adams County. The Grant County landfill has additional capacity available to receive waste. The Grant County Public Works Director indicated that the landfill is estimated to have approximately 20 years of capacity remaining (Grant County 1996; Black and Veatch 1993).

3.2.5.4 Climate

The average annual temperature is 11° C (51° F) with temperatures in January ranging from -7.3 to 1.2° C (19 to 34° F) and in July ranging from 12 to 31° C (54 to 87° F). Average annual precipitation in Grant County is approximately 18 cm (7 in), with an average relative humidity of 76 percent at 6 a.m. and 43 percent at 6 p.m. The average annual snowfall is 46 cm (18 in). One of the major advantages for aviation at this airport is the semi-arid climate. Grant County Airport advertises an average of 350 Visual Flight Rule days per year. According to the 1992 Grant County Airport Master Plan, prevailing wind directions are north in fall and winter, and south during spring and summer. Wind Roses for the Moses Lake area are shown in Figure 3-32. Approximately 65 percent of the time, wind velocity is 6 to 19 km/hr (4 to 12 mph). Additional climatic data is presented in Table 3-26 (Black and Veatch 1993; Grant County 1995).



ALL WEATHER WIND ROSE

FOR SOURCE INFORMATION SEE NOTES AND METEOROLOGICAL DATA
% CALMS, 16.4%

PERCENTAGES SHOWN DO NOT SUM TO 100% DUE TO ROUNDING ERROR AS PROVIDED BY NOAA.

IFR WIND ROSE

FOR SOURCE INFORMATION SEE NOTES AND METEOROLOGICAL DATA
% CALMS, 27.5%

PERCENTAGES SHOWN DO NOT SUM TO 100% DUE TO ROUNDING ERROR AS PROVIDED BY NOAA.

Figure 3-32. Wind Roses for Moses Lake.

Table 3-26. Climate Characteristics of Moses Lake.

Temperature Range °F (°C)	Minimum	Maximum	Median
January	18.8 (-7.3)	34.1 (1.2)	26.5 (-3.1)
March	29.7 (-1.2)	52.6 (11.4)	41.2 (5.1)
May	42.9 (6.1)	71.1 (21.7)	57.1 (10.6)
July	53.7 (12.1)	86.8 (30.4)	70.3 (21.3)
September	44.6 (7.0)	76.5 (24.7)	60.5 (15.8)
November	27.7 (-2.4)	45.9 (7.7)	36.8 (2.7)
Year	36.6 (2.6)	61.4 (16.3)	49.0 (9.7)
Precipitation	**Average Number of Days**		
Snowfall, Sleet, Hail (1" or more)	17.60		
Rain (.01" or more)	7.74		

*Source: **Washington State Standard County/City Profile**, Moses Lake Station.*

3.2.5.5 Air Quality

Grant County is primarily rural, with only modest levels of development and industrialization. Therefore, air quality in the region tends to be good. The State Department of Ecology has established ambient pollutant monitoring stations throughout Eastern Washington to measure concentrations of both PM_{10} and CO. The closest PM_{10} monitoring stations to Moses Lake are located in Yakima (two stations), Sunnyside, Othello, Wenatchee, Wallula, Kennewick, and Walla Walla. Air quality data is provided for each of these regional monitoring stations.Yakima is the only location where CO monitoring is conducted. Ambient air quality data monitored at Yakima can be found in Table 3-27.

Table 3-27. National Ambient Air Quality Standards (NAAQS) and Local Monitoring Data.

Pollutant	Averaging Time	NAAQS ($\mu g/m^3$ (ppm))		Maximum Observed Concentrations by Monitoring Location ($\mu g/m^3$ (ppm))
		Primary	Secondary	Moses Lake (Yakima)
SO_2	24 Hour	36 (0.14)	None	nm
	3 Hour	None	1310 (0.5)	nm
	annual	80 (0.03)	None	nm
NO_X	annual	100 (0.05)	100 (0.05)	nm
CO	8 Hour	10 (9) mg/m^3	None	14.2 (12.4) mg/m^3
	1 Hour	40 (35) mg/m^3	None	13.6 (11.9) mg/m^3
PM_{10}	24 Hour	150	150	126
	annual	50	50	nm
Lead	quarterly	1.5	1.5	nm
Ozone	1 Hour	235 (0.12)	235 (0.12)	nm

NAAQS are as listed in 40 CFR, Part 50.
1996 Monitoring Data presented.
nm = not monitored.

Of all the cited PM_{10} monitoring stations, only the station at Sunnyside has recorded no exceedances of the federal 24-hour PM_{10} standard (150 $\mu g/m^3$) during the past 10 years. The others have each recorded at least one exceedance during the last 10 years. All monitoring stations except Wallula maintained compliance with the Environmental Protection Agency's annual standard (50 $\mu g/m^3$), even when short-term exceedances occurred. The Yakima, Kennewick, Walla Walla, and Wallula areas have been designated as nonattainment for PM_{10} because of the number of exceedances of the short-term standard. The PM_{10} nonattainment designations in Eastern Washington are the result of a variety of factors, including agriculture and the use of uncertified wood stoves. The Department of Ecology is working with other agencies to identify and characterize sources of windblown particulates and will develop mitigation practices once the PM_{10} sources have been identified. In the Yakima area, the focus has been on replacing uncertified wood stoves with high efficiency stoves.

Yakima was designated a nonattainment area as a result of exceedances on the 8-hour CO standard each year from 1986 to 1988 and in 1991 and 1992. An inventory was conducted to identify point sources of CO in order to assess why the exceedances occurred and develop a strategy for achieving attainment. While a few nearby areas in Eastern Washington experienced difficulty in complying with federal ambient air quality standards, the Moses Lake area is believed to be in attainment for all criteria pollutants (Grant County 1996).

3.2.5.6 Airspace and Air Traffic

The Moses Lake flight track leaving Edwards would fly directly north for approximately 1,530 m (950 mi). The path would overfly 13 flight corridors managed by the Los Angeles, Oakland, Salt Lake City and Seattle Air Route Traffic Control Centers (ARTCC), and terminate at Moses Lake. Flight sectors involved are Los Angeles ARTCC Sector 16, Oakland ARTCC Sectors 46, 33, 43 and 45, Salt Lake City ARTCC Sectors 42, 43, 30, 31, and 41, and Seattle ARTCC 9, 16, 39, 47, 18, and 7. The initial flight path would originate within R-2508. The Nellis Air Range would also be crossed through in the course of nominal flight. All coordination of these ranges and the Federal Aviation Adminitration (FAA)-controlled airspace would be the responsibility of the Air Force Flight Test Center. The R-2508 Complex and Nellis Range restrictions on airspace have been previously described in Section 3.1.7.

Intervening flight areas would be over Class A FAA-controlled airspace requiring NOTAMs prior to launch. In addition, the immediate airspaces through which the X-33 would descend in the vicinity of the Grant County Airport are FAA-classified as Class B (terminal control) and Class A (positive control due to the large number of commercial air flights). Use of Classes A and B FAA-controlled airspace would require a sterile airspace, void of aircraft, from the FAA for imposing restrictions on civil, commercial, and military aircraft licensed within the U.S., when required.

3.2.5.7 Biological Resources

Vegetation

The undeveloped areas of the airport contain shrub-steppe vegetation. The structure of this plant community is open grass with scattered shrubs. Big sagebrush (*Artemesia tridentata*) is the major shrub species. The amount of sagebrush varies from area to area throughout the airport. Some areas are almost completely covered with grass while others are about 30 percent brush. Sagebrush is generally 0.9 m (3.0 ft) or less in height. There are no trees at the airport. The shrub-steppe community has been subject to grazing in the past, but is not currently grazed. There are small areas of irrigated alfalfa on the west side of the airport. These are regularly mown for hay. The developed areas are generally sparsely vegetated and are dominated by non-vegetated land (Black and Veatch 1993).

Wetlands and Floodplains

One potential jurisdictional wetland area occurs in the northeast portion of the airport. It is 0.4 to 0.8 ha (1.0 to 2.0 ac) in size and contains a few willow trees, grazed grasses and possibly reeds. The area is shown on National Wetland Inventory maps as seasonally flooded palustrine emergent wetland.

Palustrine wetlands are freshwater wetlands vegetated with trees, shrubs, or persistent emergent plants. Emergent wetlands are dominated by erect, rooted non-woody plants. Woody species may be present, but are not dominant. Traditionally, palustrine wetlands have been called marshes, bogs, swamps, or fens. These wetlands often have no open water.

No hydric soils are mapped on the airport. Soil types are Ephrata, Malaga, Timmerman, and Winchester and are either well drained or excessively drained. In this arid region, these well drained soils are unlikely to develop wetlands.

There are extensive emergent and shrub wetlands along Crab Creek located east and northeast of the airport. These wetland areas are outside the airport boundaries (Black and Veatch 1993).

Wildlife

The major wildlife habitat at Grant County Airport is formed by the shrub-steppe plant community. Parts of the area have been mapped by the Washington Department of Fish and Wildlife under the Priority Habitats and Species (PHS) Program as a priority habitat for long-billed curlews (*Numenius americanus*). Due to the PHS designation, the area may also be considered as a critical area by the Grant County Planning Department through their Critical Area Ordinance of the growth management act. This community provides wildlife with food, nesting and denning sites, escape cover, and protection from adverse weather. Wildlife is subjected to aircraft noise, but there is little disturbance from other human activity in much of this habitat on the airport. Insects, rodents such as deer mice, and seed-eating birds such as horned lark and meadowlark are the primary consumers. In turn, they are eaten by coyotes (*Canis latrans*), badgers (*Taxidea taxus*), kestrels (*Falco sparverius*), red-tailed hawks (*Buteo jamaicensis*), ravens

(*Corvus corax*), and gulls. Most of these species breed at the airport. There is a rich wildlife area along Crab Creek, which is directly east of the airport. Large numbers of geese, ducks, and other waterfowl use the area, along with muskrats, mink, deer, and other mammals (Black and Veatch 1993).

3.2.5.8 Threatened, Endangered, and Sensitive Species

Vegetation

The Natural Heritage Database has no record of any special status plants or unique habitats on airport property, and none are expected to occur in the vegetation communities at the airport, especially with their history of disturbance (Black and Veatch 1993).

Wildlife

The Nongame Program of the Washington Department of Wildlife has a record of the Kincaid meadow vole (a small rodent) offsite near the airport in the vicinity of Crab Creek. This vole is a candidate for listing as threatened or endangered by the federal government. The small rodent prefers lush grass and wet meadow habitats, such as those occurring along Crab Creek. These habitats do not occur at the airport; therefore, the vole is not expected to occur within airport boundaries (Black and Veatch 1993).

3.2.5.9 Cultural Resources

A records search performed by the Department of Community Development, State of Washington, found that no prehistoric or historic cultural resources have been recorded in this area (Black and Veatch 1993).

3.2.5.10 Water Resources

Groundwater

Groundwater in Grant County is divided into two systems: an artesian system which occurs in the basalts, and an upper system which is present in the unconsolidated silt, sand, and gravel of the Ringold formation and the glaciofluvial deposits overlaying the basalts in the Quincy Basin. There are three principal aquifers in Grant County: glacial drift, terrace and valley fill, and Columbia River Basalt. The Columbia Plateau unconsolidated aquifer consists of glacial drift and terrace and valley fill. The Columbia River Basalt aquifer includes the Saddle Mountain, Wanapum, and Grand Ronde Basalt aquifers. Groundwater in the upper aquifer in the Quincy Basin consists of artificially stored irrigation water derived from the Columbia Basin Irrigation Project and from public waters of the State of Washington (Grant County 1995).
The Wanapum Basalt aquifer lies at approximately 61 m (200 ft) below ground surface. Based on 1984 groundwater elevation data for the Columbia Plateau, the regional groundwater flow direction is generally toward the west. Median hydraulic conductivity is 1.6 m/day (5.2 ft/day). Underlying the Wanapum at approximately 66 m (215 ft) below ground surface is the Grand

Ronde Basalt aquifer. Groundwater also flows toward the west in this aquifer, and the median hydraulic conductivity is 1.5 m/day (4.9 ft/day) (Grant County 1996).

Surface Water

Moses Lake, a long, alkaline body of water, is located southwest of Grant County Airport. The lake is fed by spring water from Rocky Ford Creek and by seasonal runoff down the Crab Creek channel. Crab Creek is east and immediately adjacent to the airport and is the only extensive perennial stream of the Columbia Basin. There are no surface water bodies on airport property with the exception of a potential jurisdictional wetland in the northeast portion of the airport (Grant County 1996; Black and Veatch 1993).

Surface storm drainage to french drains is predominant at the airport. Stormwater from aircraft maintenance and repair areas, aircraft refueling and deicing areas, as well as runway surfaces and taxiways, is conveyed by sheet flow and a system of french drains to dry ground on the airport property where it percolates into the soil. Underground storm drainage collection systems are located around the airfield ramps (Grant County 1996).

3.2.5.11 Geology and Soils

Grant County is located within the Columbia Basin, a southwest dipping plain broken occasionally by mountain ridges. There are two east-west mountain ridges, the Saddle mountains and Frenchman Hills, which divide the otherwise flat plain into distinct areas. A glacial river carved the coulees of Eastern Washington and deposited large alluvial fans of boulders, gravel, and sand. One fan is the Ephrata Fan into which a broad channel was glacially cut. This channel was dammed by sand dune movement during the Holocene Epoch, creating Moses Lake. This long, formerly stagnant, and alkaline body of water is fed by spring water from Rocky Ford Creek and by seasonal runoff down the Crab Creek channel. Crab Creek is the only extensive perennial stream in the Columbia Basin. Grant County lies in the eastern portion of the Quincy Drainage Basin, which is a small enclosed plain. The Quincy Basin is bounded on the west by the Columbia River, the north by the Beezely Hills, the south by the Frenchman Hills, and the east by the scab lands forming the Eastern Uplands (Grant County 1996; Grant County 1995).

The regional geology beneath this area is mapped as the Columbia River Basalt formation. This formation is described as a series of lava flows ranging in thickness from 1 m (3 ft) to more than 31 m (100 ft). Dominant lithology of the individual flows is dense, dark basalt, which commonly displays prominent vertical jointing. Upper portions of many basalt flows are porous and vesicular (Grant County 1996).

3.2.5.12 Health and Safety

Safety at the Grant County Airport is controlled by the Port of Moses Lake Public Safety Department. This organization is responsible for ensuring that the Federal Aviation Administration, Occupational Safety and Health Administration, and Washington State Safety and Health Administration requirements are complied with. The Port of Moses Lake also provides fire protection, including significant crash rescue capability and medical first responder

services. Medical care is provided by Samaritan Hospital in the city of Moses Lake. The hospital maintains its own ambulance fleet to provide emergency medical transportation (Schott 1997).

While the Grant County Airport is a commercial facility, it has been used for several experimental programs, including launch and landing of unmanned aerial vehicles. It has sufficient requirements and capabilities in place to handle any expected contingency.

3.2.5.13 Noise

An aircraft-generated noise analysis was conducted at Grant County Airport using Version 3.10 of the Federal Aviation Administration's Integrated Noise Model. This model produces numeric and graphic representations of the noise environment around the airport as a result of total annual aircraft operations. Results appear as a series of L_{dn} noise contours that display the 1991 base year and the 2011 forecast year airport noise exposure.

The 1991 existing conditions contour is shown in Figure 3-33. The primary operating direction is north-south, thereby concentrating the noise exposure in that direction. The 75 L_{dn} noise contour is contained within airport property. The 65 L_{dn} contour extends approximately 4 km (3 mi) north of the airport. The land north of the airport is sparsely populated. According to the Grant County Comprehensive Plan, the land use north of the airport will continue to be rural residential, large acreage lots. To the south, the 65 L_{dn} contour extends approximately 3 km (2 mi) beyond the airport boundaries, but does not extend south of Highway 17. Several small residential areas are located there. The Comprehensive Plan for the City of Moses Lake indicates that a large portion of the area between the airport and Highway 17 is being considered for future use as a park or open space (Black and Veatch 1993).

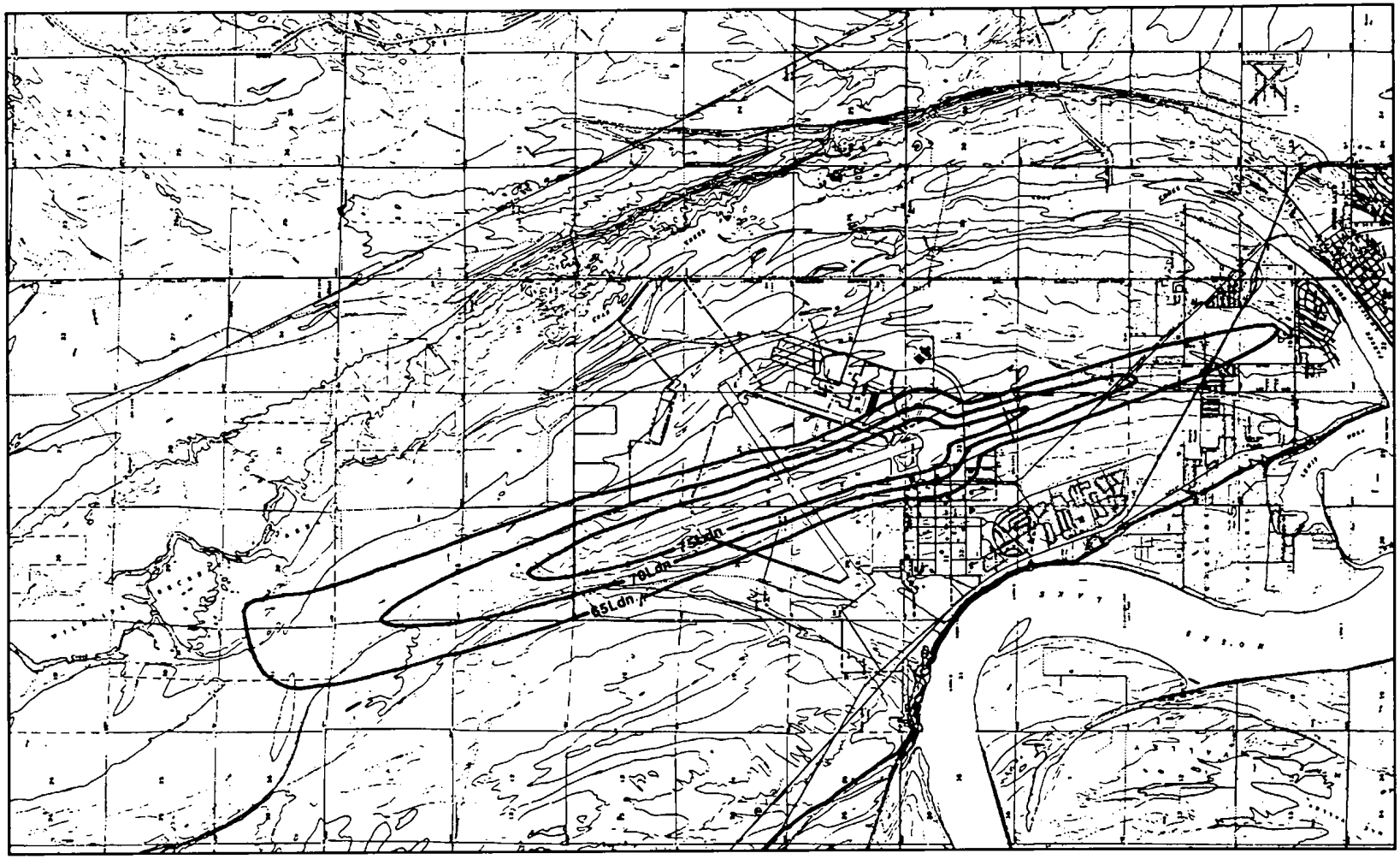


Figure 3-33. Noise Contours, Grant County Airport.

3.2.5.14 Transportation

Interstate 90 and State Highway 17 provide access to Moses Lake. Highway 17 is a two-lane, undivided highway (Figure 3-34).

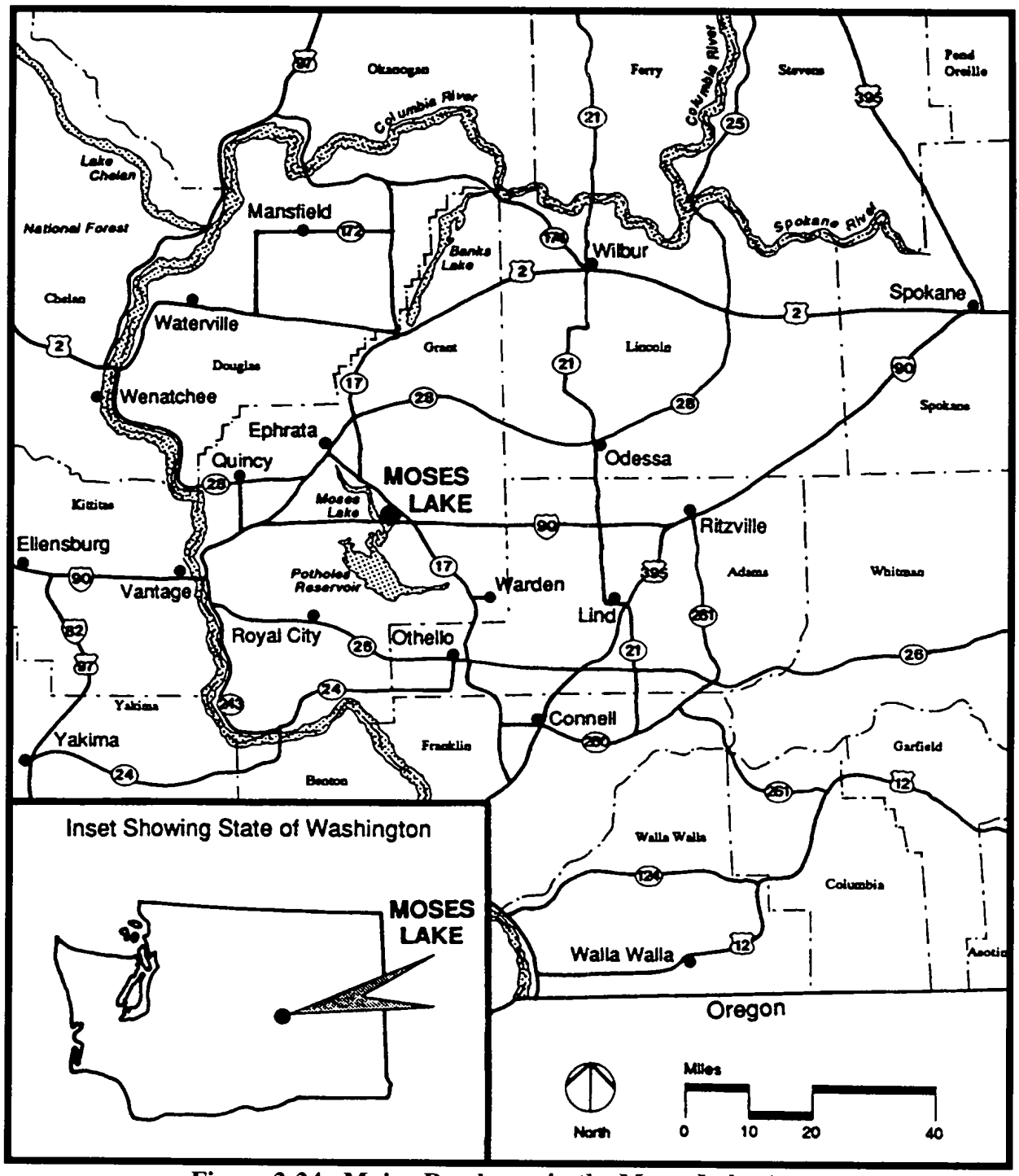


Figure 3-34. Major Roadways in the Moses Lake Area.

3.2.5.15 Population and Employment

Grant County experienced rapid population growth from 6,000 people in 1930 to over 54,000 by 1962, primarily due to military activity and major public works construction projects in central Washington. When Larson Air Force Base closed in 1966, the county population dropped from its peak of nearly 55,000 to 43,900. Beginning in the early 1970's, the area has shown steady growth to its current levels. The1994 census showed Grant County population to be 62,200. According to the Washington State Standard County Profile, the population increased about 16 percent from 1970 to 1980 and 11 percent through the 1980's. The growth has been attributed to a strong agricultural-based industry, expansion of non-agricultural industry and growth in the service sector. The state population, by contrast, as reported by the Washington State of Office of Financial Management, has grown by an average of 19.6 percent for each decade from 1950 to 1990 (Black and Veatch 1993).

The Grant County Comprehensive Plan projected an average annual population increase of 1.16 percent from 1977 to 2000. The plan indicated that the county population was increasing about 33 percent faster than that for the city of Moses Lake. An annual growth rate of 1.16 percent predicted in the plan is only slightly below the 1.2 percent average annual rate that actually occurred between 1980 and 1990. However, between 1990 and 1995, as a result of improved economic conditions in the northwest, the growth rate increased to an average of about 1.8 percent per year (Grant County 1996).

Grant County's largest city is the city of Moses Lake. The Moses Lake urban area has approximately 23,000 residents. Population projections (Table 3-28) in the Moses Lake Urban Area Transportation Study show a steady predictable growth for the next 20 years. The minimum growth rate is assumed to be 2.4 percent with the maximum growth rate not expected to exceed 5.3 percent. The Office of Financial Management expects the state population to increase 15.3 percent through the 1990's, slowing to an 11.3 percent rate from 2000 to 2010. The 1994 census for city of Moses Lake found the population to be 12,190, or about 20 percent of the county's population (Grant County 1995; Grant County 1996).

Table 3-28. Moses Lake Urban Area Population Projections.

	1990	1991	1995	2000	2010
Low Projection (2.4% Annual Increase)					
Base Year	24,000	24,000	26,388.2	29,710.5	37,662.6
Annual Rate		0.024	0.024	0.024	0.024
Annual Increase		576	633.318	713.053	903.902
Projected Population		24,576	27,021.5	30,423.6	38,566.5
Medium Projection (4% Annual Increase)					
Base Year	24,000	24,000	28,076.6	34,159.4	50,564.30
Annual Rate		0.04	0.04	0.04	0.04
Annual Increase		960	1,123.06	1,366.37	2,022.54
Projected Population		24,576	27,021.5	30,423.6	52,588.9
High Projection (5.25% Annual Increase)					
Base Year	24,000	24,000	29,456.5	38,053.6	63,507.2
Annual Rate		0.05255	0.05255	0.05255	0.05255
Annual Increase		1,261.2	1,547.94	1,991.71	3,337.30
Projected Population		25,261.2	31,004.5	40,053.3	66,844.5

Source: Moses lake Urban Area Transportation Study.

In 1990, 79 percent of the county's population was non-Hispanic white while more than 17 percent of the population had Hispanic origins. There were 2.74 persons per household.

The economic base of Grant County remains heavily agricultural compared to the remainder of the state. In 1990, 31 percent of total personal income in the county was from farming, compared to 2.8 percent in the state.

3.2.5.16 Land Use

Grant County Airport, originally Moses Lake Army Base, was activated on November 24, 1942, for training P-38 pilots and combat crews for B-17 Flying Fortresses. The name was later changed to Larson Air Force Base in honor of Major Donald A. Larson, a decorated fighter pilot from Yakima, Washington, killed in action in Germany. The base was put on standby status in 1945 and used as a Boeing test site until it reopened in 1948 as an Air Defense Command Base. In 1952, Larson became a Tactical Air Command Base, employing 3,500 military personnel and 300 civilians. The runway was lengthened to 4,115 m (13,500 ft) during the winter of 1957-1958. In 1960 the Strategic Air Command assumed command of the base, and it became the home of the 462nd Strategic Aerospace Wing. The base was declared surplus in 1962 and officially closed in 1966. On July 1, 1966, the airfield and most operational facilities, approximately 1,012 ha (2,500 ac), were transferred to the Port of Moses Lake. The Port purchased other land parcels and now owns 1,900 ha (4,700 ac) contiguous with and in the vicinity of the airport.

The largest use of land on airport property is air operations, which includes ramp areas and areas within the runway protection zones and the building restriction liens that parallel runways and taxiways. Japan Airlines currently uses the Grant County Airport to train flight crews on Boeing 747 aircraft. Boeing provides training for customers of its aircraft and performs aircraft production checkout and flight testing. Big Bend Community College utilizes the facility to train students seeking careers in the airline industry. The USAF flies Lockheed C-141 cargo aircraft into the airport for training exercises, including dropping cargo from the aircraft at a remote site from the airport, and also flies McDonnell-Douglas C-17 airlifters. The airport was previously the site of Concorde weather testing. Two aviation support land use areas (hangars) are located off airport property for Big Bend Community College and Boeing (Black and Veatch 1993).

The second largest use of land on airport property is open/agricultural, with 244 ha (604 ac) leased for agricultural purposes. Forty-three ha (105 ac) north of the airfield are leased to Takata Moses Lake for industrial use. The remaining airport property includes 6 ha (15 ac) leased for use as a recreational gun range and 36 ha (88 ac) of open land leased for future industrial use in a foreign trade zone (Black and Veatch 1993).

The major off-airport land use is open/agricultural. There are undeveloped areas on all sides of the airport. The lake is southwest of the airport, and ranchland is to the north and west. Several homes are north of the airport, but that area is zoned for densities of no less than 2 ha (5 ac) per home. Southeast of the airport is cultivated farmland. The area south of the airport, toward town, is the most developed; residential housing there is a legacy of the former Larson Air Force Base. However, there are many vacant lots and large open areas. An alternative high school, a "Project Head Start" day care center, and a church with a school are also located in the airport vicinity (Black and Veatch 1993).

Major off-airport industrial areas are the Columbia Basin Job Corps' shop area south of the airport, and the Rocket Research/Takata Moses Lake complex north of the airport. The Big Bend Community College and Columbia Basin Job Corps institutions include dormitories and other student support facilities, as well as educational facilities. Commercial land use in the vicinity of the airport include an animal shelter and a convenience store. Utilities include the Larson Sewage Treatment Plant, the Yellowstone Pipeline terminal, and the Public Utility District substation. Water storage tanks are south of the airport (Black and Veatch 1993).

3.2.5.17 Snow Conditions

In winter months, snow accumulates in high mountain areas, providing conditions suitable for alpine skiing and similar winter sports. An issue was raised during scoping in Great Falls, Montana, about the potential for sonic booms to trigger snow avalanche, especially in areas of high use. A discussion of snow avalanche is provided in Section 3.2.3.17

Snow avalanches are caused by disturbance or perturbation of unstable snow slopes. The susceptibility of a given snow slope to unstable snow conditions depends on factors such as angle, area, shape, and presence of natural obstacles such as rocks and trees. On a slope that is susceptible to unstable snow conditions, the manner in which snow is deposited is the primary factor that governs snow stability. In certain conditions, the perturbation required to cause a

highly unstable snow slope to avalanche can be quite small. Once a slope has built up conditions of highly unstable snow, an avalanche usually cannot be avoided.

Developed areas situated near avalanche-prone snow slopes (for example, mountain passes and alpine and cross-country ski areas) generally employ methods to artificially trigger snow avalanches, thus avoiding the possibility of human injury or damage to structures. Typical avalanche control measures include ski-cutting (skiing above or below an avalanche-prone slope) and explosive detonation to physically remove the means of structural support for the snow slope. Once an area of unstable snow has been stabilized through artificial release of avalanche, the risk of subsequent perturbations causing additional avalanches is minimal.

Ski areas employing explosives to artificially trigger the release of avalanches use charges ranging from 1.0 to 1.5 kg (2.2 to 3 lb). Ideally, the charges are detonated at a height of 1 m (3.3 ft) above a key fault in the snow pack. Charges placed in this manner are considered to be 100 percent effective in triggering avalanches in unstable snow slopes up to a range of 85 m (280 ft) (Gubler 1992). The explosive power of 1.0 kg (2.2 lb) of TNT results in an overpressure of approximately 1.0 kPa (20 psf) at a range of 85 m (280 ft) (Navy 1997). Sonic booms from aircraft as measured at ground level are much smaller than this, usually less than 0.50 kPa (10 psf) depending on the aircraft shape and elevation. The X-33 is expected to generate sonic booms in limited areas of 0.53 kPa (11 psf) or less at ground level (Wyle 1997).

In conditions of highly unstable snow slopes, the slightest overpressure could theoretically trigger an avalanche; therefore, it is not possible to set a minimum overpressure that ensures that no avalanche will occur. For the purposes of this analysis, an overpressure threshold of 0.02 kPa (0.5 psf) was established because this overpressure represents the lowest vibration and sound level that would become noticeable at ground level and that is usually quantified through modeling. For comparison, a 16 km/hr (10 mi/hr) wind gust will produce an overpressure of approximately 0.02 kPa (0.5 psf) on a snow slope.

3.3 Global Environment

The main global environmental issues relevant to the X-33 Program are related to the tropospheric and stratospheric layers of the atmosphere. The Earth's atmospheric layers are delineated in Figure 3-35. X-33 test flights would occur in and transit all layers of the Earth's atmosphere to maximum altitudes of 76 km (47 mi). Consideration of the effects of X-33 possible successor reusable launch vehicles (RLV's) on the troposphere and especially the stratosphere, are important since these effects cannot be mitigated.

3.3.1 Troposphere

The troposphere extends from sea level to approximately 10 km (6 mi) of altitude. A global concern to the troposphere is the "greenhouse effect." Shortwave light or radiation from the Sun is transmitted through all atmospheric layers to the Earth's surface, where it heats the Earth and its atmosphere, resulting in the emission of long-wave (infrared) radiation. Part of the outgoing infrared radiation is trapped by trace gases in the troposphere, an effect called "greenhouse warming." Man-made gases, especially carbon dioxide, have been increasing in concentration. Concern that significant increases in "greenhouse gases" will elevate the Earth's average temperature and negatively affect or alter the natural balance of our ecosystems has resulted in panels being formed to address "greenhouse warming" issues (NAS 1991).

3.3.2 Stratosphere

The stratosphere contains the "ozone layer" which protects Earth's biological systems—plants, animals, and humans—from dangerous ultraviolet-B light, which can cause skin cancer, cataracts, and other genetic alterations (NAS/NRC 1984 and EPA 1987). The stratosphere spans an altitude range of approximately 10 km (6 mi) to 50 km (31 mi). This atmospheric layer has been the subject of intensive research due to scientific theories, projections, and preliminary evidence that manmade chemicals, especially chlorofluorocarbons such as freon, are reducing ozone concentrations in the stratosphere (Molina/Rowland 1974, NAS/NRC 1984, WMO 1985, WMO 1989, WMO 1991, and WMO 1994).

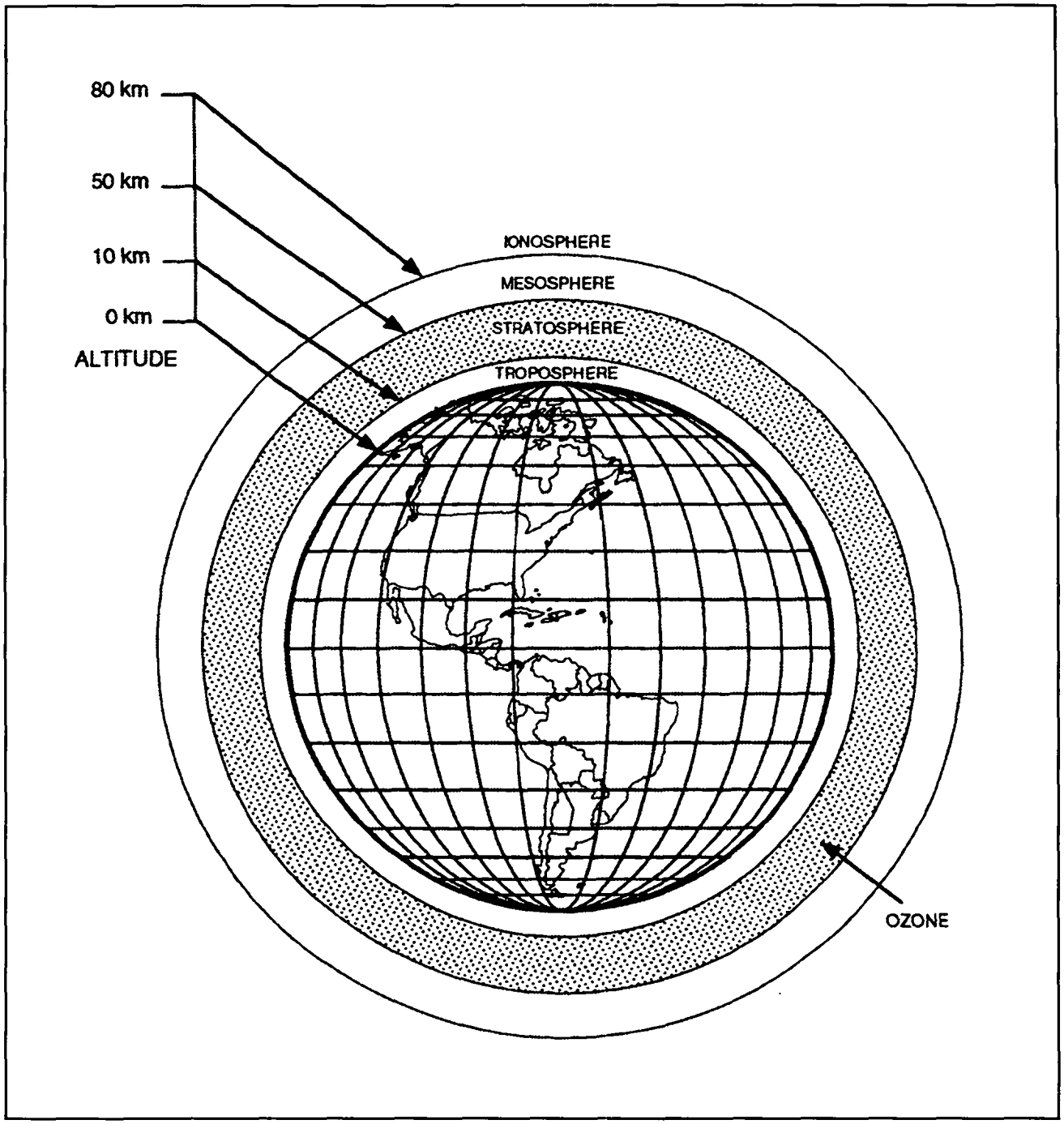


Figure 3-35. Approximate locations of the Atmospheric Layers.

4.0 ENVIRONMENTAL CONSEQUENCES

Section 4 is a detailed analysis of environmental impacts associated with implementation of the proposed action at the proposed alternatives as delineated in Figure 2-1. Criteria for determination of significance are defined in Table 4-1. Since no direct or immediate environmental impacts would result from implementation of the No Action alternative, this alternative is not separately addressed in this section. However, if the X-33 is successful and if a commerical RLV becomes operational as a result, there should be some long-term reduction in acid deposition and a reduction in stratospheric ozone depletion.

Table 4-1. Significance Criteria.

Significance	Criteria
N/A	Issue has no relevance to the site or global environs.
None	No impacts expected.
Minimal	Impacts are not expected to be measurable, or are measurable but are too small to cause any change in the environment.
Minor	Impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with little effort and resources so that the impact is not substantial.
Moderate	Impacts which are measurable but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for with effort and resources so that the impact is not substantial.
Major	Environmental impacts which individually or cumulatively could be substantial.

4.1 Proposed Flight Operations and Launch: Edwards Air Force Base

Approximately 15 test flights would be conducted from one of two sites within Edwards: (1) Haystack Butte and (2) Space Port 2000. The X-33 would be air-ferried in a piggy back mode on the Shuttle Carrier aircraft, which is a specially equipped Boeing 747. The Boeing 747 would land on the paved runway on Edwards main base. All mate/demate operations involving the Boeing 747 and X-33 would occur at the Orbiter mate/demate facility on Dryden Flight Research Center at Edwards AFB. The vehicles would be towed between facilities.

Basic components of the launch complex common to both alternative launch sites would include: (1) launch mount structure mates for the aft end of the X-33; (2) exhaust trench for channeling and deflecting engine hot exhaust flows; (3) bulk storage and delivery systems for LH_2, LOX, GHe, GN_2, and LN_2; (4) a system for providing conditioned air and gaseous nitrogen for vehicle cooling and purging; (5) shelter for protection of the X-33 when in a horizontal position for processing; (6) rail system to move the X-33 from its shelter to the pad; (7) translating system to move the X-33 from a horizontal to vertical position; and (8) water system for suppression of launch ignition overpressure loads on the vehicle and cooling of the exhaust trench. Both of these proposed sites would require a similar amount of infrastructure development and construction.

Approximately 100 to 150 employees will be present during site preparation (18 months or less) activities and 200 to 250 for operational activities. An Operations Control Center (OCC), which houses the command and monitoring capabilities for all phases of X-33 operations, would need to be placed at the selected launch site. A temporary radar/telemetry site would also be constructed just south of the takeoff sites. Additional security personnel will be needed for traffic and crowd control during the 30 planned events (15 launches and 15 landings) over a period of approximately 1 year.

Impacts unique to the Haystack Butte alternative would include: (1) disturbance of 19 ha (47 ac) which includes 9.3 ha (23 ac) and 9.7 ha (24 ac) of disturbance in the launch area and utility/roads, respectively; (2) modifications of the interior of Buildings 9800 and 9804 for the OCC; (3) construction of a new road linking the existing Mars Boulevard to the launch site; (4) construction of two turnout lay-by areas along Mars Boulevard to allow safe passage of the vehicles; (5) installation of a water line from the existing water line near Mars Boulevard to the launch site; and (6) extension of electrical and telephone lines and fiberoptic links from existing lines near Phillips Laboratory to the launch site.

Impacts unique to the Space Port 2000 alternative would include: (1) disturbance of 9.3 ha (23 ac); (2) extension of water line from nearby existing water line; (3) improvement of road to launch site; and (4) connection to nearby electrical and communication lines and fiberoptic links.

4.1.1 Site Infrastructure

Airfields, runways, hangars, and a complex of support buildings are located in the center of the base. Phillips Laboratory is an Edwards tenant located east of Rogers Dry Lake on Leuhman Ridge. An Operations Control Center (OCC), which houses the command and monitoring capabilities for all phases of X-33 operations, would be needed at the selected launch site. Reasonable alternative launch sites considered are Haystack Butte and Space Port 2000. At Haystack Butte, Buildings 9800 and 9804, which are approximately 1.6 km (1.0 mi) southeast of the launch site, would be modified on the interior for the OCC. Portable buildings would be used for the OCC at the Space Port 2000 site.

Runway

After each test flight, the X-33 would be ferried back to the launch site by the X-33 Carrier Aircraft for preparation of the next test flight (see Figure 2-8). The runway used for landings would be the Main Base runway. Therefore, no impacts are expected because the runway can accommodate the X-33 spaceplane and 747 carrier aircraft configuration without modification.

Water Supply and Distribution

A water line approximately 1,220 m (4,000 ft) would have to be installed from the existing line near Mars Boulevard to the X-33 proposed launch site at Haystack Butte. Water lines at the Space Port 2000 launch site would be tied in to existing water lines at the site.

Wastewater

Individual sanitary sewer collection and treatment systems serve the Main Base, South and North Bases, and Phillips Laboratory. The WWTP has a design capacity of 9.5 mLd (2.5 mgd). The North Base plant has a design capacity of 0.08 mLd (0.02 mgd), while the facility at Phillips Laboratory has a design capacity of 0.20 mLd (0.05 mgd). The Phillips Laboratory plant treats an average of 189,500 LPD (50,000 GPD), which is 37 percent of its treatment capacity.

Wastewater from the X-33 would consist of two types: domestic wastewater resulting from additional personnel and industrial wastewater resulting from processing and launch operations. It is anticipated that during launch and flight test operations no more than 200 to 250 people would be working on the program at Edwards. Domestic wastewater generated during site preparations would be expected to be 17,000 LPD (4,500 GPD) and during flight operations to be 28,000 LPD (7,500 GPD). Impacts to any of the treatment plants would be expected to be minimal due to excess available capacity.

Industrial wastewater can result from normal operations and maintenance of the X-33 vehicle and from non-utilized deluge water associated with launch. With respect to the former waste streams, those that cannot be discharged to an existing on-site treatment plant would be containerized and shipped off-site for treatment and disposal. As for excess deluge water used for protection of launch facilities and sound suppression, it is expected that 80 to 90 percent of the 303,000 L (80,000 gal) of water used for each launch would be volatilized and discharged to the atmosphere as steam. The remaining 10 to 20 percent (30,300 to 60,600 L (8,000 to 16,000 gal)) of water would be captured in the flame trench, treated via filtration and recycled to the holding tank, and used for the next launch operation. Water quality sampling and analyses would be conducted on water collected from the first three flights, and the data obtained prior to any release of the water. Dependent on the results of water quality sampling, there is potential for deluge water to be released onto project area soils. If required, a permit application would be prepared by Lockheed Martin Skunk Works in coordination with Edwards Environmental Management Office, which would submit it to the proper agency. This procedure would not be used if any water applicable facility standards are exceeded (see Section 3.1.1). Should the water be determined unusable, it would be shipped off-site for treatment and disposal. In any case, no or minimal impacts to wastewater treatment systems are expected.

Electricity

Southern California Edison (SCE) provides electricity to Edwards, Main and South Bases, and Phillips Laboratory areas at 34.5 and 12.47 kV. Peak demand at Edwards is less than 40 MVA; therefore, the present SCE line can feed over twice the present requirement. The Haystack Butte launch site would require extension of electrical lines from existing lines near Phillips Laboratory or Mars Boulevard a distance of approximately 1,710 m (5,600 ft). The Space Port 2000 site would tie to existing nearby lines. The increase in demand for electricity would be minimal in comparison from existing demand on each range.

Communications

All Air Force Flight Test Center core facilities, North and South Bases, and Phillips Laboratory are connected to the communications fiberoptic ring. Four strands are required to support the telephone system, leaving 44 strands available for computer networking and future growth. Telephone lines and fiberoptic links must be made to existing lines near Phillips Laboratory or Mars Boulevard. A temporary radar/telemetry site would also be placed just south of the proposed launch sites. Overall impact to communications networks would be minimal, because existing systems have adequate capacity to accept the increased data traffic.

Fuel

Fuel (unleaded gasoline and diesel) required to support X-33 Program needs would be small in comparison to existing uses and should result in minimal impact. The Range also maintains storage and dispensing capabilities for aviation fuels. Potential impact involves aviation fuel usage by weather observation and chase planes during test and transport aircraft returning the spaceplane to either proposed launch site. Due to the limited number of test flights, impact to aviation fueling is expected to be minimal compared to the substantial aviation support capability for ongoing test activities.

X-33 Program operations would increase the amounts of LH_2 and LOX used and stored on base (see Table 2-3).

4.1.2 Hazardous Materials and Hazardous Waste

If hazardous substances are not handled properly, exposure to hazardous substances could result in two types of impacts: impacts to health and safety, and impacts to the environment. The degree of impact depends on the nature of the substance and circumstances of exposure. Some hazardous substances can be life threatening; others would not pose any chronic health problems. The following information on asbestos, lead, and PCB's is provided to address potential health concerns due to hazardous substances remaining in old buildings. If undisturbed, no health hazard is expected.

Asbestos is a known human carcinogen and lung disease hazard, and poses a serious health risk to renovation-related personnel. When disturbed, ACM can release asbestos fibers that easily become airborne. Once airborne, the aerodynamic shape and density of the fibers enable them to stay airborne for days. Inhalation or ingestion of these tiny asbestos fibers can occur without workers or occupants being aware of their exposure.

Lead is a cumulative poison that enters the body by inhalation, ingestion, or absorption. The optic, digestive and nervous systems can be affected by lead. Lead is considered a threat to human health and the environment if uncontrolled, treated or disposed of improperly.

If PCB-containing equipment is removed or worked on improperly, there is a risk of personnel exposure to PCB. PCBs are considered toxic to humans and the environment. Polychlorinated

biphenyls are potential carcinogens and may also cause liver damage. Routes of entry into humans or animals include inhalation, ingestion, and absorption.

The LH_2 and LOX propellants used in the X-33 Program would be stored and delivered as cryogens. A cryogen is gas refrigerated to a temperature below its boiling point, allowing more economical and condensed storage as a liquid. The extremely cold temperatures associated with these substances when handled in this form create unique hazards such as freezing of skin when direct contact with the liquid or cold gas occurs. Other hazards such as fire, explosion, overpressurization, and oxygen deficiency are related to specific chemical or physical properties of the gas liberated as the liquid evaporates.

LH_2 is colorless and odorless as both a liquid and gas (Air Products and Chemicals, 1990a). It is classified as a simple asphyxiant from a health hazard perspective because, in high enough concentrations, it can displace air causing asphyxiation to workers in a contained environment. It is not an inhalation hazard or listed as a carcinogen and has no Threshold Limit Value, Permissible Exposure Limit or Emergency Exposure Guidance Limits as defined by the American Conference of Governmental Industrial Hygienists, OSHA, and the National Research Council, respectively (Air Products and Chemicals, 1990a; Federal Emergency Management Agency, et al., 1989). LH_2's principal hazard is associated with its extreme flammability range (4.0 percent Lower Flammability Limit to 74.2 percent Upper Flammability Limit); LH_2 requires minimum energy to ignite a gas mixture. Hydrogen can burn with an almost invisible flame. Once ignited the flame will travel rapidly through a hydrogen mixture and explosions can occur. It is not currently listed as an extremely hazardous substance under Community-Right-to-Know laws.

LOX is pale blue, and gaseous oxygen is colorless (Air Products and Chemicals, 1989). Both liquid and gas are odorless. Oxygen is not listed as a carcinogen or an inhalation hazard and, in fact, is necessary for life. Breathing an extremely high concentration of oxygen (60 percent or greater) can produce central nervous system effects. There are no work place or emergency limits for oxygen (Air Products and Chemicals, 1989). Atmospheric oxygen concentrations greater than 25 percent are considered severe fire hazards. Although oxygen itself is nonflammable, it vigorously supports and accelerates combustion of flammable materials. Some materials that are considered to be noncombustible in air (i.e., at 20.8 percent oxygen by volume) readily burn in the presence of oxygen. However, guidelines set by the National Institute of Health and Safety recommend the oxygen content in air be maintained between 19.5 and 25.0 percent by volume. Environments with an atmosphere oxygen content of less than 19.5 percent are considered oxygen deficient and cannot support the requirements of human respiration.

Both liquid nitrogen and helium are colorless and odorless (Air Products and Chemicals, Inc., 1990b and 1990c). They are considered to be simple asphyxiants as they can displace air to levels insufficient to support life. No work place or emergency limits have been established for nitrogen or helium (Air Products and Chemicals, Inc., 1990b and 1990c; Federal Emergency Management Agency, et al., 1989). Nitrogen and helium are classified as inert gases, nonflammable, and nonexplosive.

Because of the diverse research activity of the Air Force Flight Test Center, Air Force, and tenant organizations including NASA and Phillips Laboratory, hazardous materials used at Edwards and

hazardous waste generated is substantial. Quantities and types of hazardous materials associated with the X-33 Program are expected to be small due to the limited number of planned flights; therefore, no impact from using hazardous materials or conducting hazardous waste operations would be expected.

Contamination

Edwards is currently conducting an evaluation for potential contamination in all areas of the base. Potential sites for X-33 activities would be included in this investigation. Approximately 200 individual sites have been investigated with no impacts to nearby operations or installation restoration program (IRP) activities. As a general practice, IRP field activities are planned in conjunction with nearby base activities so that impacts are avoided. Field activities are scheduled with flexibility built in to allow downtime due to contiguous base operations. For example, many locations near the Burke Flight Test Center were investigated, but only when they would not impact the B-2 mission.

Site specific field surveys and/or preliminary evaluation of existing contamination would be expeditiously conducted prior to significant subsurface penetrations to determine the presence and extent of such soil (and possible groundwater) contamination at the selected site. Should contamination be found, a plan for remediation, avoidance, or baselining of the contamination issues with provisions developed to ensure that no X-33 activity would contribute to migration of the contaminant other than by existing conditions would also be expeditiously developed in order to ensure that construction activities conform to the plan. Therefore, only minor impact to potential cleanup operations may occur.

Hazardous Waste

Hazardous wastes from site preparation activities would result from painting, cleaning operations, field servicing of equipment, etc. Due to hazardous waste minimization efforts, it is expected that approximately 380 L (100 gal) of spent solvents, 190 L (50 gal) of paint wastes, and 380 L (100 gal) of hydraulic fluid would be generated during construction similar in nature to those currently generated on Edwards. The volumes are relatively small. Therefore, existing collection and disposal systems are expected to be able to accommodate the wastes with minimal impact.

4.1.3 Solid Waste

Solid waste generated by the X-33 Program at either proposed launch site would consist of debris from site preparation and a relatively minimal amount of debris and waste generated by approximately 200 to 250 test program personnel during normal operations. The amount of waste would be minimal compared to the waste produced daily by regular base operations. While the Main Base Landfill has sufficient design capacity for project waste, daily permit limits would probably make off-base disposal necessary for X-33 solid waste disposal. Therefore, impacts to the Main Base Landfill are not anticipated.

4.1.4 Air Quality

Under the general conformity regulations issued by EPA to comply with the CAAA of 1990, federal agencies are required to ensure that any proposed action(s) that may affect a nonattainment or maintenance area conforms to the State Implementation Plan (SIP). Both proposed launch sites are located in non-attainment areas for one or more criteria pollutants and subject to conformity analysis. The attainment status and *de minimis* levels for all of the flight operations/launch and landing sites are outlined in Table 4-2.

Table 4-2. Federal Attainment Status and Conformity *de minimis* Levels for X-33 Proposed Flight Operations/Launch and Landing Sites.

Site	Ozone		PM_{10}		Other Criteria Pollutants
	Classification	Conformity *de minimis* Level (NO_X & VOC's)	Classification	Conformity *de minimis* Level	Classification
Haystack Butte on Edwards	severe non-attainment	22.8 mtpy (25 tpy)	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Space Port 2000 on Edwards	serious non-attainment	45.5 mtpy (50 tpy)	attainment	N/A	attainment
China Lake Naval Air Weapons Station	serious non-attainment	45.5 mtpy (50 tpy)	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Silurian Lake	attainment	N/A	moderate non-attainment	91.0 mtpy (100 tpy)	attainment
Dugway	attainment	N/A	attainment	N/A	attainment
Malmstrom	attainment	N/A	attainment	N/A	attainment
Moses Lake	attainment	N/A	attainment	N/A	attainment

40 CFR Part 51, Subpart W, §51.853(b).
mtpy = metric tons per year
tpy = tons per year
N/A = Not applicable; location is in attainment with NAAQS for that pollutant.

Air basin emission inventories and regionally significant levels for the California sites are outlined in Table 4-3. Since all of the regionally significant levels presented in Table 4-2 exceed the federal *de minimis* levels for a significant new air source, the more conservative federal *de minimis* levels were used for the conformity analyses provided in Appendix C.

Table 4-3. Air Basin Emission Inventories and Regionally Significant Levels.

Location	Air Basin Inventory mtpy (tpy)			Regionally Significant Levels mtpy (tpy)		
	Ozone Precursors			Ozone Precursors		
	NO_X	VOC[e]	PM_{10}	NO_X	VOC[e]	PM_{10}
Haystack Butte on Edwards[a]	49,823 (54,750)	20,261 (22,265)	59,787 (65,700)	4,982 (5,475)	2,026 (2,226)	5,979 (6,570)
Space Port 2000 on Edwards[b]	10,297 (11,315)	8,304 (9,125)	N/A	1,029 (1,131)	830 (912)	N/A
China Lake Naval Air Weapons Station[c]	10,297 (11,315)	8,304 (9,125)	15,943 (17,520)	1,029 (1,131)	830 (912)	1,594 (1,752)
Silurian Lake[d]	N/A	N/A	159,544 (175,323)	N/A	N/A	15,954 (17,532)

[a] Total San Bernardino County for 1995.
[b] Total Kern County in Southeast Desert Air Basin for 1994.
[c] China Lake and Space Port 2000 are in the same air basin and have the same emission inventory.
[d] Total Mojave Desert emission inventory for 1990.
[e] Volatile organic compounds.
mtpy = metric tons per year
tpy = (tons/day) x (365 days/year).

The proposed launch site at Haystack Butte is located in Western San Bernardino County, just east of the border between Kern County and San Bernardino County. This area is located in the Mojave Desert Air Basin and is under the jurisdiction of the Mojave Desert Air Quality Management District (AQMD). The Haystack Butte site is currently designated as moderate non-attainment for PM_{10} and severe non-attainment for ozone. Because of these designations, emissions from ground support were calculated to determine conformity for the State Implementation Plan (SIP) currently in effect. If total emissions for nitrogen oxides (NO_X), volatile organic compounds (VOC's), and particulates less than 10 microns in size (PM_{10}) are found to be less than the *de minimis* levels and not regionally significant (<10 percent of design value), no more detailed analysis and demonstration of compliance with the SIP is required under the general conformity regulations (40 CFR Part 51, Subpart W). A comparison of the emission calculations for 1997 through 1999 and the *de minimis* regulatory threshold levels can be found in Table 4-4. The maximum estimated emission levels for NO_X, VOC's, and PM_{10} are less than the *de minimis* regulatory threshold levels. Therefore, X-33 Program emissions would conform to the SIP, and no formal conformity determination is required.

Table 4-4. Emission Summary for Haystack Butte on Edwards.

Emission Data or Issue	Estimated Emissions metric tons/year (tons/year)		
	Nitrogen Oxides (NO_X)	Volatile Organic Compounds (VOC's)	Particulate Matter (PM_{10})
1997 totals	7.36 (8.11)	0.87 (0.96)	40.6 (44.7)
1998 totals	9.25 (10.2)	5.84 (6.44)	51.4 (56.7)
1999 totals	14.6 (16.1)	4.24 (4.67)	13.1 (14.4)
de minimis regulatory threshold	22.8 (25)	22.8 (25)	91.0 (100)
Conformity Determination Required?	NO	NO	NO

Classification: O_3 (Severe non-attainment); PM_{10} (moderate non-attainment)

The Space Port 2000 launch site is located in Kern County and is also within the Mojave Desert Air Basin. This section of the basin is under the jurisdiction of the Kern County AQMD and is currently designated as serious non-attainment for ozone. Because of this designation, emissions from ground support were calculated to determine conformity to the SIP. A comparison of the emission calculations for 1997 through 1999 and the *de minimis* regulatory threshold levels can be found in Table 4-5. The maximum estimated emission levels for NO_X and VOC's are less than the *de minimis* regulatory threshold levels. Therefore, X-33 Program emissions would conform to the SIP, and no more detailed analysis and demonstration of compliance with the SIP is required under the general conformity regulations.

The propellants used by the X-33 are LH_2 (fuel) and LOX (oxidizer). These propellants produce only water as a byproduct of combustion. Water poses no threat to air quality.

Table 4-5. Emission Summary for Space Port 2000 on Edwards.

Emission Data or Issue	Estimated Emissions (metric tons/year (tons/year))		
	Nitrogen Oxides (NO_X)	Volatile Organic Compounds (VOC's)	Particulate Matter (PM_{10})
1997 totals	7.36 (8.11)	0.87 (0.96)	NA
1998 totals	9.25 (10.2)	5.84 (6.44)	NA
1999 totals	14.6 (16.1)	4.24 (4.67)	NA
de minimis regulatory threshold	22.8 (25)	22.8 (25)	NA
Conformity Determination Required?	NO	NO	NO

Classification: O_3 (Severe non-attainment); PM_{10} (moderate non-attainment)
Conformity determination regulations are not applicable (N/A) for attainment areas.

An air permit for the on-site concrete batch plant would be required to support construction activities and would be the responsibility of the concrete batch plant owner to acquire prior to operation. Air permits for internal combustion equipment such as generators and boilers, flare stacks, and process areas which would utilize and potentially release to the atmosphere cleaning solvents and other chemicals classified as volatile organic compounds or ozone precursors would be required prior to operation. The permit applications would be prepared by Lockheed Martin

in coordination with Edwards Environmental Management Office, which would then submit them to the proper air district.

4.1.5 Airspace and Air Traffic

All nominal ascents originating within Edwards would be within the R-2515 military restricted airspace and would not leave this sector prior to achieving altitudes above the FAA's Class A airspace. Ascents would exceed 18,300 m (60,000 ft) in altitude from 7.8 km (4.9 mi) to 11.7 km (7.3 mi) downrange of the launch site as calculated in Appendix D. X-33 flight tests would be compatible with current aeronautical operations at the facility. Scheduling use of affected airspace within R-2508 would be the responsibility of AFFTC. The AFFTC would also have to precoordinate X-33 flights with the joint management, i.e., the R-2508 Complex Control Board. Approximately 350 aircraft sorties occur daily within the R-2508 Complex as a whole (USAF 1995). Some disruption to the military flight sorties utilizing the R-2515 restricted airspace of the R-2508 Complex would occur. All aircraft during X-33 flight test would be required to divert around the flight track of the X-33 for a distance of approximately 9.5 to 11 km (6 to 7 mi) for approximately 1-4 hours beginning 1 hour in advance of scheduled launch time.This clear airspace would be within the boundaries of the Edwards Air Force Base and R-2515 restricted airspace. In addition, provisions for NOTAM's with information concerning test flight of the X-33 would be required for the general aviation within the R-2508 Complex. A frequently used general aviation route exists between the boundaries of R-2515 and R-2505 (see Appendix D, Figure D-12).

Impact is considered minimal for initial ascent of the X-33 from Edwards. Even though each test flight would require some unique considerations, these operations are within the mission of the base. Flight operations on base are generally flexible to accommodate special activities. However the X-33 test flight schedule would be provided to AFFTC well in advance of flights to minimize disruption of any other base activity. An analysis of civil and commercial aviation potentially affected from flights originating within Edwards and terminating at remote landing sites is provided in Appendix D. Further details of the remaining flight path to the landing sites will be provided in the sections on Airspace and Air Traffic for each proposed landing site and Section 4.3.

4.1.6 Biological Resources

Vegetation

At Haystack Butte, 19 ha (47 ac) of land would be needed for the launch pad and other infrastructure, an access road, utilities lines, and a towway. The launch site itself would encompass 9 ha (23 ac). Of this area, approximately 5 ha (12 ac) would be graded to remove vegetation and leveled for preparation of support facilities. The habitats at Haystack Butte, Joshua tree woodland and creosote bush scrub, would remain undisturbed except for fragmentation by dirt roads. Development of 19 ha (47 ac) of these habitats would represent a loss of 0.08 percent of the total amount of Joshua tree woodland and 0.05 percent of the total creosote bush scrub available on Edwards (EAFB 1994A). These percentages are overestimates, because portions of the access road, utilities lines, and towway would follow existing routes or would be in the unvegetated Rogers Dry Lake.

The maximum amount of land needed to support launching from the Space Port 2000 site is 9 ha (23 ac), which is less than similar requirements for the Haystack Butte site because there are some existing facilities, access roads, and utilities, and the towways would follow existing roads. Vegetation at this site is halophytic phase saltbush scrub. Development of 9 ha (23 ac) of this habitat would represent a loss of 0.05 percent of the total halophytic phase saltbush scrub available on Edwards (EAFB 1994A). The impact of removal of such small amounts of any of the affected habitats at either launch site as compared to the total areas available is considered to be minimal.

Wetlands and Floodplains

There are currently no jurisdictional wetlands documented on Edwards. If the Spaceport 2000 site is selected as the launch site, construction within this probable floodplain may result in flooding out the launch site during an extremely heavy rainfall period. Construction of the launch facilities would require coordination with the U.S. Army Corps of Engineers to determine the need for any permits or other Federal or State requirements (prior to the beginning of construction activities). Construction of a dike around all or a portion of the launch site or raising the elevation of facilities might be required.

Wildlife

Wildlife surveys performed on Edwards during 1993-1994 documented 15 reptile species, 60 bird species, and 23 species of mammals. Impacts to wildlife would occur from habitat loss and disturbance caused by preparation of the launch support facilities. Because such a small proportion of the available habitats would potentially be affected (between 0.05 and 0.08 percent maximum), the impacts to wildlife populations are expected to be minimal. Wildlife in the area would be exposed to noise associated with launches. In addition, a focus sonic boom with an expected peak pressure of 0.34 kPa (7.0 psf) would occur in a very small area less than 91 m (100 yd) wide (reference Section 4.4). These disturbances would be infrequent and of short duration. The effects of this exposure to wildlife populations are expected to be minimal.

Construction, maintenance, and launchings may impact wildlife either by direct mortality or indirectly by habitat alteration. Direct mortality may result from vehicles and equipment crushing ground dwelling wildlife. Removal of nesting and roosting sites, destruction of burrows, and crushed or removed vegetation serving as food, shelter, and nesting sources may result in direct mortality. Joshua tree woodland is often used by wildlife for nesting, roosting, or shelter. Red-tailed hawks and great horned owls have been observed nesting and roosting within Joshua trees. Other migratory bird species may be found using these trees. Desert wood rats, desert spiny lizards, and night lizards select downed Joshua trees for shelter. In general, loss of this habitat is anticipated to reduce food, shelter, and breeding opportunities for wildlife species. Local wildlife species may be affected by noise and dust from launchings.

4.1.7 Threatened, Endangered, and Sensitive Species

Vegetation

Ten species of plants that are designated as sensitive by the California Native Plant Society have been documented on Edwards; three species that could occur in the habitats at the proposed launch sites are listed in Table F-1. The proposed access road/utility corridor at the Haystack Butte launch site would traverse through a population of desert cymopterus containing 58 individuals. Some desert cymopterus plants within work perimeters will likely be disturbed. Alkali mariposa lily populations at the south gate would not be impacted as long as the proposed turn loop remained within the previously disturbed area. In addition, there are no identified sensitive plant populations associated with the Space Port 2000 launch site. Any impacts to these species would occur from the loss or disturbance of habitat associated with preparation of launch support facilities. Because such a small proportion of the available habitats would potentially be affected (between 0.05 and 0.08 percent maximum), the impacts to plant populations are expected to be minimal at either site. No federally or state listed plant species have been observed on Edwards.

Wildlife

If Haystack Butte is chosen as the launch site, a maximum of 19 ha (47 ac) of desert tortoise critical habitat would be disturbed by structures and buildings necessary to support launch, the access road, utilities lines, and towway. Given the desert tortoise density estimate of 13 tortoises per 2.6 sq km (13 per sq mi) at the Haystack Butte site, this amount of habitat would be expected to support 2 to 3 tortoises. Because tortoises are not sedentary, it is likely that over the course of the X-33 project, several tortoises from the general area would be encountered. While the exact number is impossible to calculate, 20 of the 2.6 sq km (1 sq mi) sections of habitat (see Figure 3-8) may be crossed, potentially containing an averaged total of 320 tortoises. It is reasonable to assume that 5 percent of these animals may be encountered. Therefore, between 15 and 20 tortoises might be affected.

If Space Port 2000 is chosen, a maximum of 9 ha (23 ac) would be developed where the tortoise density estimate ranges between 0 and 2 tortoises per sq km (0 to 6 sq mi). The amount of habitat disturbed would not be expected to support more than one desert tortoise. However, as in the case with the Haystack Butte alternative, additional tortoises can be expected to be encountered over the duration of the X-33 project.

Short-term impacts resulting from the X-33 flight test program at Edwards AFB are anticipated. Short-term impacts include potential harassment of desert tortoises and other wildlife due to construction activities, human interactions, and predators attracted to the site; altering of wildlife behavioral patterns due to increased human and equipment activity; wind induced soil erosion due to soil and vegetation disturbance; and noise distrubance during launchings. Once construction is complete and soil stabilization and vegetation recovery has taken place, short-term impacts are expected to be dramatically reduced. Noise is expected to be supressed by the deluge water and would only occur during static fire and launch events over a one year period.

Long-term impacts would include potential desert tortoise mortalities. Another long-term impact would be the permanent loss (grading) of an estimated 19 ha (47 ac) of desert tortoise critical habitat consisting of creosote bush scrub and Joshua tree woodland habitat. As a result, any desert tortoises discovered in the launch area or other areas where construction activities are expected to occur would be displaced and alternative sites would need to be secured. Minimization measures outlined below are intended to reduce or eliminate these adverse short-term and long-term impacts. A biological assessment containing detailed information concerning the desert tortoise was provided to the U.S. Fish and Wildlife Service. This assessment can be found in Appendix E.

4.1.8 Cultural Resources

Based on the cultural resource surveys performed in February 1997 at the Haystack Butte launch site and followup surveys in March 1997, project activities (road placement and site clearing) could occur in the vicinity of seven archaeological sites. Three of these seven fall within the area of potential effect. Two of the three sites were formally evaluated by Edwards personnel and determined to be ineligible for listing on the National Register of Historic Places (NRHP) (McGetrick 1997). The remaining four sites are located within 152 m (500 ft) of the area of potential effect. These four sites have not been formally evaluated for eligibility for the NRHP. These four and the one site described above as being within the actual area of potential effect would be flagged for avoidance prior to beginning site preparation activities. Therefore, no effect on properties listed or eligible for listing by NRHP would be anticipated. This avoidance effort would be coordinated with the Base Historic Preservation Officer (BHPO).

Five roadside turnouts would be prepared along the proposed alternate route for transporting the X-33 to the Haystack Butte site. The exact locations of the turnouts are flexible. Cultural resources that could be adversely affected by site preparation activities are known to exist along these roadways. All major road margins have been surveyed previously and site locations are known. The BHPO would be contacted once turnouts are selected in order to resolve potential conflicts.

The Haystack Butte site is also associated with Test Area 1-56, which may be potentially eligible to the NRHP. Under the same theme, the entire Phillips Laboratory may be potentially eligible to the NRHP as a historic district. If either Test Area 1-56 or Phillips Laboratory is evaluated and found potentially eligible to the NRHP, Buildings 9800 and 9804 would require evaluation to determine whether they are contributing or noncontributing members. However, the proposed project would not impact potential eligibility of Test Area 1-56 or Phillips Laboratory for the NRHP. Potential plans for any modifications to either Building 9800 or 9804 would require notification of the Base Historic Preservation Officer to implement cultural resource protection measures. The historical status of this area is being coordinated between the Base Historic Preservation Officer and the State Historic Preservation Officer.

Road placement leading to Space Port 2000 has the potential to disturb an identified prehistoric cultural resource site. The project area would cross the archaeological site which has not been evaluated for the NRHP, and a Phase II evaluation for its potential eligibility may be necessary. No action would be taken that might affect this archaeological site prior to completion of the

Section 106 process. These efforts would be coordinated with the Base Historic Preservation Officer and California State Historic Preservation Officer (CA SHPO).

4.1.9 Water Resources

Approximately 200 to 250 additional people may be stationed throughout Edwards during peak times of the X-33 project, but the increase in water usage (approximately 28,000 LPD (7,500 GPD) would be negligible compared to the 13,443 employees presently being served. Each launch would also require 303,000 L (80,000 gal) of water for deluge and sound suppression. However, only 15 launches are planned over a 9- to 10-month period of time. An imported water supply and a backup groundwater supply are available. Therefore, the increased water demand from the project is anticipated to result in minimal impacts to the system as a whole.

4.1.10 Geology and Soils

Impacts to the geology and soils of the proposed launch sites would result from site preparation and placement of special test equipment. These impacts would be minimal as a result of the limited scope of activities and size of the affected area (less than 5 ha (12 ac)) (MSFC 1996A). A description of the proposed launch site, support facilities and roads to be constructed and utilities to be linked is given in Section 2.1.4.

Preparation of the proposed launch site area has potential to produce soil erosion in swale areas. Soil erosion would be minimal due to the gradual slope and contours of the land at the launch site. Soil erosion may also occur if deluge water is disposed of by release onto project area soils. The degree of erosion would be dependent on the slope of the ground and rate of water release. Soils on base are moderately to highly susceptible to wind erosion, especially in areas disturbed by site preparation or vehicular traffic.

Rock slides could be triggered by noise or sonic booms produced during launch. However, the possibility of this occurring is remote, and the elevated topography in the area is located away from facilities and should not be considered a safety issue.

As demonstrated by previous rocket test programs and flight operations, including sonic boom-producing flights, implementation of the X-33 Program should not produce seismic events. However, seismic events from geological faults within the region have potential to inflict damage to structures and services at the X-33 flight operations facilities. Although earthquakes in this region cannot be prevented, severity of the impacts can be substantially reduced by allowing for earthquake stresses in the design phase of the project.

In accordance with Edwards Air Force Base and California construction standards developed for potentially earthquake active zones, X-33 launch facilities would be built to California Zone 4 earthquake standards to minimize damage from a significant seismic event in the region. In addition, containment facilities around propellant, fuel, and any other hazardous material storage area would be designed and built to contain potential spills from tank ruptures due to seismic or any other natural or physical event. The launch facilities are located with respect to each other as

well as other facilities on Edwards to prevent damage from propagating from one area to another in the event that a fire and/or explosion were to occur.

4.1.11 Health and Safety

Launch facilities at the Space Port 2000 and Haystack Butte sites can be geographically positioned to meet required quantity distance (QD) separations from inhabited buildings. The required distance from the fully fueled X-33 vehicle is 620 m (2,030 ft). Explosive siting maps for both proposed sites are shown in Figures 4-1 and 4.2. The propellant bulk storage areas for LH_2 and LOX would be located on opposite sides of the launch pad to provide separation of the commodities for safety purposes. Areas for bulk storage of gaseous helium, gaseous nitrogen (N_2), and liquid N_2 would be provided adjacent to the launch mount structure. The QD separation distance for the hydrogen bulk storage facility is 43 m (140 ft) and for the oxygen bulk storage facility is 61 m (200 ft). The QDs were calculated in accordance with the requirements of DOD 6055.9 (Sverdrup 1997).

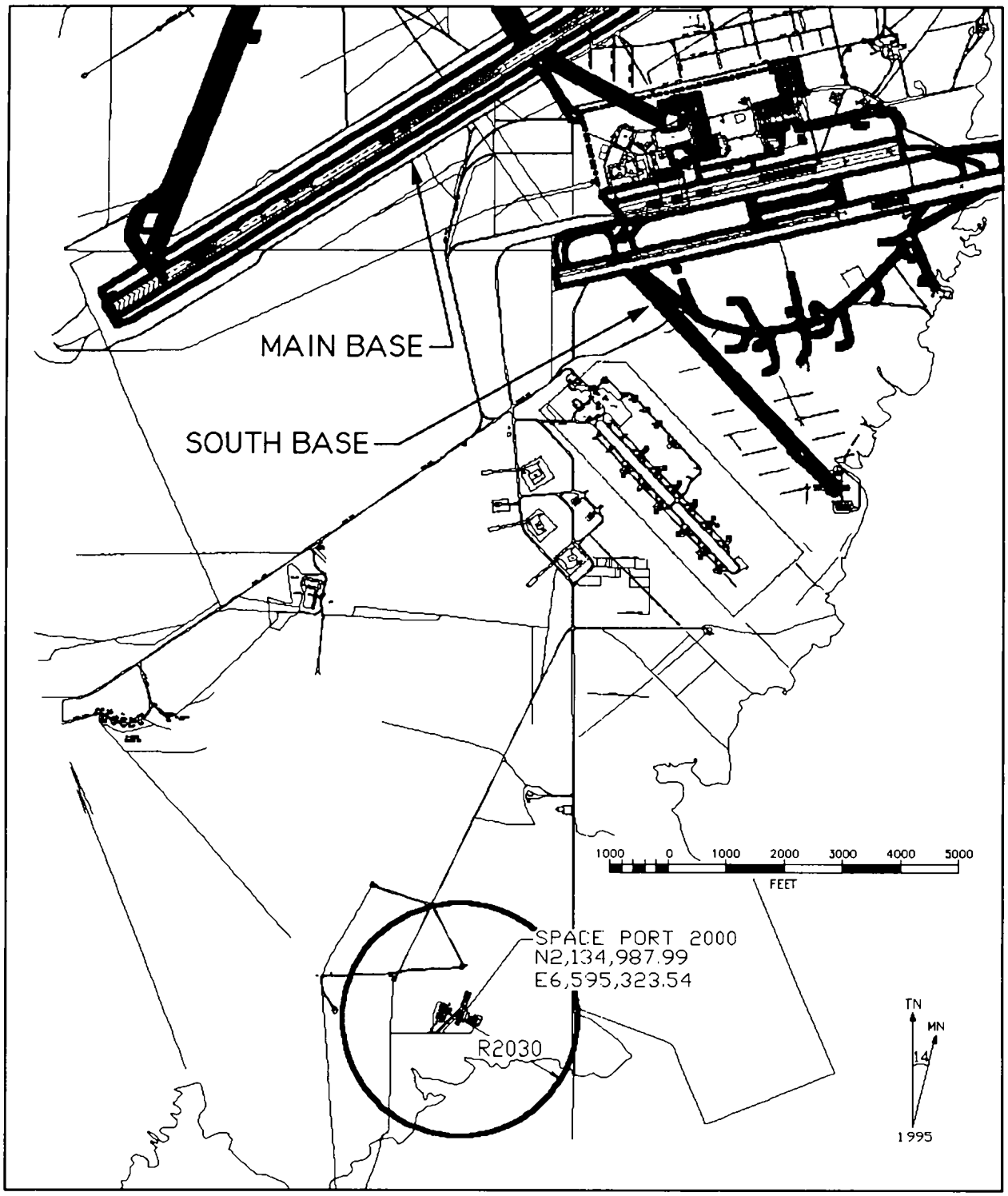


Figure 4-1. Explosive Siting Map for Space Port 2000 Site (The Circle Shown Defines the Maximum QD Around the X-33 Launch Site).

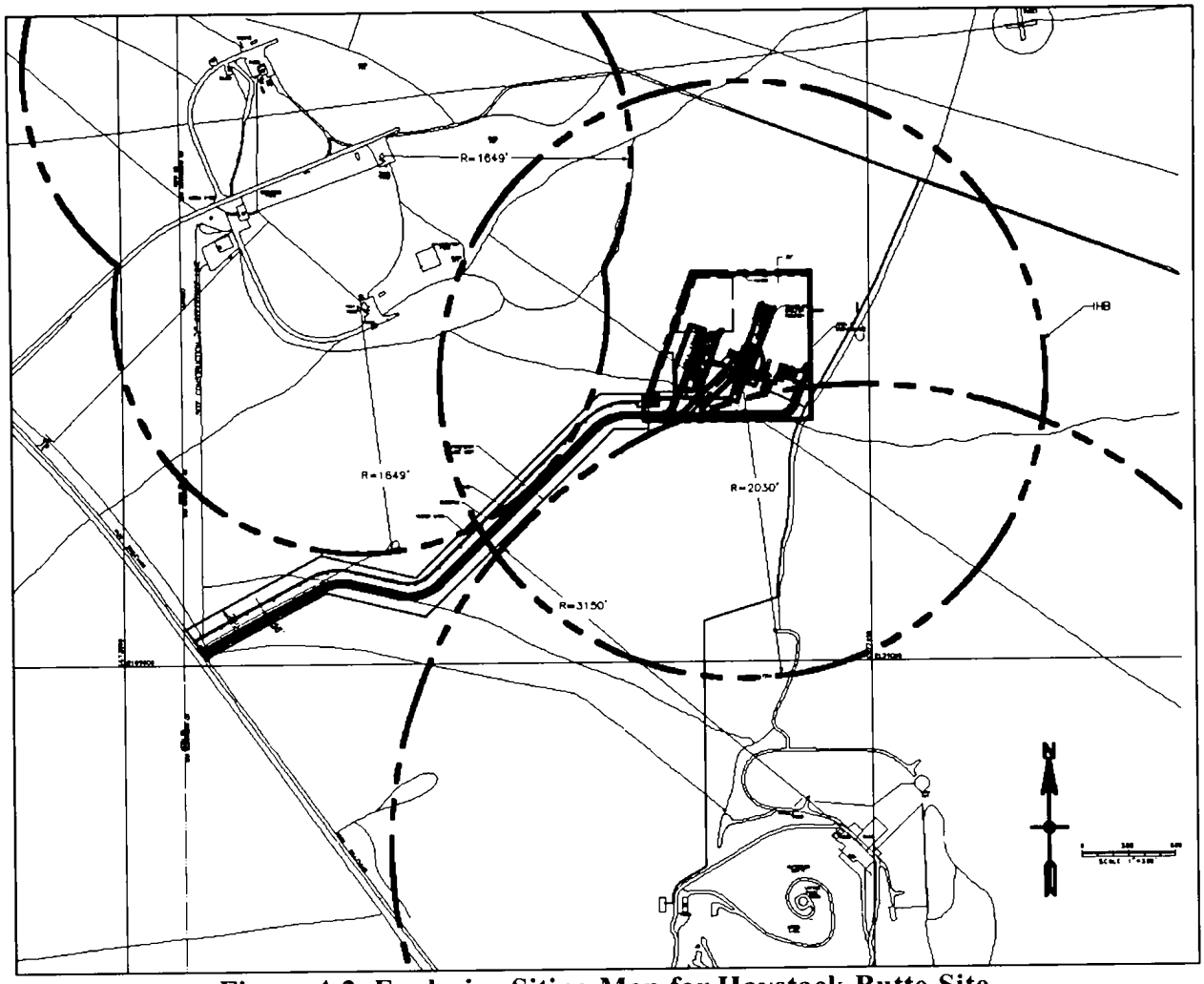


Figure 4-2. Explosive Siting Map for Haystack Butte Site.

LH_2 and LOX in the quantities provided in Section 2.1.7 would be transported from a supplier in the Los Angeles area to the selected launch site via tankers designed to carry these commodities. These trucks must meet the U.S. and California Departments of Transportation's design requirements in order to travel over public roadways. Design requirements are intended to minimize possibility of spill, fire, or explosion in the event of a vehicle accident. Established routes for transport of hazardous commodities on site are designed to minimize risk to personnel and transport vehicles. Edwards has had limited experience with these commodities but has not experienced any transportation incidents involving explosive materials. There is no expected impact due to the transportation of LH_2/LOX to the proposed site.

Off-site tankers carrying hazardous materials travel over public roadways. The routes used for off-site transport would be on highways approved by the California Highway Patrol for transport of hazardous materials by 18-wheel trailer trucks (USAF 1992 A). Based on 3 FRFs and 15 flight tests, there would be either: (1) 36 rail cars of LOX and 90 rail cars of LH_2 ; or (2) 72 truck loads of LOX and 180 truck loads of LH_2. All shipments would be delivered to the launch site over a one year period. Shipping of LH_2 and LOX must meet DOT standards and regulations in 49 CFR Part 171 for transporting hazardous materials including liquified gases such

as LH_2 and LOX. Transportation of LH_2 has had an excellent safety record. As an example, a local supplier of LH_2 has reported only one accident in 30 years that resulted in the venting of hydrogen. No injuries were reported in this accident (USAF 1992C). Based on stringent design requirements of the vehicles and proven safety records of the companies involved in production and transportation of LH_2/LOX, no impacts resulting from transportation of hazardous materials over public roadways or rail are anticipated.

Site preparation at launch sites would be done in accordance with safety requirements of the Occupational Safety and Health Administration as well as state of California and Edwards safety requirements. Job site safety would be monitored by the construction contractor. The only anticipated unique safety hazards associated with site preparation of either launch site alternative would involve the possibility of unexploded ordnance being found on the Haystack Butte site. The area around Haystack Butte has been the test site for development and evaluation of Air Force aircraft and weapons delivery systems for over 60 years. Weapons tested included those using live ammunition, high explosives, and chemical devices. Bombing targets in the area have no real boundaries because live rounds of ammunition, high explosive bombs, or chemical weapons occasionally missed their targets or skipped off into areas surrounding the targets. In the past, chemical weapons and ordnance have been discovered buried in these areas. Areas of concern with respect to the health and safety of project personnel would include these bombing targets/disposal sites, areas surrounding these sites, and possibly the proposed X-33 launch site.

The Space Port 2000 site has not been used as a test or training site for ordnance. Therefore, it is not anticipated to have any unexploded ordnance.

The 95th Civil Engineer Group, Explosive Ordnance Disposal Division, is responsible for removal of exploded ordnance fragments and unexploded munitions which have been dropped on or near specific targets. Ordnance removal occurs regularly during the year. Every 5 years a major decontamination is accomplished. However, Haystack Butte has not been fully investigated for the presence of hazardous materials.

A decontamination effort in the launch site area would be accomplished prior to the beginning of site preparation activities. Explosive Ordnance Disposal personnel are available in the event that unexploded ordnance material not found during the decontamination effort is encountered. Access to the site would be controlled by Range Control to ensure that personnel do not go into areas where testing or hazardous activities are ongoing.

The X-33 Launch Control Area would be cleared of all non-essential personnel when vehicle fueling begins in preparation for launch. There would be progressively larger areas of personnel control depending on the stage of processing. During launch processing activities not involving propellants, the control area would be small, encompassing the area immediately around the launch complex. During propellant tanking, the control area would be expanded and shortly prior to, during, and immediately after launch, it would be expanded again. Just prior to launch, all personnel would be moved approximately 10 km (6 mi) back from the launch site with the exception of a small number of critical personnel who would remain near the site during launch in a protective bunker located 1.3 km (0.8 mi) from the launch pad. It is anticipated that the entire Launch Control Area would be inside the boundaries of Edwards.

Edwards is an active military airfield with a mission to test experimental aircraft. Personnel at Edwards have extensive experience in handling possible contingencies associated with projects similar to the X-33. All necessary equipment and personnel are available to deal with catastrophic occurrences on or near the base. Emergency response plans addressing all credible failures and accident scenarios are being developed by NASA, Lockheed Martin Skunk Works, and the Air Force

Based on the mitigating factors above and Edwards previous experience with similar programs, minimal impact to safety and health is expected.

4.1.12 Noise

This section considers the major noise sources associated with the X-33, including launch site operations, liftoff, ascent, and sonic boom. Noise effects on wildlife are discussed in the Biological Resources sections for each alternative launch site.

As discussed in Section 3.1.13, the Day-Night Average Sound Level (L_{dn}) value is used to evaluate the effect of noise on a community. L_{dn} does not represent the sound level heard at any particular time; it represents the total sound exposure. Scientific studies and social surveys of community annoyance to all types of environmental noise have found the L_{dn} to be the best measure of community annoyance and its use is endorsed by the scientific community (ANSI 1980; ASA 1988; EPA 1974; FIC 1980; FIC 1992). Results by Schultz (1978) show consistency between the attitudinal surveys conducted to find the percentages of groups of people (as opposed to individuals) who express various degrees of annoyance when exposed to different levels of L_{dn} (Figure 4-3). In general, there is a correlation coefficient of 0.85 to 0.95 between the percentages of groups of people who are highly annoyed and the level of average noise exposure; that is, the sound level is 85 to 95 percent successful in predicting community response.

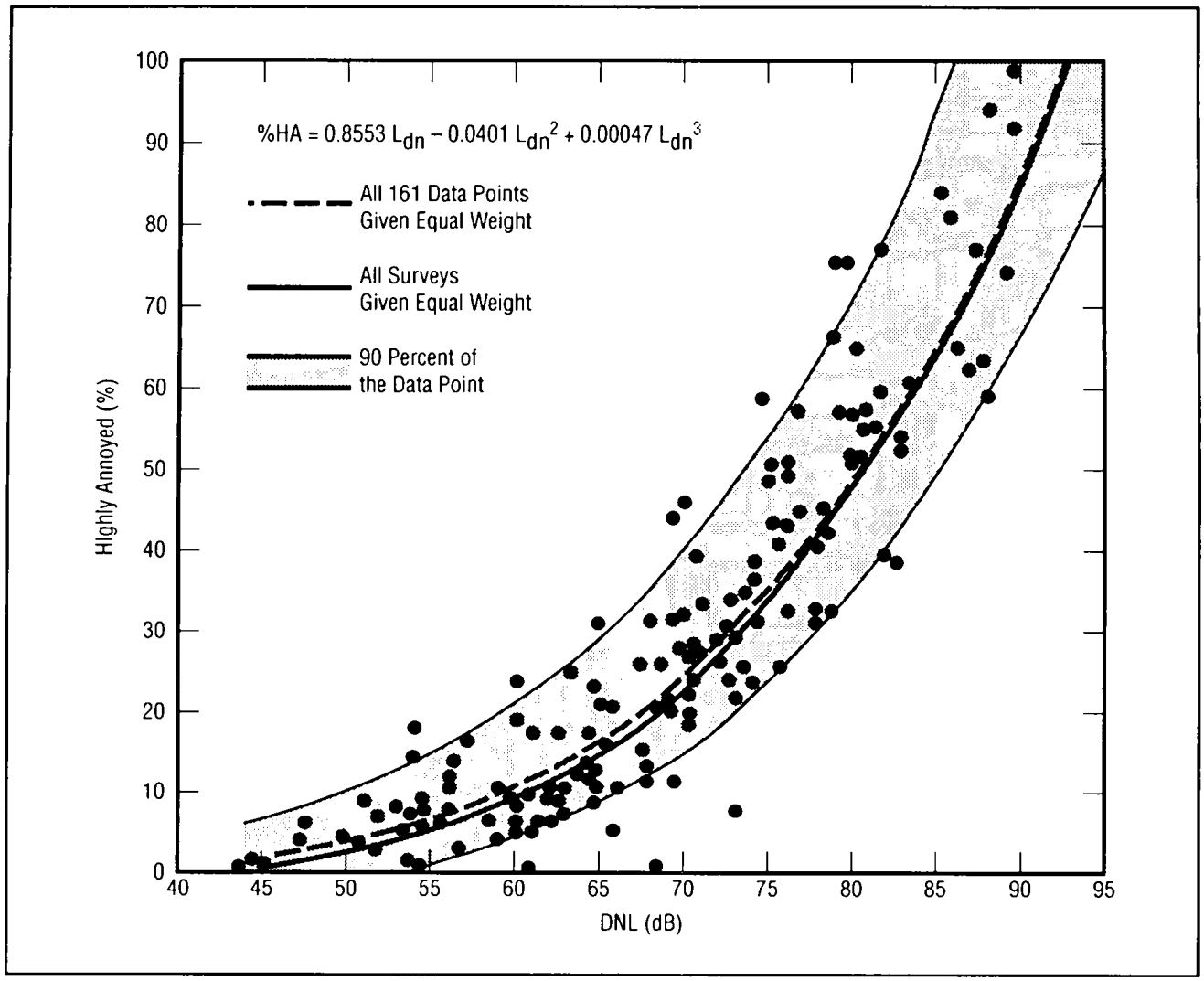


Figure 4-3. Community Surveys of Noise Annoyance.

The Schultz curve (see Figure 4-3) has been reaffirmed by various studies, most recently by Finegold et. al. (1994) which proposed a slightly different equation that does not differ significantly from Schultz's original result. Studies of impulsive noise (CHABA 1981) have shown that a curve similar to Schultz's is applicable to impulsive noise such as sonic booms but that C-weighting should be used rather than A-weighting. C-weighting is a method of limiting low and high frequencies to more closely match the human audible frequency range for impulse noise events such as sonic booms. The CHABA study defined levels of L_{Cdn} that result in annoyance equivalent to various values of L_{dn}.

A limitation of L_{dn} (or L_{Cdn} for impulsive noise) analysis is that the data upon which it is based (Schultz 1978; CHABA 1981; Finegold et al 1994) are from long-term noise exposure. Noise and sonic booms from the X-33 would occur infrequently. Therefore, potential impact of individual noise events is also addressed in this EIS.

Operational Noise

Personnel exposure levels in industrial shops and processing facilities at Edwards are routinely monitored for compliance with standards established by Occupational Safety and Health Administration. The vast airspace available and Edwards' isolated location in a remote and sparsely populated area greatly mitigate the noise caused by aircraft testing on base. Flight corridors are carefully planned within the proscribed airspace at altitudes and over geographic areas that successfully avoid populated communities. The USAF Air Installation Compatible Use Zone Program has established zoning plans to reduce noise effects on surrounding communities. For these reasons, Edwards, Dryden, and Phillips Laboratory have had minimal environmental noise problems with respect to communities, population concentrations, and the public in general.

Flight Noise and Sonic Boom

Noise generated by X-33 testing was analyzed for three distinct conditions:

- Liftoff/Flight Readiness Firing
- Ascent
- Sonic Boom

The liftoff/test firing and ascent phases of the X-33 flight were assessed for the noise generated by the rocket engine. Engine noise is a quasi-static event; that is, the noise level generated by the engines changes slowly with corresponding changes in thrust and distance that separates the space vehicle and receiver. In addition to engine noise, the liftoff noise environment is influenced by the exhaust deflector and associated trench. By contrast, the ascent noise environment is influenced by the vehicle speed and altitude. The sonic boom assessment determines the amplitude and location of the pressure waves generated by the X-33 during supersonic flight. A sonic boom is a transient event lasting only about 1/4 of a second. The sonic boom amplitude and location is mainly determined by the vehicle shape and weight, the flight trajectory, and the atmospheric conditions. A sonic boom is comparable to thunder from a nearby storm lightning strike.

Launch Noise

Launch and static test farfield noise environments were estimated using methodology defined by the Chemical Propulsion Information Agency (CPIA 1971). To estimate takeoff noise environments, conservative values of thrust, nozzle exit gas velocity, and nozzle exit diameter were used (thrust = 916,334 N per engine (206,000 lb_f per engine), exit gas velocity = 3,634 m/s (11,923 ft/s), nozzle diameter = 2.0 m (7.0 ft)). The noise environment at the receptor also depends on the location of the noise source. The launch pad and associated exhaust deflector/trench were oriented approximately 18 degrees east of north.

At Haystack Butte the liftoff noise levels would be at or below 110 dB (90 dBA) at approximately 6 km (4 mi) from the launch site as shown in Figures 4-4 and 4-5. Workers would hear noticeable takeoff noise at distances up to 10 km (6 mi). A static test firing (or flight

readiness firing) would run for approximately 20 seconds and would result in L_{dn} of 55 dBA along the 90 dBA maximum A-weighted contours (see Figure 4-5). For flight conditions, the liftoff model predictions use a duration of 10 seconds which results in a L_{dn} of 45 dBA along the 90 dBA maximum A-weighted contour. These L_{dn} levels are below the maximum L_{dn} recommended for all land-use compatibility areas. At 110 dB, some structural damage may be expected, but all of the area exposed to these levels is within Edwards boundaries. At 103 dB and lower levels, the probability of damage claims is much smaller and the areas exposed are mostly on Edwards and a small area on sparsely populated land south of the base. For hearing conservation purposes, personnel close to the launch pad would have hearing protection and/or be restricted to protective structures. Speech interference could occur outdoors well outside of Edwards, but the flights and tests are infrequent and, therefore, the impact would be minimal. Some task interference may occur, but, again, the flights and tests are infrequent. Therefore, the impact would be minimal.

The X-33 launch and ascent engine noise can be compared to past Titan static test firing noise contours in Section 3.1.13, Figure 3-10A.

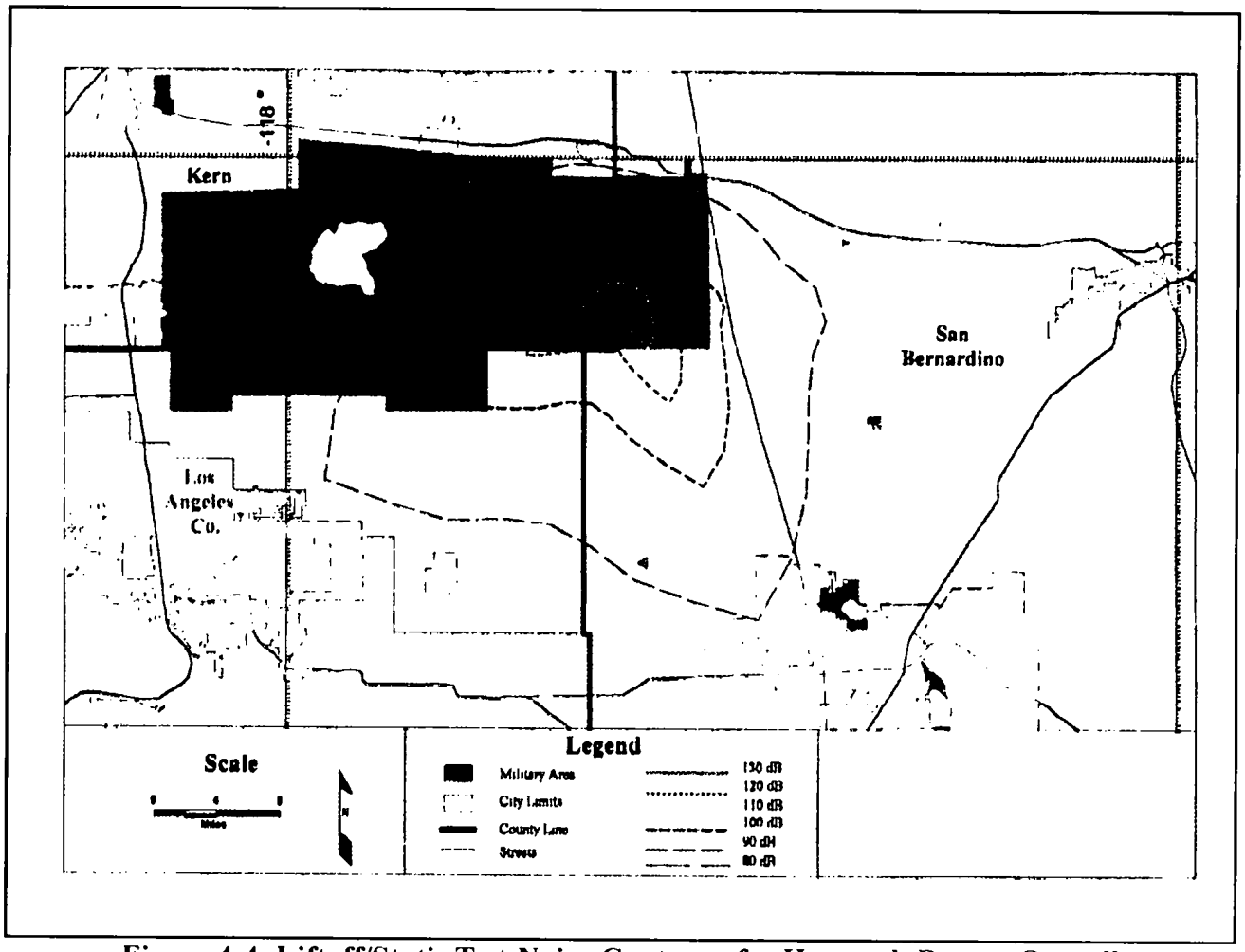


Figure 4-4. Liftoff/Static Test Noise Contours for Haystack Butte - Overall Sound Pressure Levels.

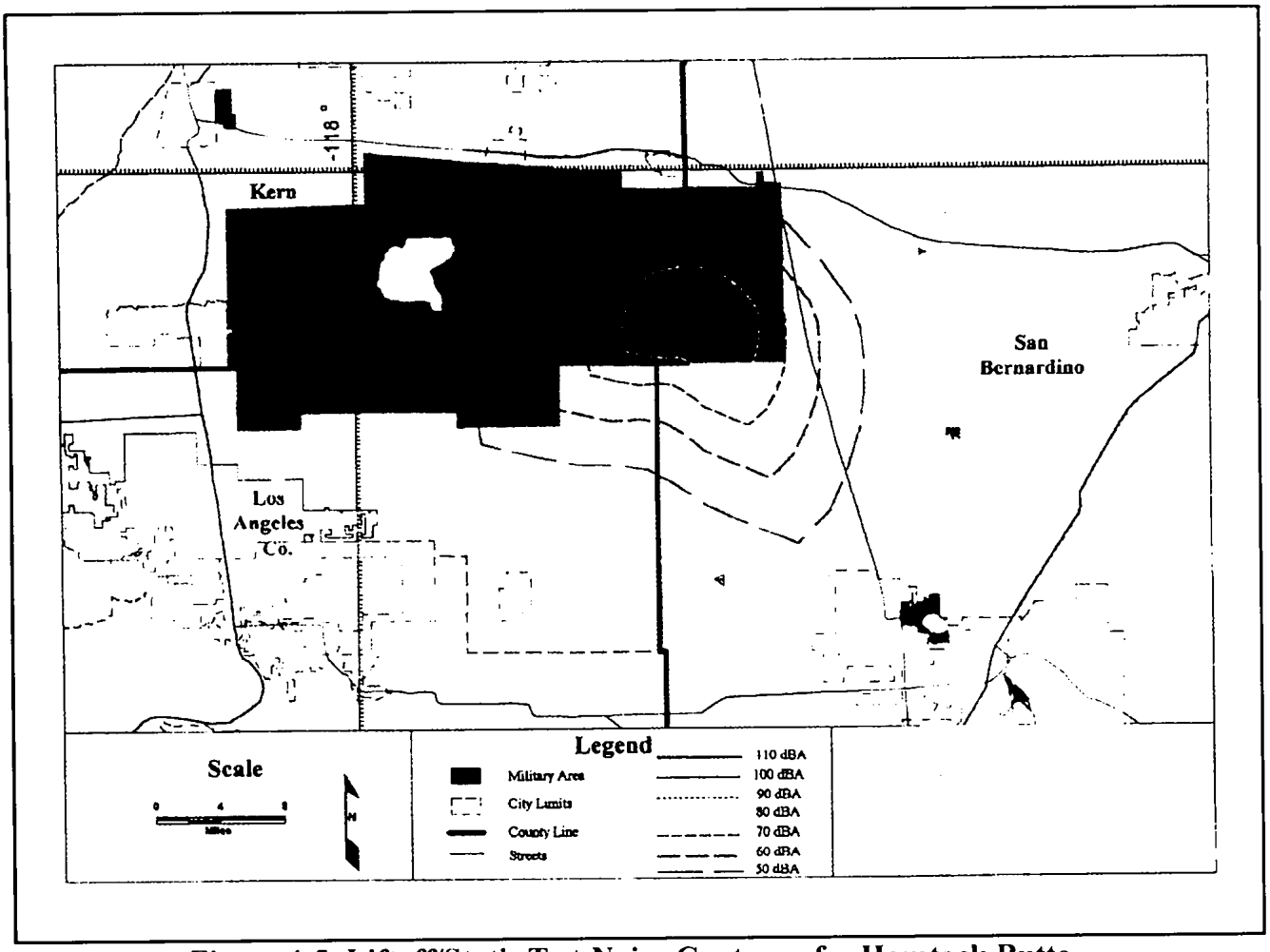


Figure 4-5. Liftoff/Static Test Noise Contours for Haystack Butte - Maximum A-Weighted Sound Levels.

At Space Port 2000 the liftoff noise levels would be at or below 110 dB (90 dBA) at approximately 6 km (4 mi) from the launch site as shown in Figures 4-6 and 4-7. Workers would hear noticeable takeoff noise at distances exceeding 10 km (6 mi). A static test firing (or flight readiness firing) would run for approximately 20 seconds and would result in L_{dn} of 55 dBA along the 90 dBA maximum A-weighted contours (Figure 4-7). For flight conditions, the liftoff model predictions use a duration of 10 seconds which results in a L_{dn} of 45 dBA along the 90 dBA maximum A-weighted contour. These L_{dn} levels are below the maximum L_{dn} recommended for all land use compatibility areas. At 110 dB, some structural damage may be expected, but all of the area exposed to these levels is within Edwards boundaries. At 103 dB and lower levels, the probability of damage claims is much smaller, and the areas exposed are mostly on Edwards and a small area of sparsely populated land south of the base. A small on-base residential area south of the Edwards main runway could be exposed to levels up to 105 dB which has a very low probability of potentially causing some damage in the form of a cracked window. For hearing conservation purposes, personnel close to the launch pad would have hearing protection and/or be restricted to protective structures. Speech interference (interrupting conversation) could occur outdoors well outside of Edwards, but the flights and tests are infrequent and, therefore, the

impact would be minimal. Some task interference may occur, but, again, the flights and tests are infrequent; therefore, the impact would be minimal. Residents living on Edwards could briefly experience significant speech interference and some task interference, but the flights and tests would be of short duration and infrequent. Therefore, the impact would be minimal.

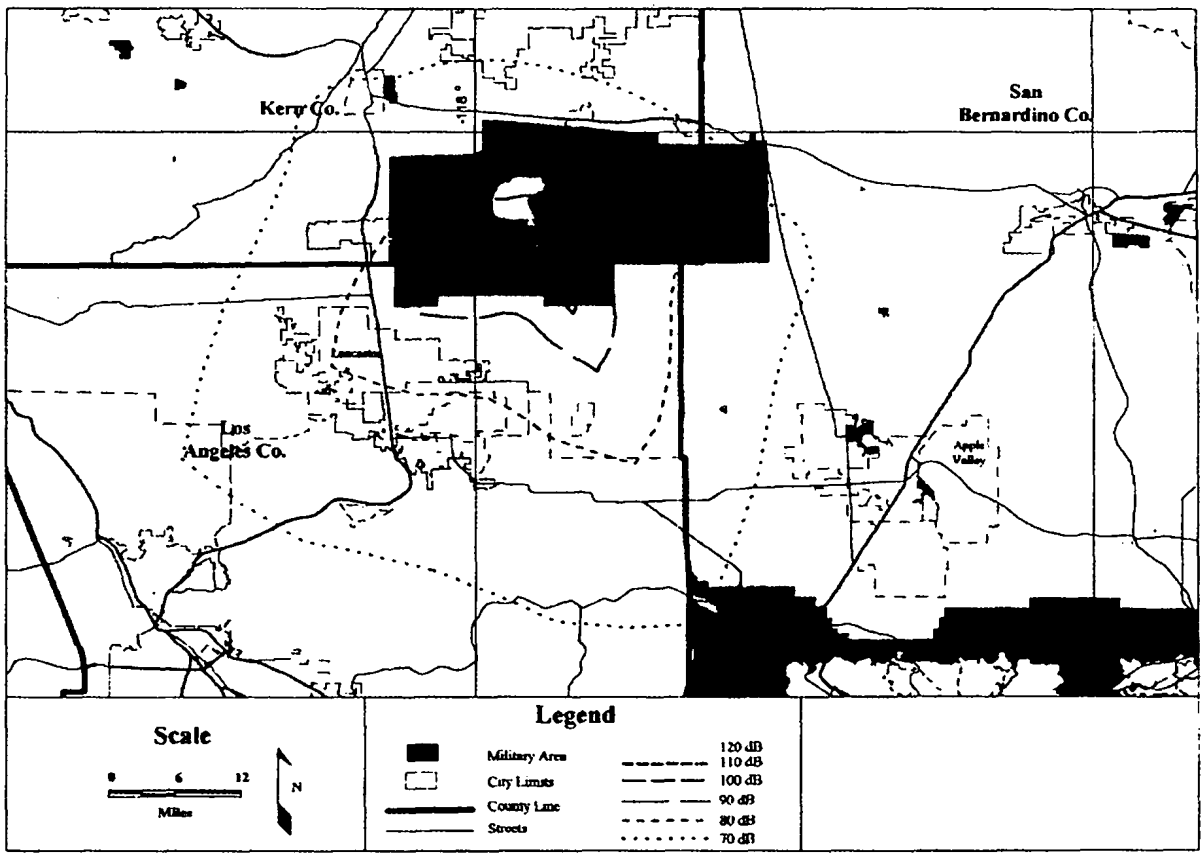


Figure 4-6. Liftoff/Static Test Noise Contours for Spaceport 2000 Launch Site - Overall Sound Pressure Levels.

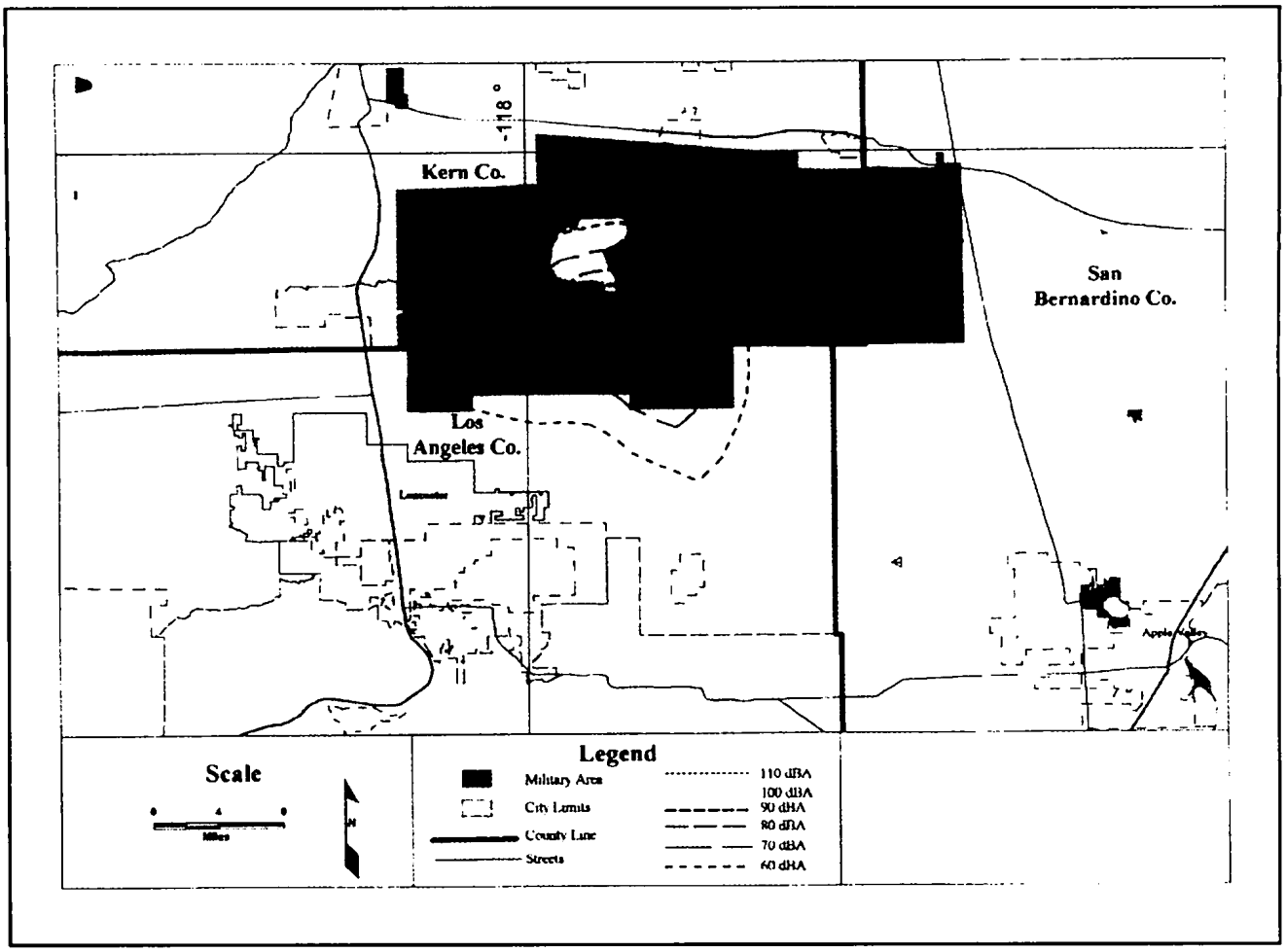


Figure 4-7. Liftoff/Static Test Noise Contours for Spaceport 2000 Launch Site - A-weighted Sound Levels.

Moving Rocket Noise

Although the moving rocket noise generation process is the same as the launch/static test case, the farfield noise environment of an ascending rocket is predicted using a different model. The main differences between models are a deflected exhaust for launch/static test condition and the effects of an accelerating rocket moving away from a listener for the moving rocket case. The ascending rocket noise model, RNOISE, uses the method of NASA (MSFC 1963), and the noise emission characteristics (total sound power, spectrum, and directivity) are taken from the method of Sutherland (1993). Absorption of sound by the atmosphere is calculated with ANSI Standard S1.26-1978, and the effect of the ground is calculated by the method of Chien and Soroka (1980). Moving rocket noise levels are a function of thrust, nozzle exit gas velocity, nozzle exit diameter, altitude, downrange distance, flight path angle, and ground track direction. Conservative values of thrust, nozzle exit gas velocity, and nozzle diameter were used for all cases (thrust = 916,334 N per engine (206,000 lb_f per engine), exit gas velocity = 3,634 m/s (11,923 ft/sec), nozzle diameter = 2.0 m (7.0 ft)). The nominal X-33 trajectories were used for the model trajectory inputs. A detailed description of the launch noise as related to altitude and position is provided in Appendix G.

At Haystack Butte, Figures 4-8 through 4-17 illustrate overall and A-weighted noise levels for the nominal trajectories. Maximum noise levels outside Edwards boundaries are expected to be 100 dB and 80 dBA. These sound levels should not annoy or damage property beyond the ranges. The Day-Night Average Sound Level, L_{dn}, does not exceed 45 dBA outside Edwards boundaries. An L_{dn} of 45 dBA is well below the minimum federal guidelines for land use compatibility. Hearing protection measures for liftoff would also protect for the ascending rocket phase. Outside the base boundary, some speech interference and task interference would be experienced by receivers near the southeast area of Edwards, but because of the short duration and infrequent flights, the impact would be minimal.

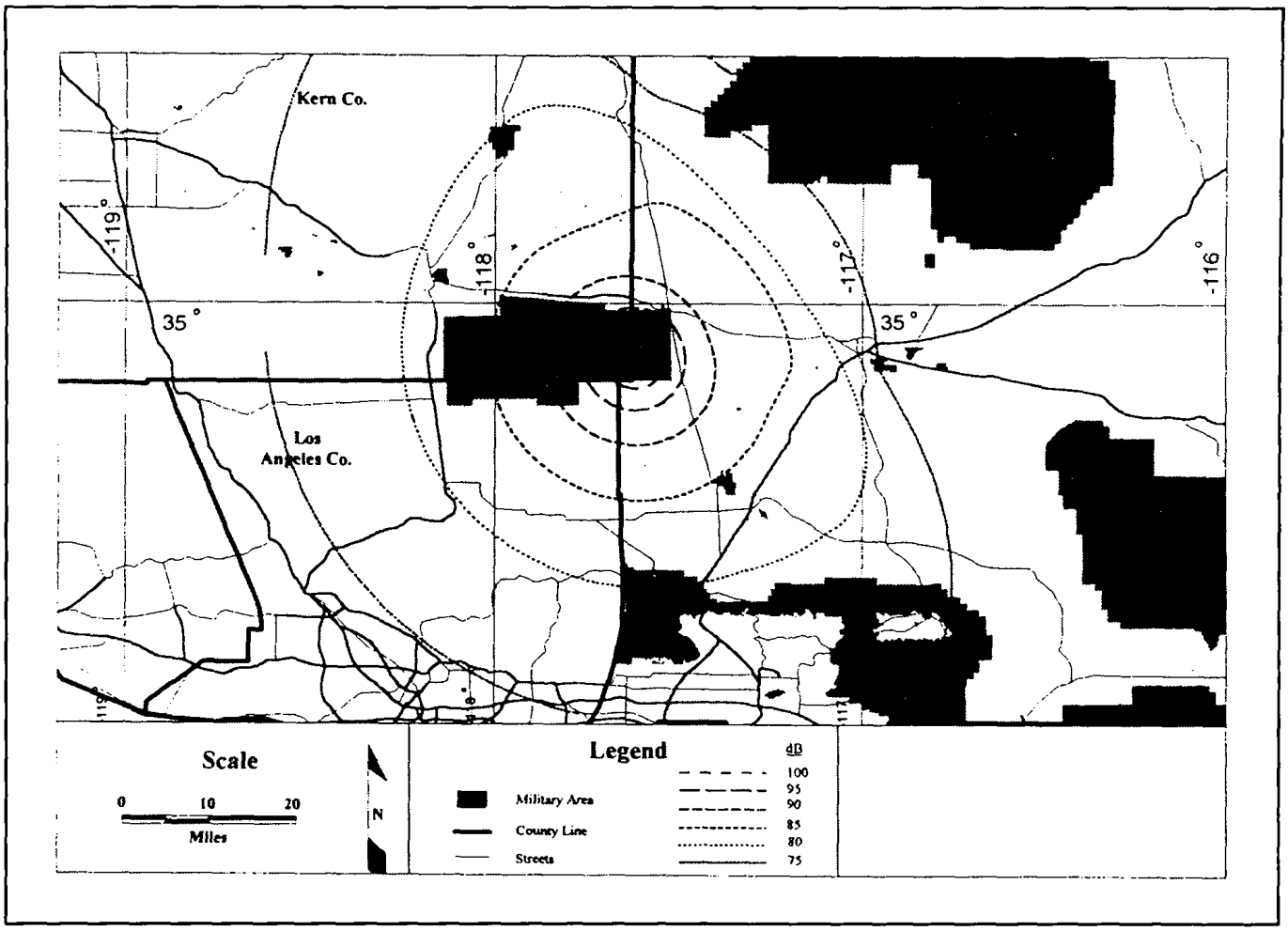


Figure 4-8. Maximum Overall Rocket Noise Contours for Launch from Haystack Butte to Silurian Lake.

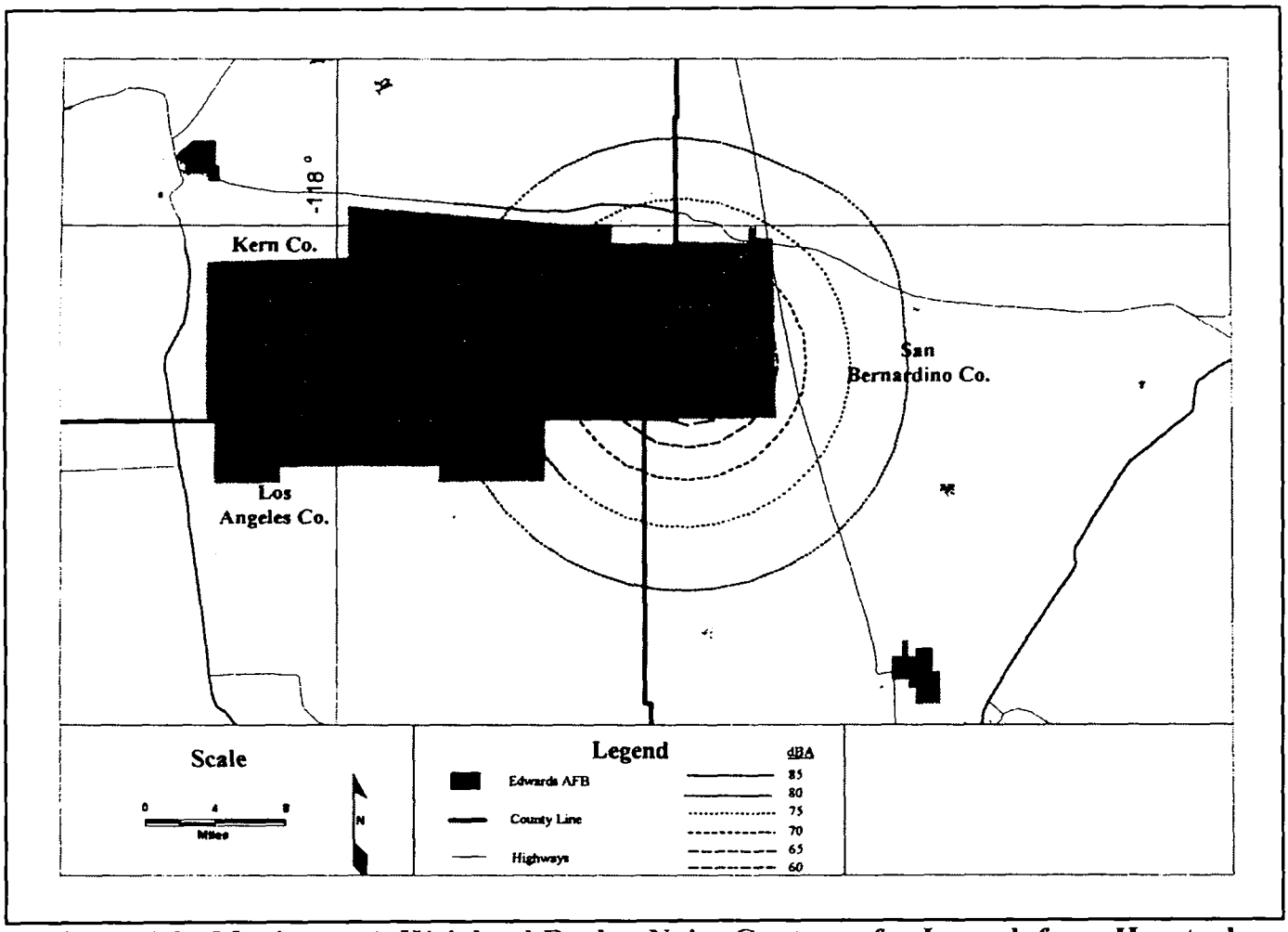


Figure 4-9. Maximum A-Weighted Rocket Noise Contours for Launch from Haystack Butte to Silurian Lake.

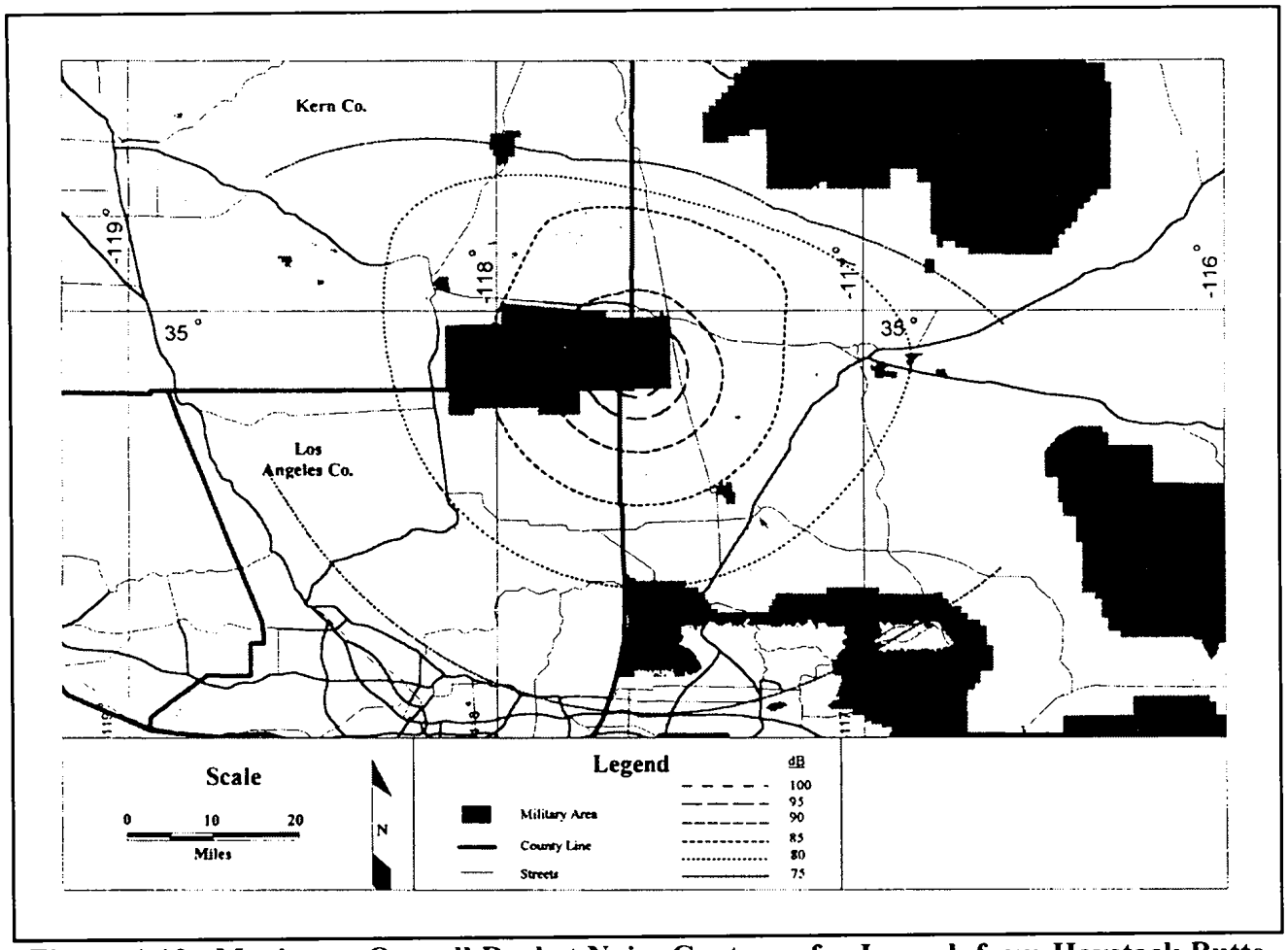


Figure 4-10. Maximum Overall Rocket Noise Contours for Launch from Haystack Butte to China Lake.

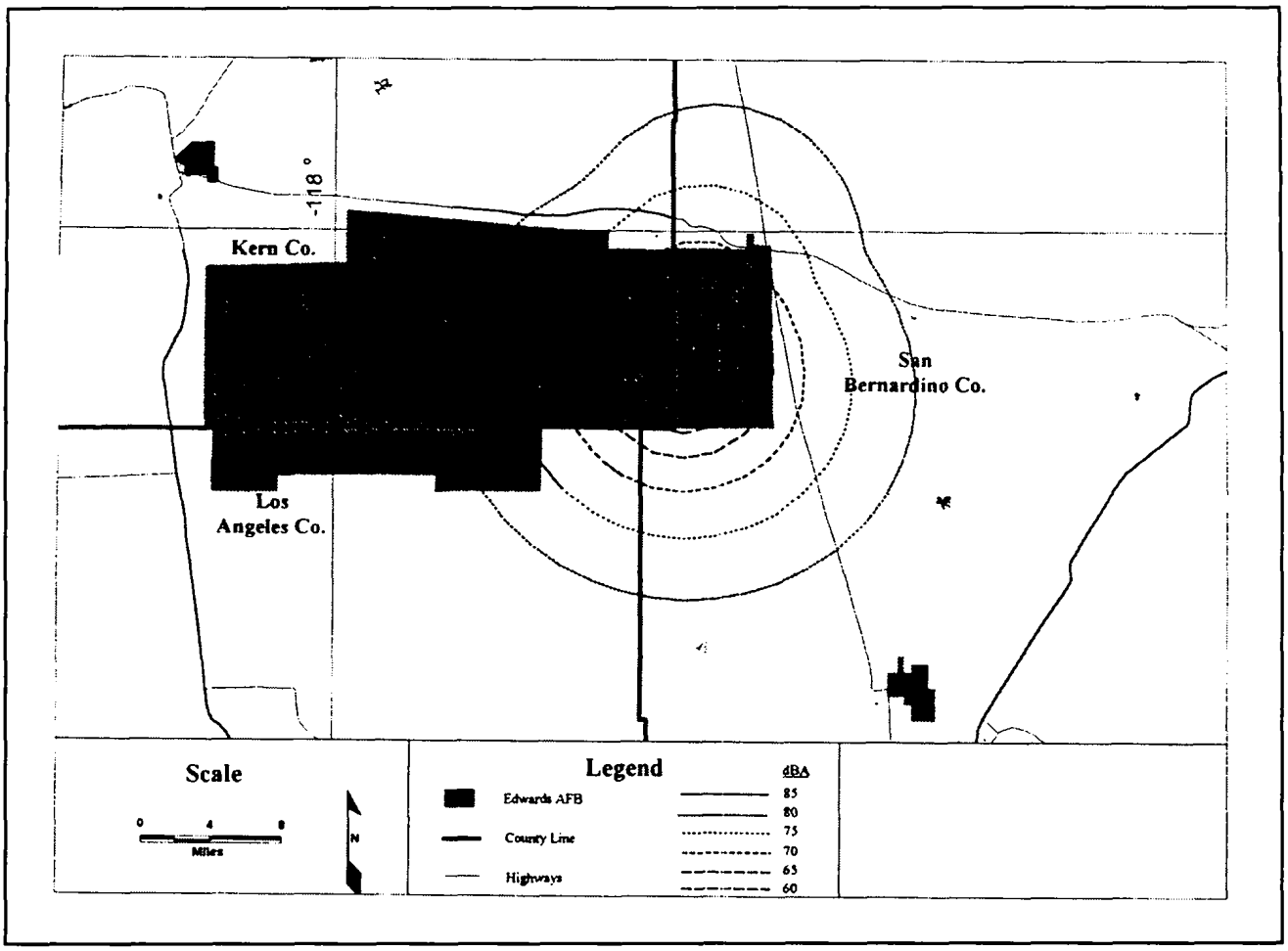


Figure 4-11. Maximum A-Weighted Rocket Noise Contours for Launch from Haystack Butte to China Lake.

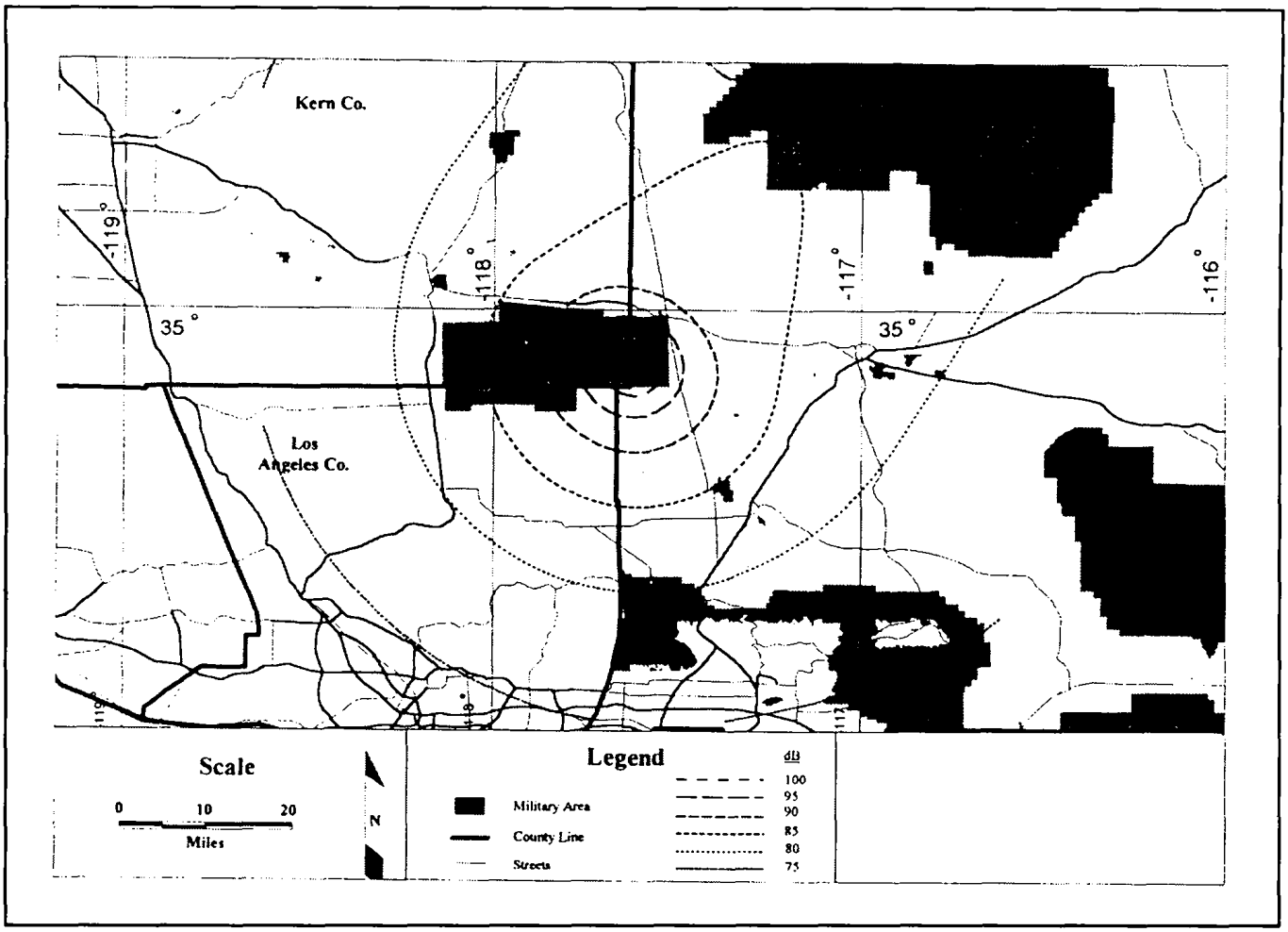


Figure 4-12. Maximum Overall Rocket Noise Contours for Launch from Haystack Butte to Dugway.

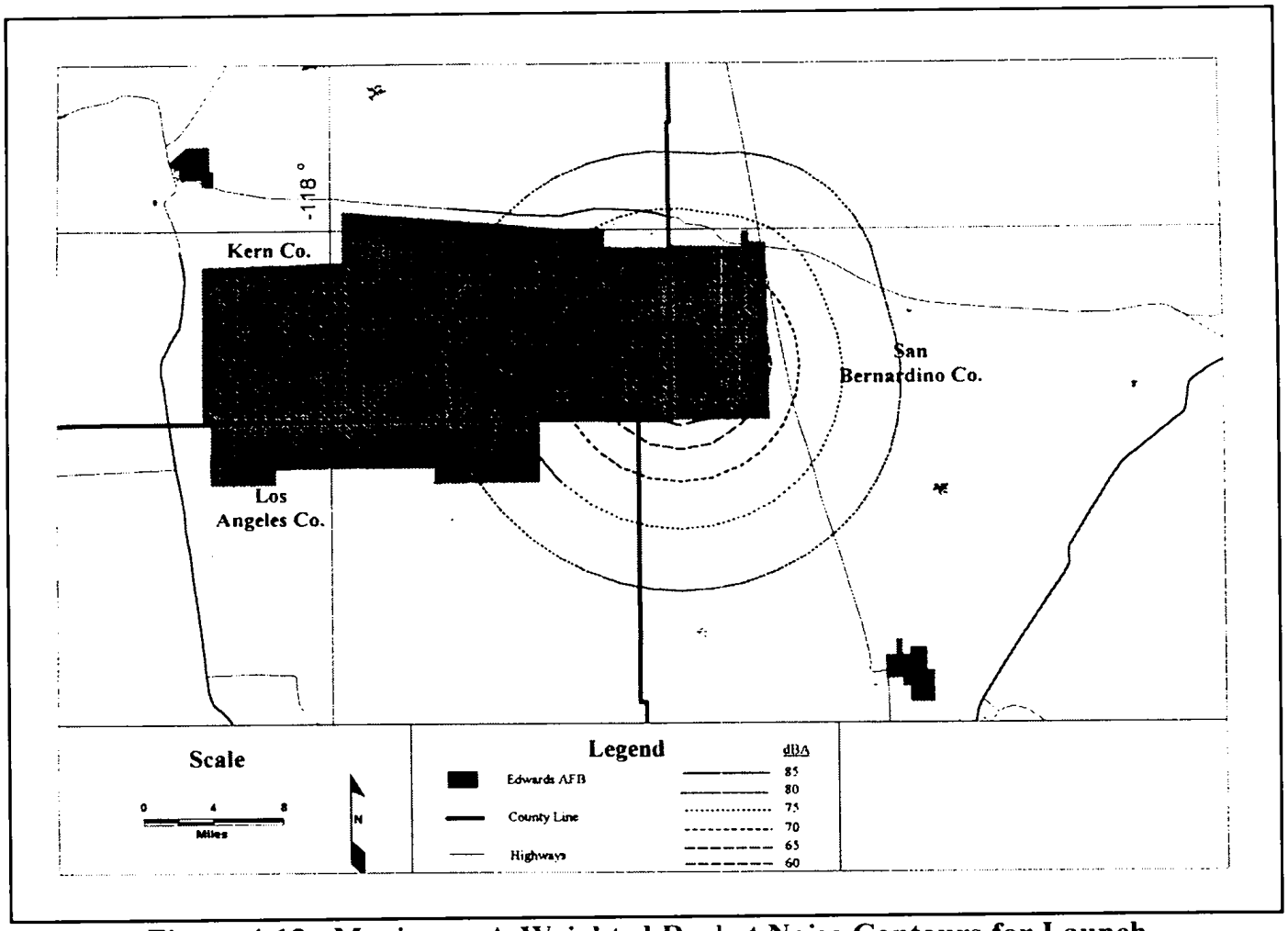


Figure 4-13. Maximum A-Weighted Rocket Noise Contours for Launch from Haystack Butte to Dugway.

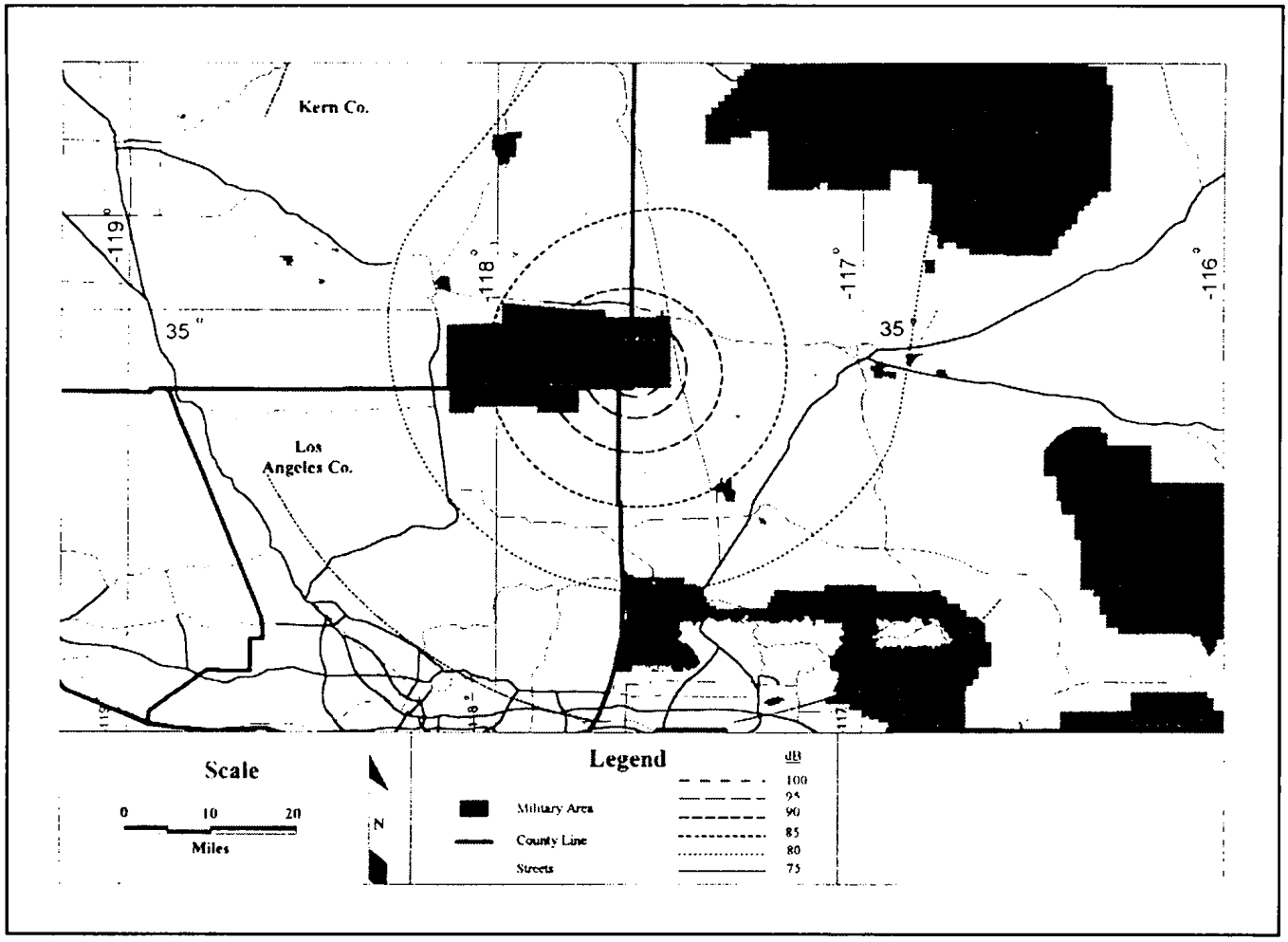


Figure 4-14. Maximum Overall Rocket Noise Contours for Launch from Haystack Butte to Malmstrom.

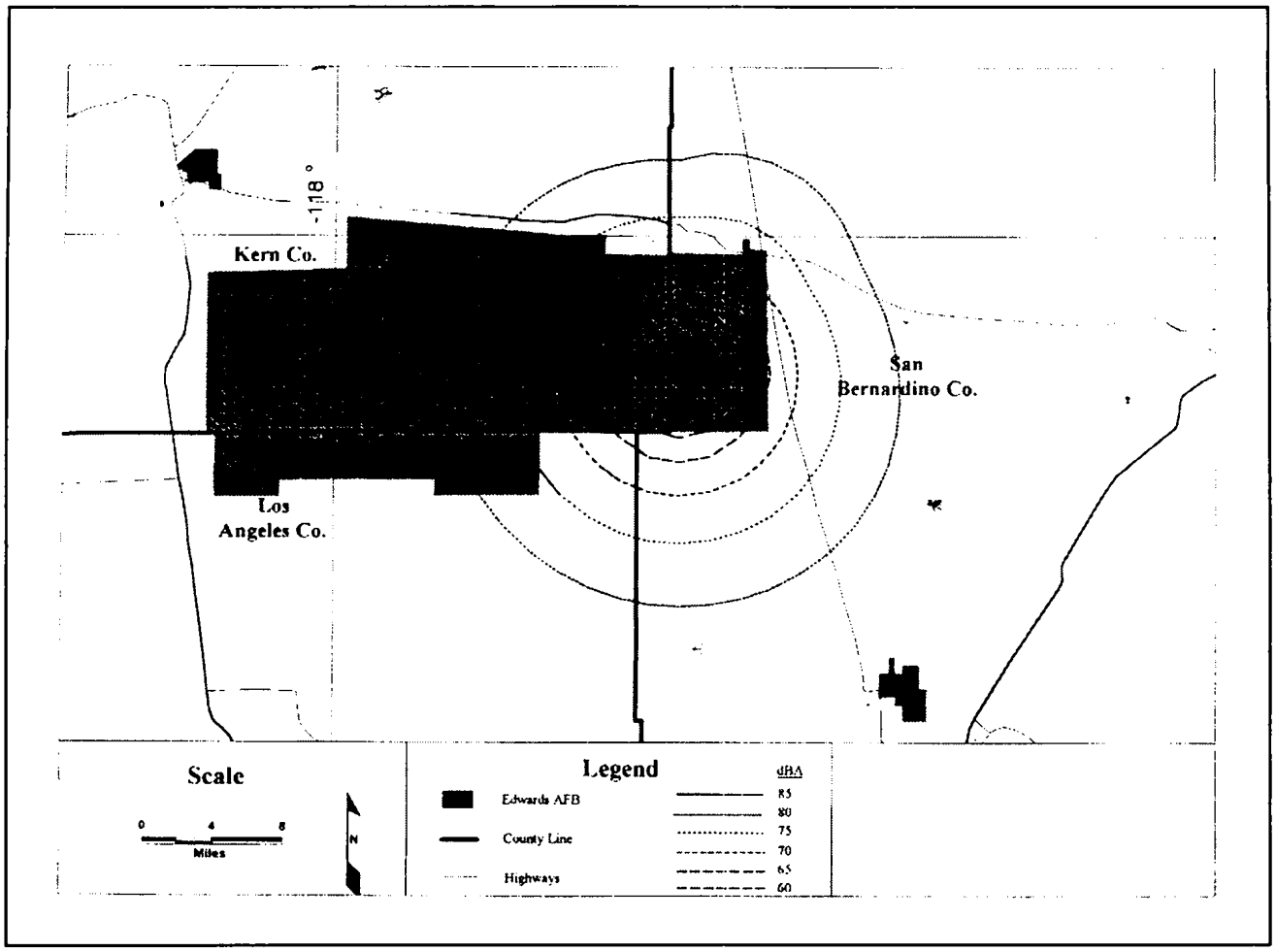


Figure 4-15. Maximum A-Weighted Rocket Noise Contours for Launch from Haystack Butte to Malmstrom.

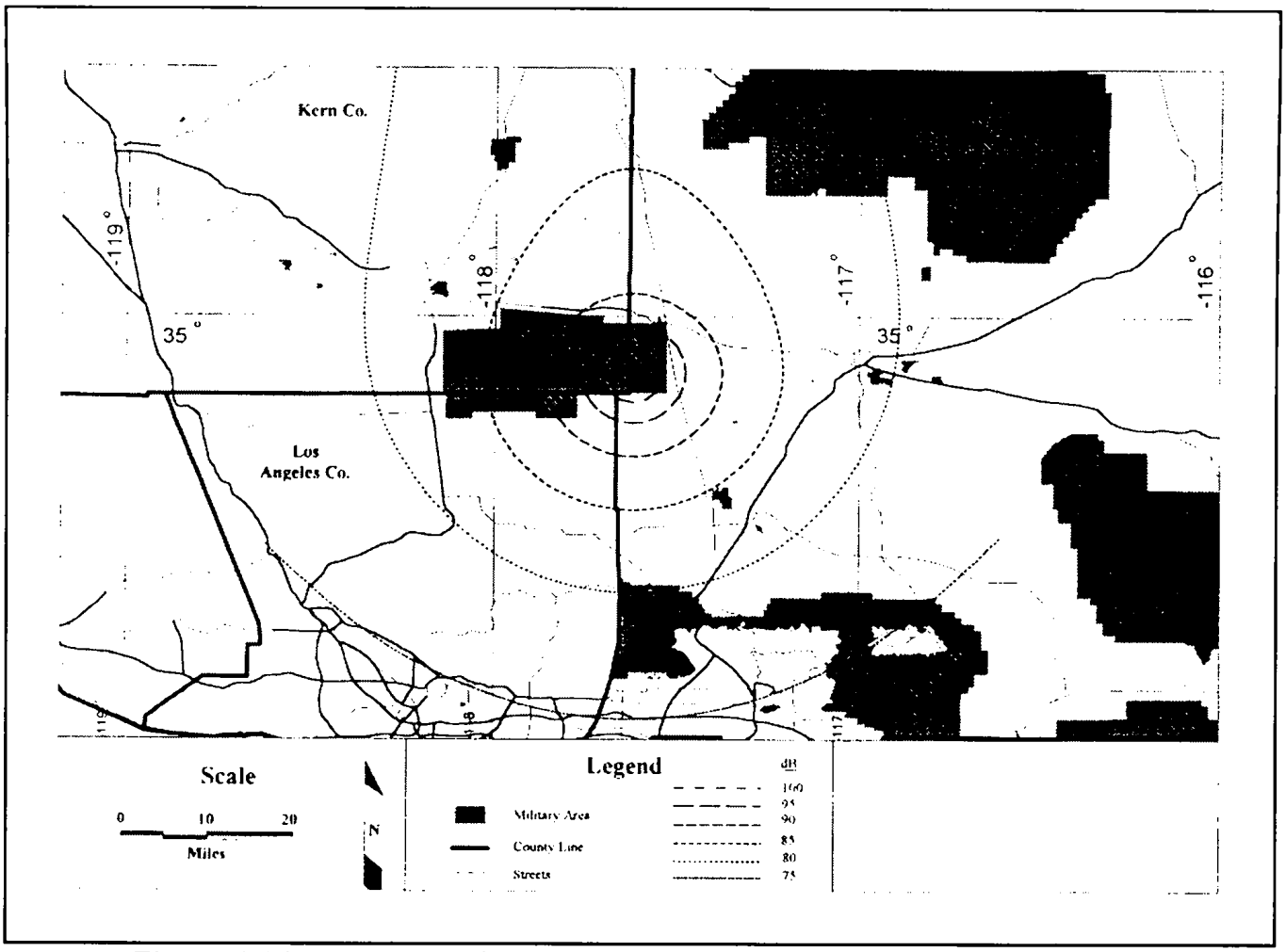


Figure 4-16. Maximum Overall Rocket Noise Contours for Launch from Haystack Butte to Moses Lake.

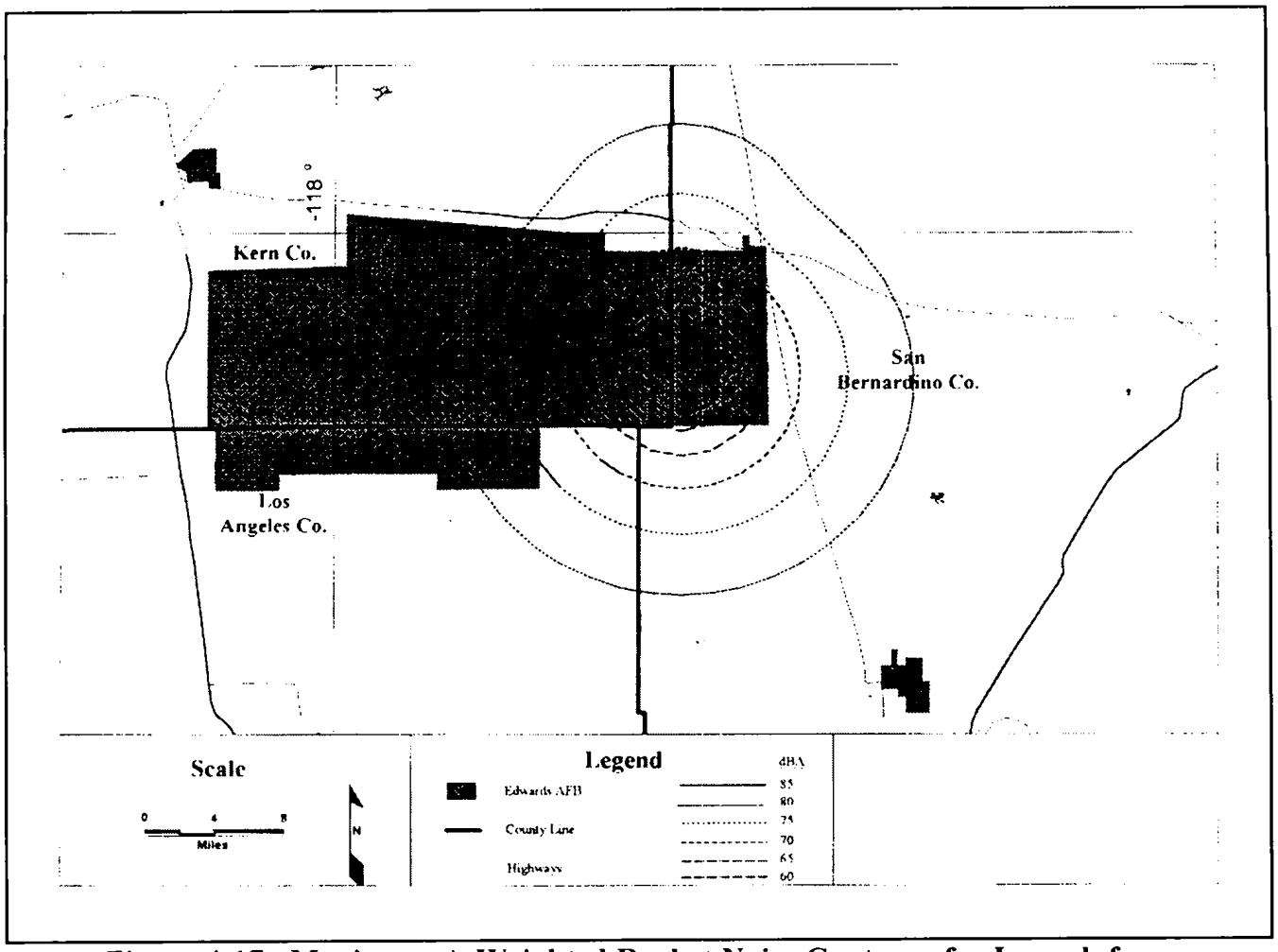


Figure 4-17. Maximum A-Weighted Rocket Noise Contours for Launch from Haystack Butte to Moses Lake.

At Space Port 2000, Figures 4-18 through 4-27 illustrate overall and A-weighted noise levels for the nominal trajectories. The maximum noise levels outside Edwards boundaries are expected to be 100 dB and 80 dBA. The Day-Night Average Sound Level, L_{dn}, does not exceed 45 dBA outside Edwards boundaries. An L_{dn} of 45 dBA is well below the minimum federal guidelines for land use compatibility. Hearing protection measures for liftoff would also protect for the ascending rocket phase. Outside the base boundary, some speech interference and task interference could be experienced by receivers near the south area of Edwards, but because of the short duration and infrequent flights, the impact should be minimal. A small on-base residential area south of the Edwards main runway could be exposed to levels up to 105 dB, which could potentially cause some structural damage.

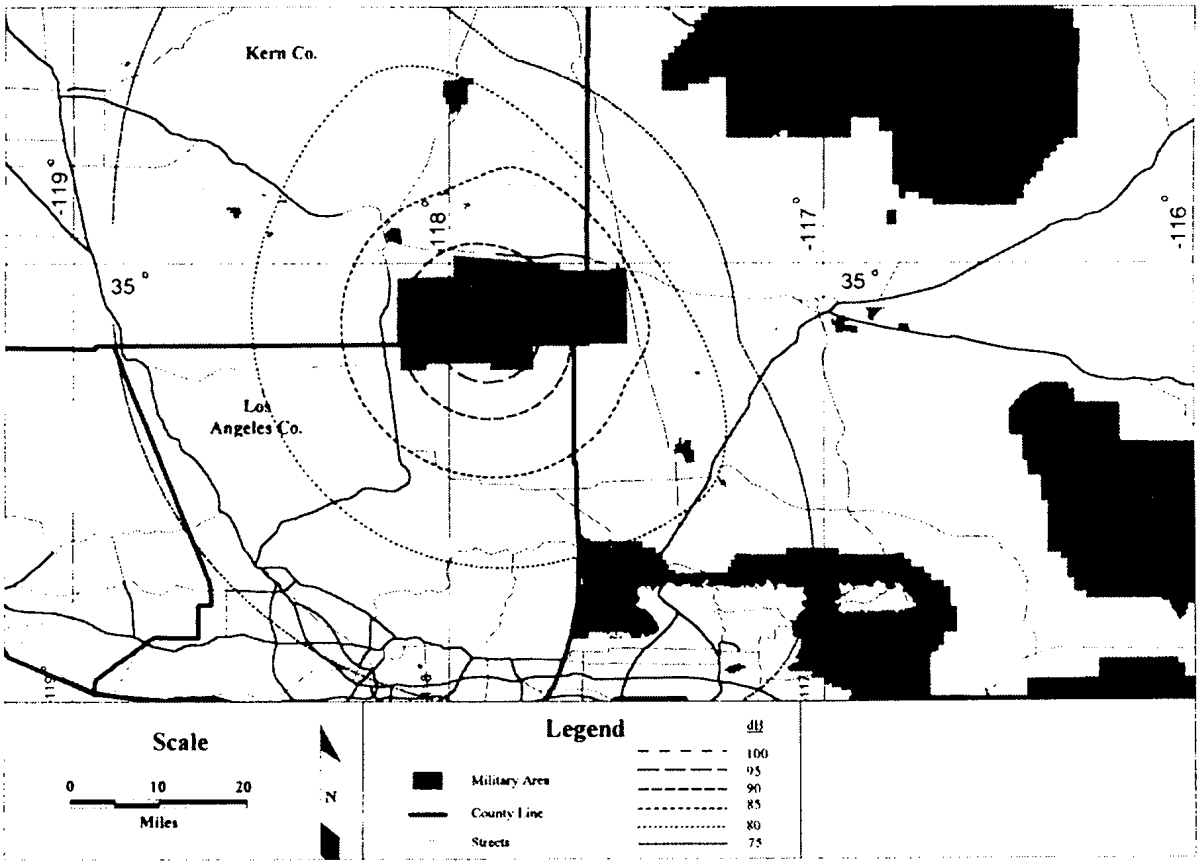


Figure 4-18. Maximum Overall Rocket Noise Contours for Launch from Space Port 2000 to Silurian Lake.

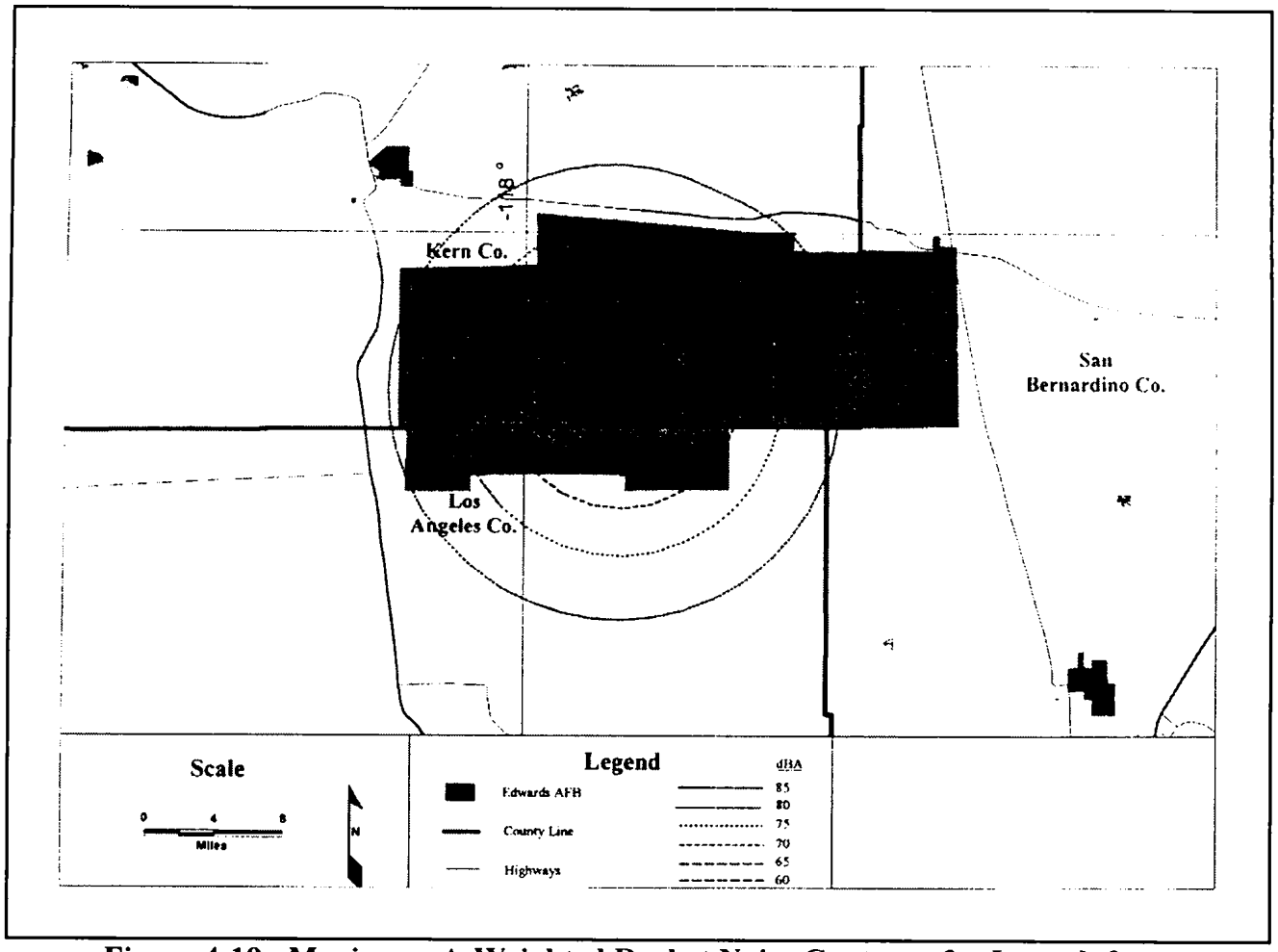


Figure 4-19. Maximum A-Weighted Rocket Noise Contours for Launch from Space Port 2000 to Silurian Lake.

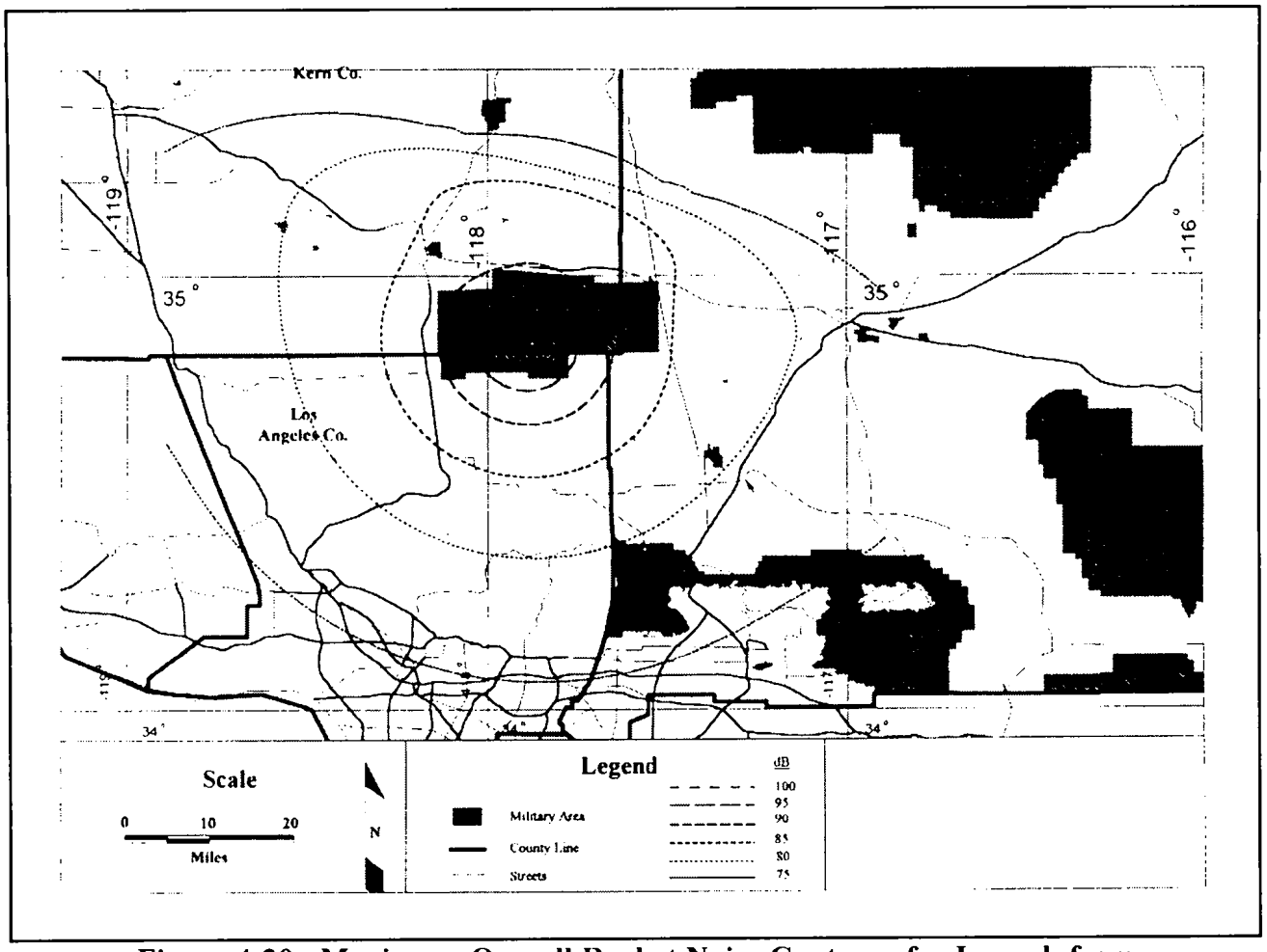


Figure 4-20. Maximum Overall Rocket Noise Contours for Launch from Space Port 2000 to China Lake.

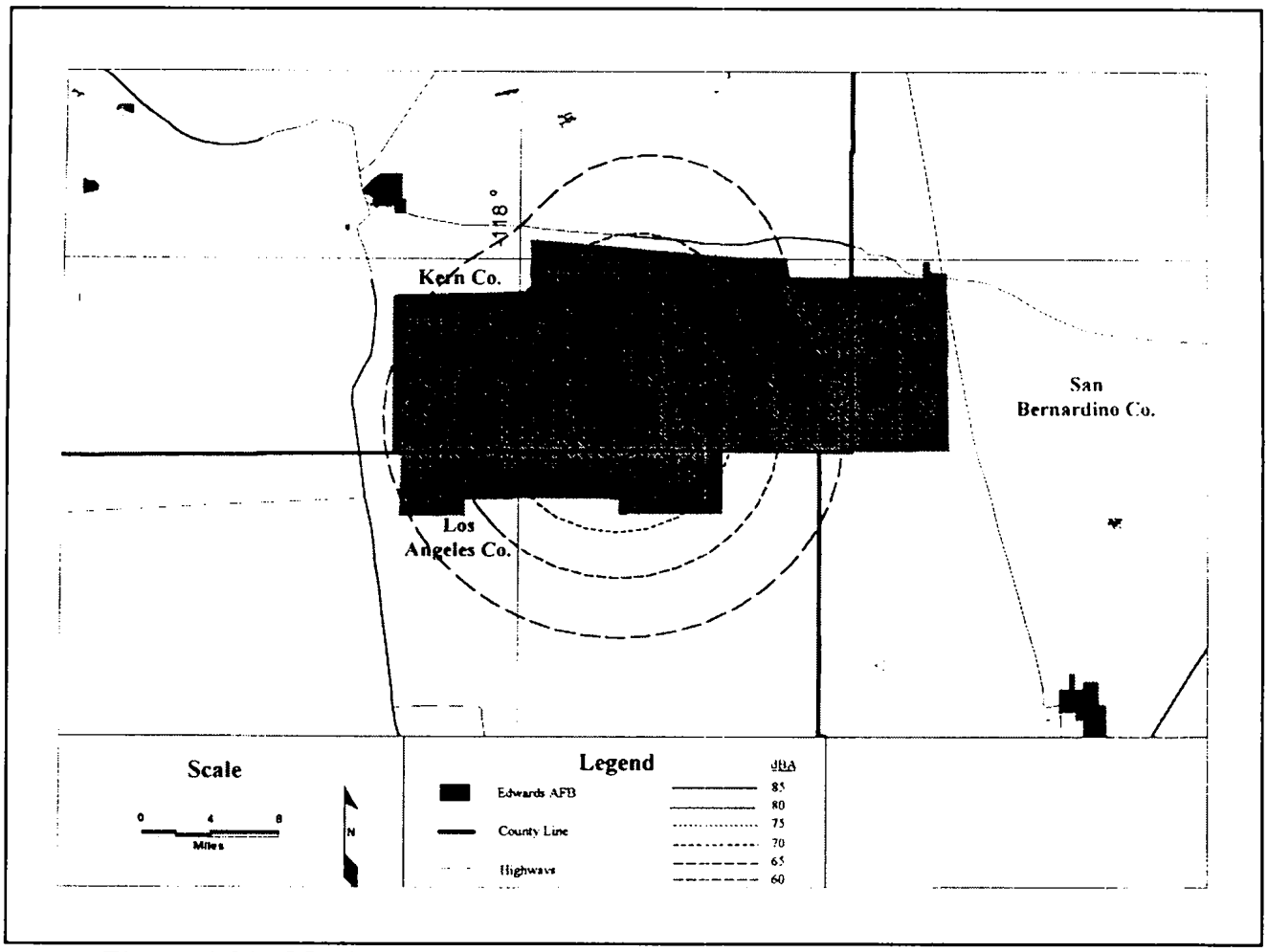


Figure 4-21. Maximum A-Weighted Rocket Noise Contours for Launch from Space Port 2000 to China Lake.

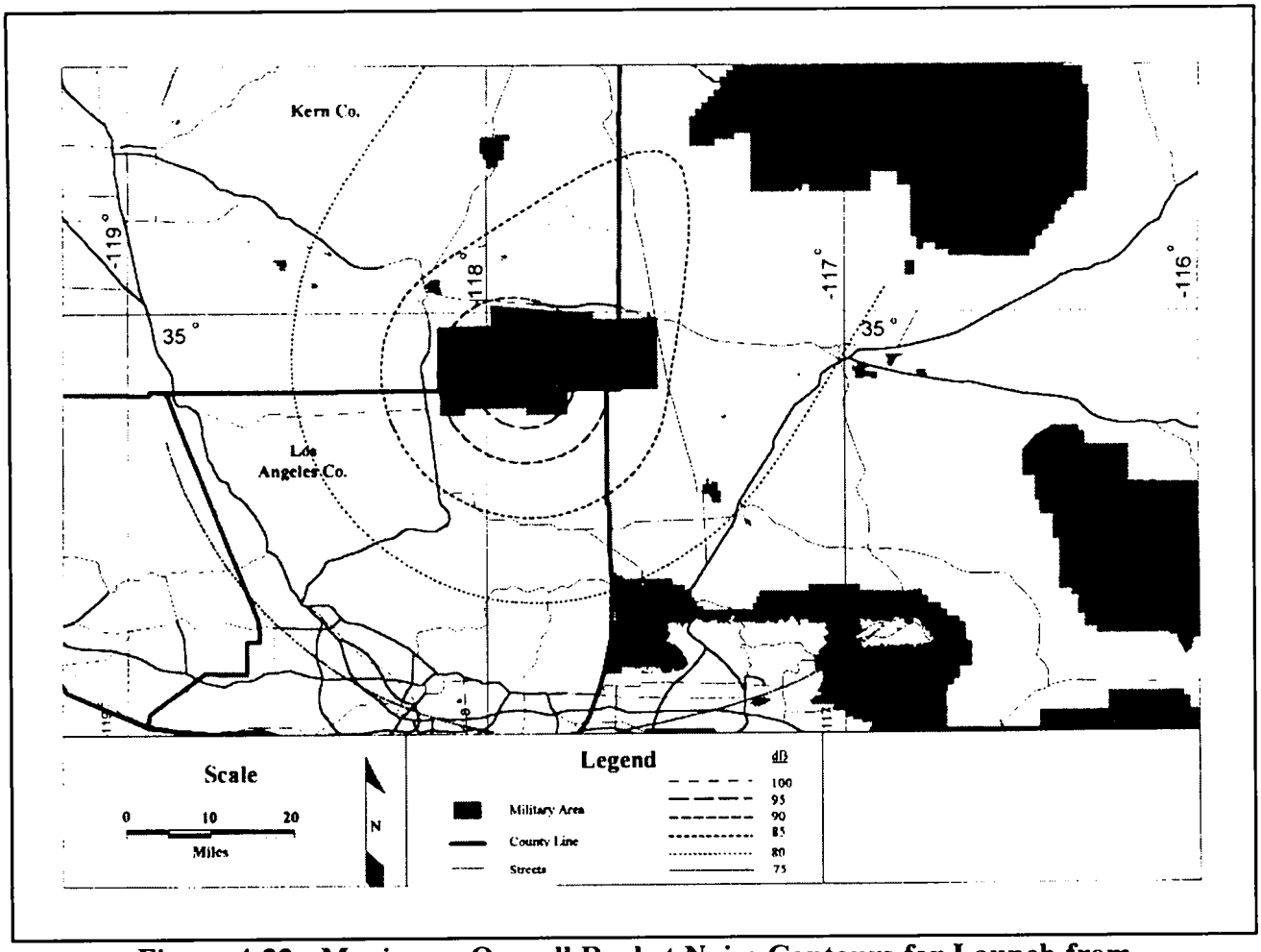


Figure 4-22. Maximum Overall Rocket Noise Contours for Launch from Space Port 2000 to Dugway.

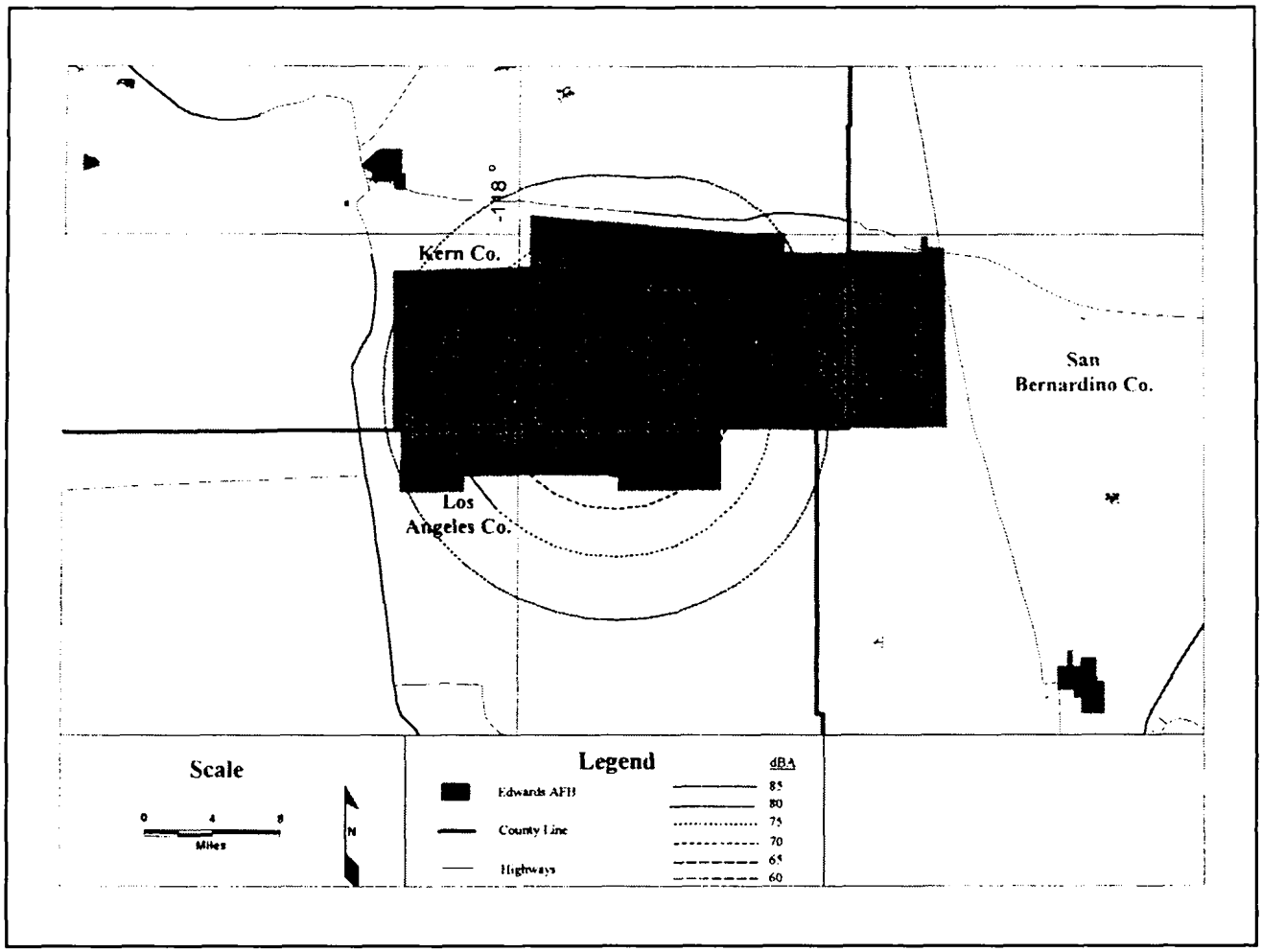


Figure 4-23. Maximum A-Weighted Rocket Noise Contours for Launch from Space Port 2000 to Dugway.

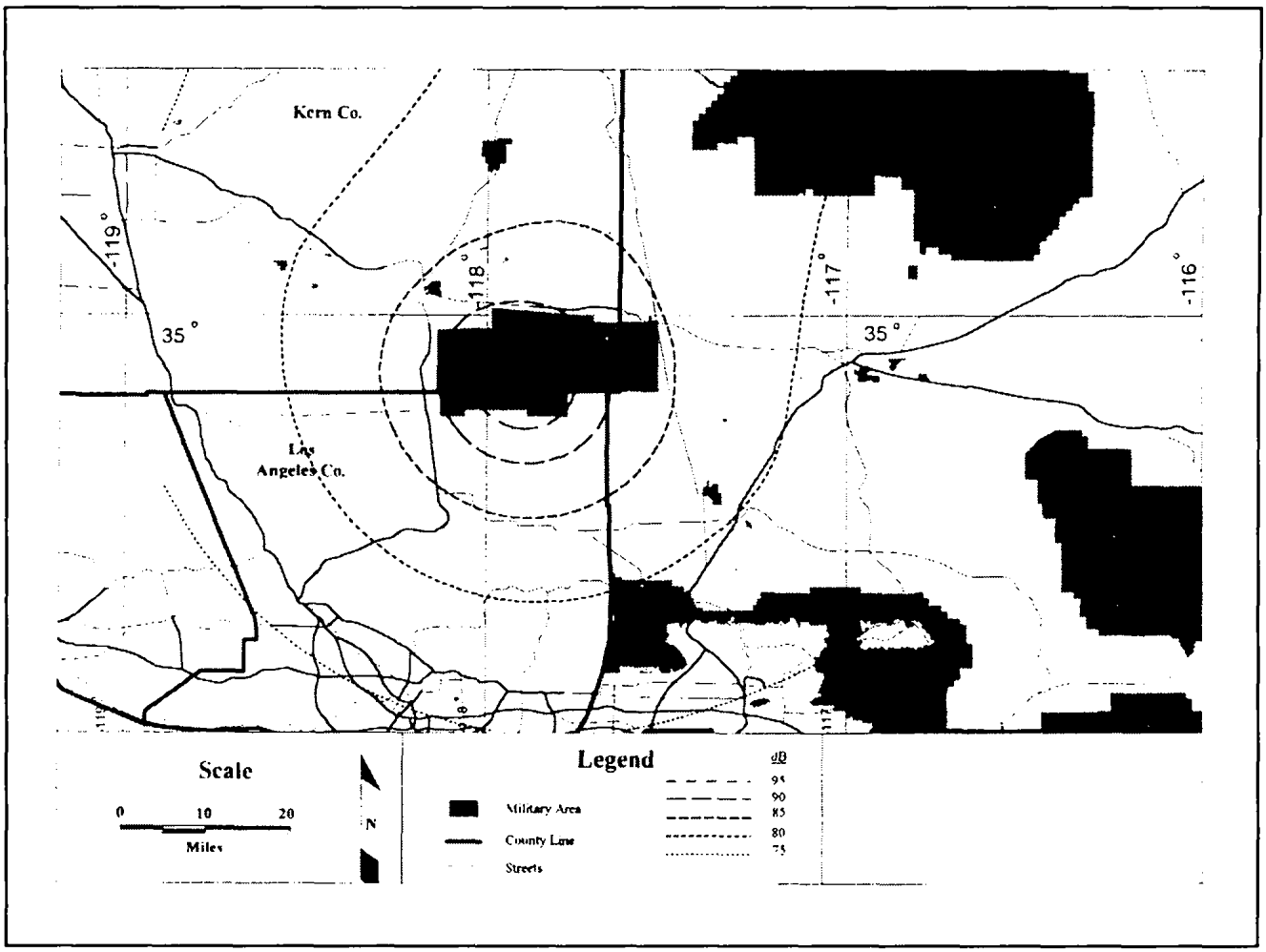


Figure 4-24. Maximum Overall Rocket Noise Contours for Launch from Space Port 2000 to Malmstrom.

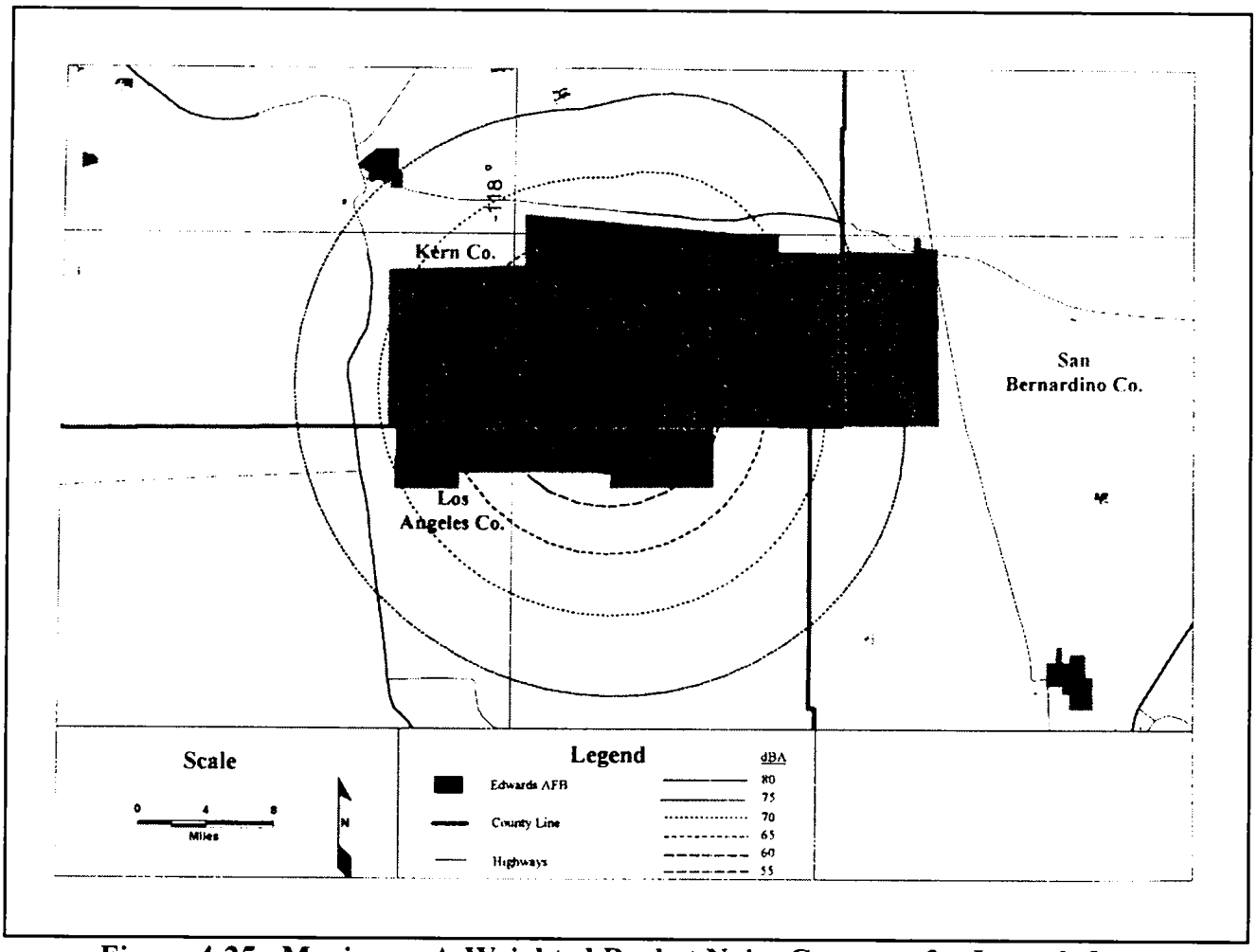


Figure 4-25. Maximum A-Weighted Rocket Noise Contours for Launch from Space Port 2000 to Malmstrom.

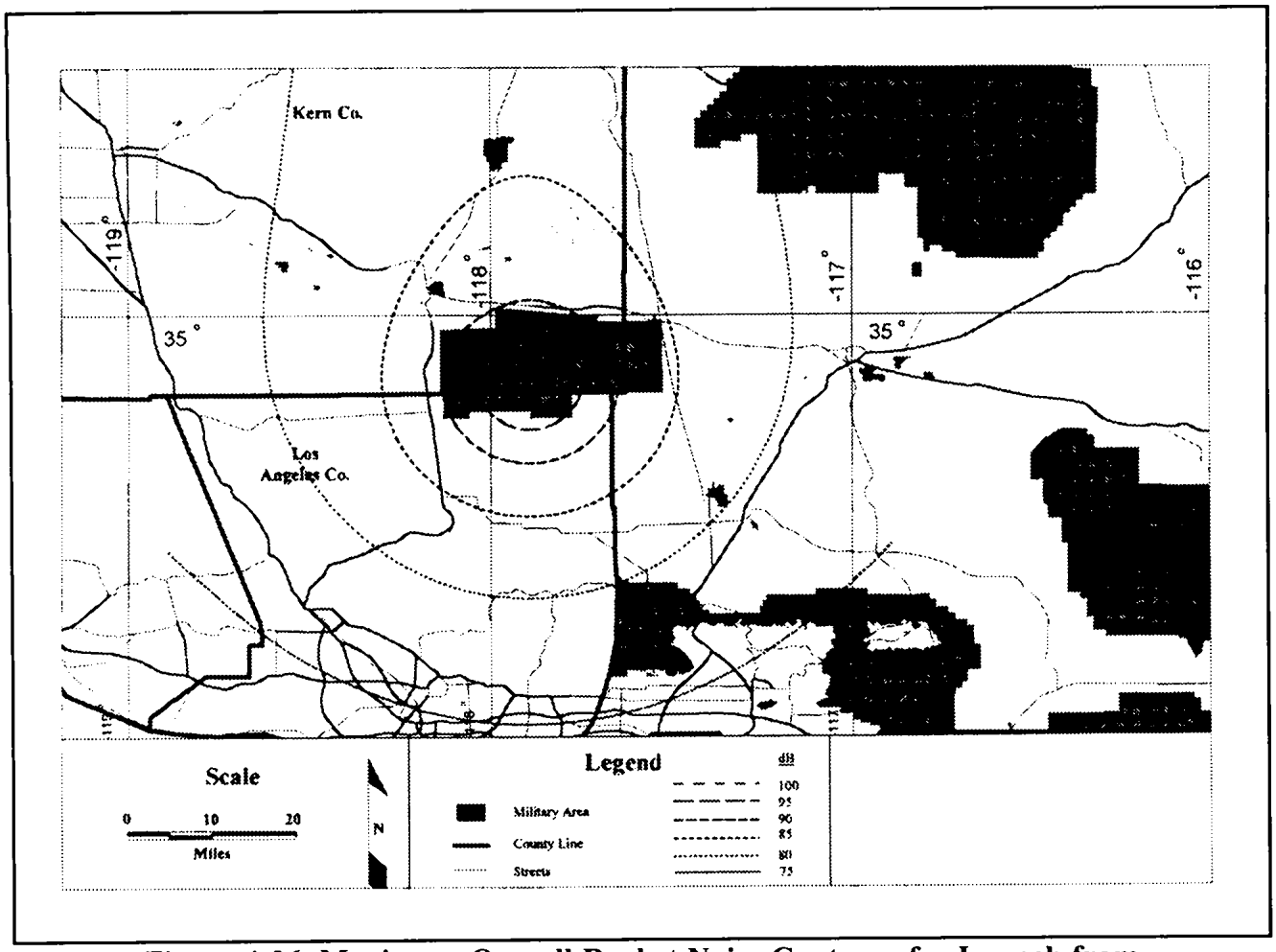


Figure 4-26. Maximum Overall Rocket Noise Contours for Launch from Space Port 2000 to Moses Lake.

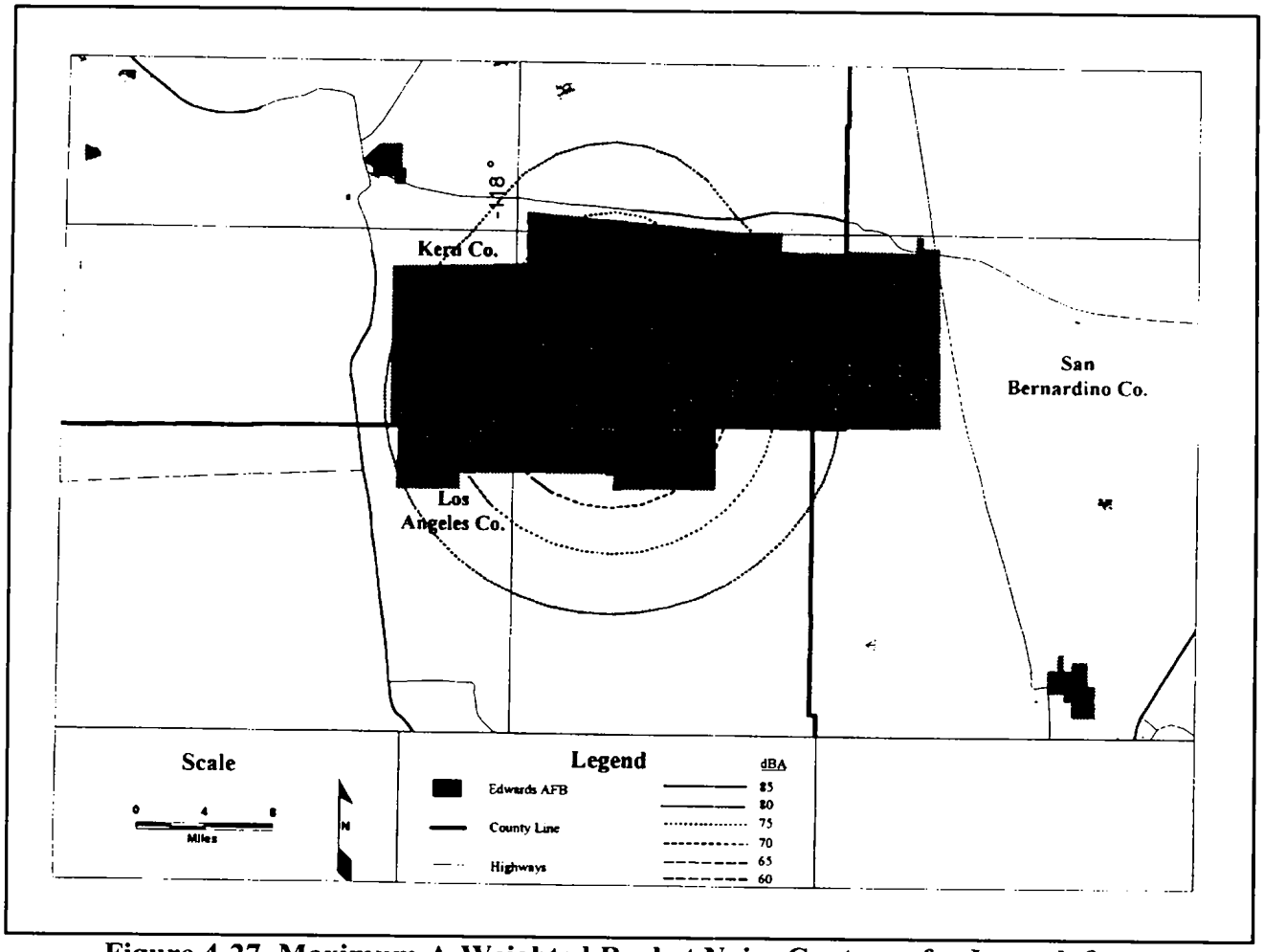


Figure 4-27. Maximum A-Weighted Rocket Noise Contours for Launch from Space Port 2000 to Moses Lake.

Acoustic Focusing

Another important factor that determines the acoustic environment is acoustic focusing due to certain atmospheric conditions. This effect is related to the refraction or "reflection" of the acoustic energy as it propagates (moves) through the atmosphere. Refraction occurs when meteorological conditions of temperature and winds are such that the speed of sound increases with increasing altitude. This condition refracts the sound energy, resulting in higher levels at a given point than those that would otherwise be expected. Generally, for liftoff/static test conditions, the speed of sound profile characteristics of only the lower atmosphere [altitudes less than 4,900 to 10,000 m (16,000 to 32,000 ft)] are effective in returning sound energy to the ground. Experience shows that sound pressure levels in the farfield can increase in some areas on the order of 20 dB because of atmospheric refraction effects. Acoustic focusing is not modeled in the launch/static test and ascending rocket noise predictions in this report. Because of the ever-changing meteorological conditions with respect to time and space, it is virtually impossible to predict the effects of acoustic focusing without knowing the atmospheric conditions during the flight.

Overview of Sonic Booms

The X-33 spaceplane would fly supersonic velocities over long distances (i.e., more than 800 km (500 mi)). Therefore, areas overflown would experience the pressure wave generated by the spaceplane, generally referred to as a sonic boom. Good summaries of sonic boom data are presented by Plotkin (1989) and by Maglieri and Plotkin (1991). In general, the amplitude, duration, and location of a sonic boom are functions of the spaceplane shock signature (shape), trajectory, and atmospheric conditions. The sonic boom environment for the ascent portion of the flight is also influenced by the rocket exhaust plume size and shape. To better define the shock signature of the X-33 vehicle, computational fluid dynamics analyses were performed by NASA/MSFC. The results of these analyses were incorporated into the sonic boom model, PCBoom3 (Wyle 1996). The shock signature of the rocket exhaust plume was calculated by combining dimensional and aerodynamic parameters from a universal plume model (Jarvinen and Hill 1970) with blunt body sonic boom theory (Tiegerman 1975). The nominal trajectory simulations were used for vehicle flight conditions. Trajectories for the X-33 were supplied by Lockheed-Martin, Dryden, and MSFC. The sonic boom ascent analyses used Edwards' average annual temperature and wind profiles (temperature and wind vectors at increasing altitudes) (Johnson 1993). The reentry atmospheric conditions would depend on the vehicle landing location.

Sonic booms are commonly associated with structural damage. Most damage claims are for brittle objects such as glass and plaster. Table 4-6 summarizes the threshold of damage that might be expected at various overpressures. There is a large degree of variability in damage experience, and much damage depends on the pre-existing condition of a structure. Breakage data for glass, for example, spans a range of two to three orders of magnitude (100 to 1,000 times) at a given overpressure. While glass can suffer damage at low overpressures (see Table 4-6), laboratory tests of glass (White 1972) have shown that properly installed window glass will not break at overpressures below 0.50 kPa (10 psf) even when subjected to repeated booms.

Table 4-6. Possible Damage to Structures From Sonic Booms (Haber/Nakaki 1989).

Sonic Boom Overpressure Nominal kPa (psf)	Type of Damage	Item Affected
0.02 - 0.10 (0.5 - 2) Compares to piledriver at construction site	Cracks in plaster	Fine; extension of existing; more in ceilings; over door frames; between some plaster boards.
	Cracks in glass	Rarely shattered; either partial or extension of existing.
	Damage to roof	Slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail hole.
	Damage to outside walls	Existing cracks in stucco extended.
	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass; e.g., large goblets can fall and break.
	Other	Dust falls in chimneys.
0.10 - 0.20 (2 - 4) Compares to cap gun or firecracker near ear	Glass, plaster, roofs, ceilings	Failures show which would have been difficult to forecast in terms of their existing localized condition. Nominally in good condition.
0.20 - 0.50 (4 - 10) Compares to handgun as heard at shooter's ear	Glass	Regular failures within a population of well-installed glass; industrial as well as domestic greenhouses.
	Plaster	Partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured, or very old plaster.
	Roofs	High probability rate of failure in nominally good state, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Walls (out)	Old, free standing, in fairly good condition can collapse.
	Walls (in)	Inside ("Party") walls known to move at 10 psf.
> 0.50 (> 10) Compares to fireworks display from viewing stand	Glass	Some good glass will fail regularly to sonic booms from the same direction. Glass with existing faults could shatter and fly. Large window frames move.
	Plaster	Most plaster affected.
	Ceilings	Plaster boards displaced by nail popping.
	Roofs	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gale-end and will-plate cracks; domestic chimneys dislodged if not in good condition.
	Walls	Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Bric-a-brac	Some nominally secure items can fall; e.g., large pictures, especially if fixed to party walls.

Carpet Booms

The most common description of a sonic boom is for an aircraft in steady-level supersonic flight. Shock waves from the aircraft form a conical pattern that reaches the ground in a crescent-shaped region. Because of atmospheric gradients, the conical pattern is somewhat distorted, so the crescent-shaped region has a finite width across the flight track. The length of the region parallel to the flight track is, at a given instant, comparable to the length of the aircraft. The sonic boom signature (pressure vs. time) in this region is usually an "N-wave." As the aircraft moves, the

crescent-shaped instantaneous footprint moves with it, and eventually the boom impacts a "carpet," which is the length of the flight track and the width of the crescent.

A maneuvering vehicle has a more complex footprint than the simple carpet described above. However, it is common to refer to regions with nominal N-wave signatures that are not affected by focusing phenomena (discussed below) as carpet booms.

Effects of sonic booms tend to be relatively insensitive to duration, so it is most common to define boom amplitude by the peak overpressure. A person on the ground hears the shock waves. If the boom has a duration longer than the auditory time constant (70 to 125 milliseconds), the familiar double bang of each shock is heard.

Sonic booms are sometimes described on the decibel scale. The peak overpressure can be converted into a peak level, denoted by L_{pk}. L_{pk} for a 0.05 kPa (1 psf) sonic boom is 127.6 dB. As specified by CHABA (1981), the quantity used for community noise impact is the C-weighted sound exposure level, CSEL. This represents the time-integrated sound energy with C-weighting applied.

Focus Booms

When a vehicle maneuvers, situations can arise where booms generated at different times can converge simultaneously at a given location. Such concentrated regions, which have an analogy to focusing by lenses, are referred to as *focus booms* or *superbooms*. The peak pressure of a focus boom can be 2 to 5 times the pressure of a carpet boom from comparable flight conditions (Plotkin 1993). The ratio of 2 to 5 is often referred to as a *focus factor*. Focus booms are somewhat distorted, with the shock waves having a spiked shape relative to a carpet boom N-wave. The adverse impact of a focus boom with a focus factor of 5 is only 2 or 3 times the impact of a carpet boom.

The most common focus boom situation is during acceleration from subsonic to supersonic speeds in the region where the boom first reaches the ground. This region is crescent-shaped and opens down track. Its width is nearly that of the carpet boom. Its length is typically 91 m (100 yd); hence, only a small region is affected. The greatest amplitude is along the centerline. An acceleration focus always occurs when a vehicle accelerates from subsonic speed to a supersonic speed great enough for a sonic boom to reach the ground.

The next most common focus situation is a turn focus. If a supersonic vehicle turns sharply enough, the boom toward the inside of the turn would coalesce into a focal zone.

Post-Focus Booms

Focusing is most important when it occurs at the ground level. However, sonic booms can converge to focal zones above the ground. The boom propagates through these foci and can reach the ground. These *post-focus* booms are significantly attenuated relative to carpet booms. They usually reach the ground in locations that are also reached by carpet booms, and they arrive shortly after the carpet boom. When heard, post-focus booms are perceived as either rumbling or

as double "pops" that are smaller than the carpet boom's double bang. With some complex maneuvers, post-focus booms can reach the ground in regions that do not receive carpet booms.

Sonic Boom From X-33

The nominal missions of the X-33 from Haystack Butte and Space Port 2000 would exhibit ascent boom footprints typical of launch vehicles in powered mode. The rocket engine plume or exhaust is a significant contributor to the level of the boom by increasing the "effective size" of the vehicle that disturbs the atmosphere. In addition, all boom footprints have an initial acceleration focus with a characteristic forward-facing, crescent-shaped focal zone. This focus happens at altitudes of 24,000 to 27,000 m (80,000 to 90,000 ft) with a Mach number of approximately 3, at which point the vehicle has pitched over and the boom can propagate to the ground. The maximum focus boom ranges from about 0.17 to 0.5 kPa (3.5 to 10 psf). Depending on the target landing site, the focus boom reaches the ground approximately 32 to 40 km (20 to 25 mi) to the north or northeast of the base. The focal zone is narrow and transitions into a carpet boom that diminishes rapidly as the vehicle gains altitude. Within 10 to 15 seconds after the focus occurs, the carpet boom is below 0.05 kPa (1 psf). The maximum focus overpressure from the X-33 is somewhat lower than the 0.48 to 0.53 kPa (10 to 11 psf) associated with the initial acceleration focus of the SR-71 during its routine training missions (Plotkin 1993). The SR71 was designed as a reconaissance vehicle capable of hypersonic speeds that is currently used for high-speed, high-altitude aeronautical research. Launch focus booms for each landing site are discussed with overall trajectory impacts in the respective landing site impact discussions.

The noise level produced by the sonic booms can be compared to other common environmental noises. For example, distant thunder produces an overpressure of approximately 0.01 kPa (0.3 psf), and close to the lightning strike the overpressure from thunder may exceed 0.14 kPa (3.0 psf).

Noise Effects on Structures

Damage to buildings and structures from noise is generally caused by low frequency sounds. The probability of structural damage claims has been found to be proportional to the intensity of the low frequency sound. One claim in 10,000 households is expected at a level of 103 dB; one in 1,000 households at 111 dB; and one in 100 households at 119 dB (Figure 4-28). The liftoff/static engine tests noise model estimates the highest levels to structures near the launch pad. Figure 4-29 compares the maximum liftoff noise spectrum 6 km (3.7 mi) from the launch pad (closest distance to off-range property) to the criteria for damage to residential structures (Sutherland 1968). These data show noise-induced damage to structures outside Edwards property boundaries would be minimal. The ascending rocket noise levels are similar to the liftoff/static engine test levels; therefore, they would have minimal damage to structures outside Edwards boundaries.

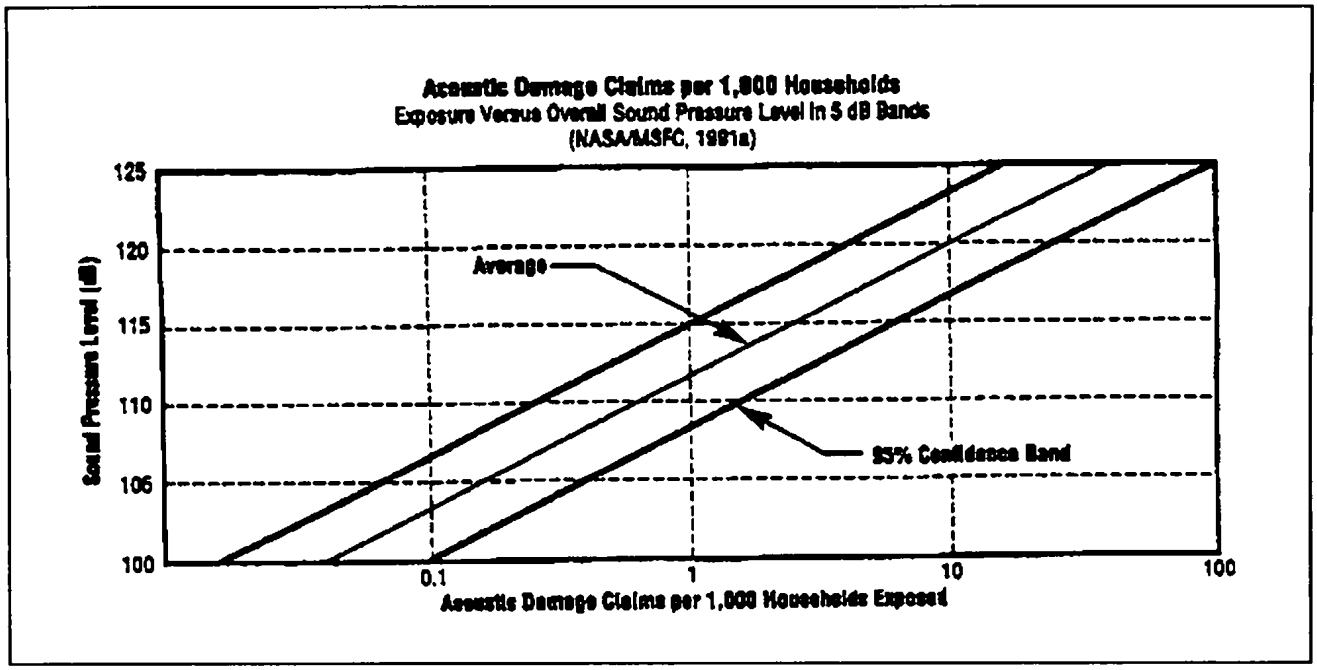


Figure 4-28. Structural Damage Claims versus Overall Sound Pressure Level.

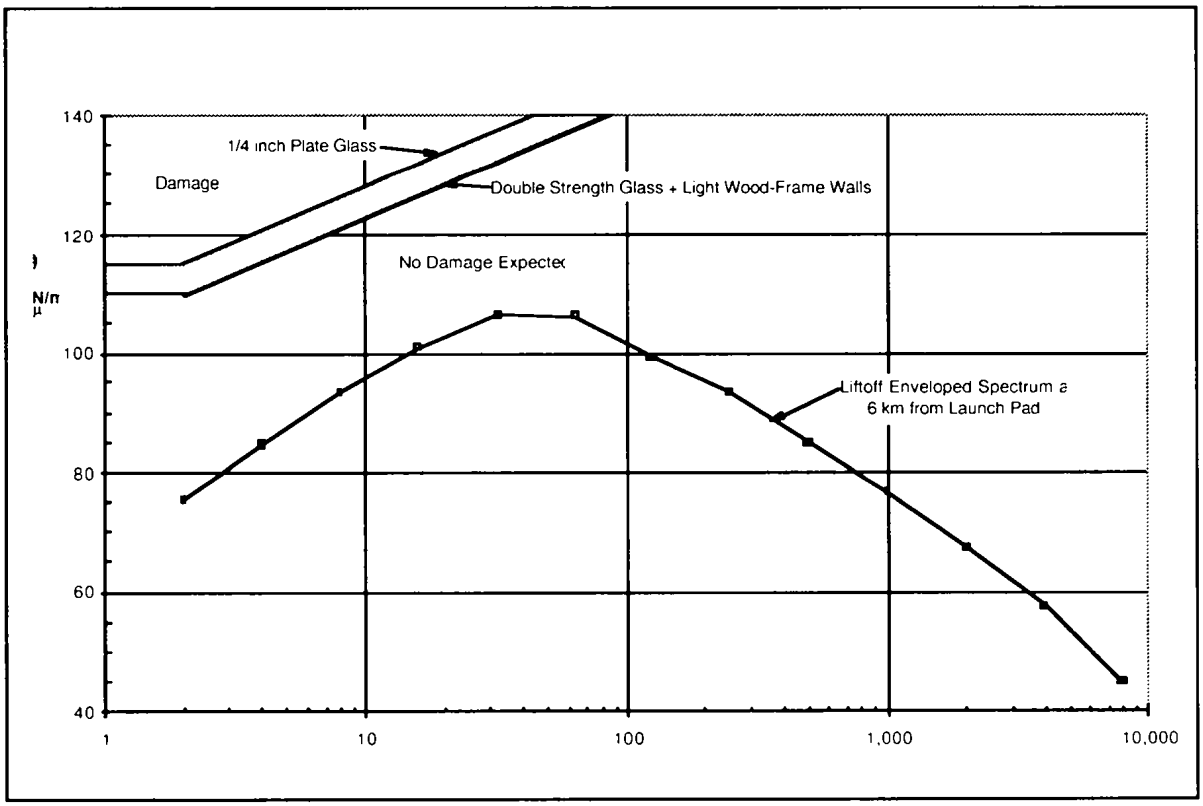


Figure 4-29. Maximum Sound Pressure Level Spectra 6 km (4 mi) from Launch Pad Compared to Structural Damage Criteria for Acoustic Excitation of Residential Structures.

Most of the area exposed to sonic booms from the X-33 would be below 0.1 kPa (2 psf), with a small probability of damage. Boom amplitude would exceed this in limited areas associated with focusing, with maximum overpressures in the 0.50 kPa (10 psf) range. Because of the limited area involved in a focal zone, adverse impact would depend on the relation of the focal zones to sensitive receptors.

Speech Interference

Speech interference (conversation disruption) can occur at ambient noise levels above 60-70 dBA. This effect means that people engaged in conversation outdoors have to speak louder or move closer together to continue the conversation when the ambient noise level is above 60 dBA. In some locations, the level would be above 70 dBA during tests or flight and conversation would be momentarily interrupted. However, test and flight noise would be infrequent and of short duration (2 to 3 minutes); therefore, the impact of the disruption would be minimal.

Sleep Interference

Interference with sleep can occur at levels as low as 45 dBA. The X-33 flight tests would occur during daytime. Other components of the test program may occur at any hour of the day. Because most people sleep at night, daytime testing activities would not interfere with sleep patterns. People who sleep during the day must normally learn to sleep with a greater level of exterior noise. However, at levels approaching 95 dBA, some interference to daytime sleepers is also expected. Because of the infrequency of tests, the short duration, and small number of daytime sleepers, the impacts would be minimal.

Task Interference

Due to startle effects, some task interference may occur from sonic booms. Rocket engine exhaust noise may also cause some task interference in areas very close to Edwards. Because the tests and flights would be very infrequent, the impact would be minimal.

Hearing Loss

Federal guidelines for maximum noise exposure and the duration of a noise event are shown in Table 4-7. Exposure to impulsive noise should never exceed 140 dB peak sound level (29 CFR 1910.95). Federal workplace standards for protection from hearing loss allow a time-averaged level of 90 dBA over an 8-hour work period, or 85 dBA averaged over a 16-hour period. Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4000 Hz, after a 40-year exposure) suggests a time-average sound level of 70 dBA over a 24-hour period. Although the maximum noise level of approximately 85 dBA can be expected beyond Edwards boundaries, the duration of these events would be less than 1 minute. The maximum L_{dn} off-base would be approximately 55 dBA.

Table 4-7. OSHA Permissible Noise Exposures Without Hearing Protection.

Duration (hours/day)	Sound Level (dBA)
8.0	90
6.0	92
4.0	95
3.0	97
2.0	100
1.5	102
1.0	105
0.5	110
0.25	115

Health

Nonauditory health effects of long-term noise exposure where noise may act as a risk factor have never been found at levels below federal guidelines to protect hearing loss. Most studies attempting to clarify such health effects have found that noise exposure levels established for hearing protection also protect against potential non-auditory health effects, at least in workplace conditions. A good scientific summary is contained in the lead paper of the National Institutes of Health Conference on Noise and Hearing Loss held January 22-24, 1990, in Washington, DC.

4.1.13 Transportation

Edwards has access to major roads as well as good internal roadway networks. Local roads adjacent to the base boundary are simply tracks in the desert, subject to infrequent use and little maintenance. The small number of people involved in the test program would have very little effect on road congestion. Space Port 2000 would require road improvements to approximately 5 km (3 mi) of existing roadway. A new road would have to be constructed linking the existing Mars Boulevard to the Haystack Butte launch site (approximately 1.6 km (1.0 mi)). Up to five new turnout lay-by areas must be placed along this route to allow safe passage of the vehicle (Figure 4-30). Based on the current proposed launch sites, there would be minor impact at Edwards due to needed substantial roadway improvements. No public roads would be closed as a result of the X-33 Program.

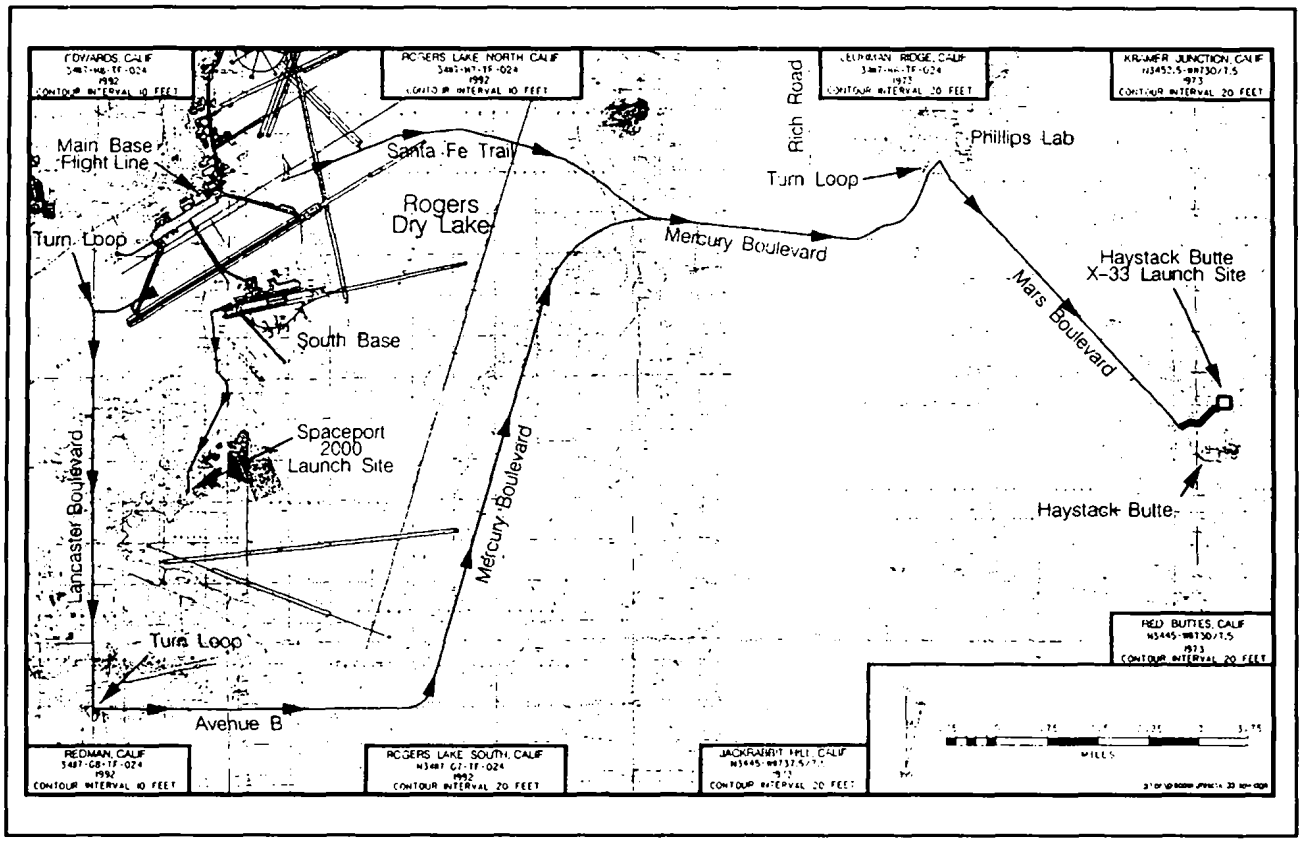


Figure 4-30. Proposed Towways to the Haystack Butte Launch Site.

4.1.14 Population and Employment

Many military and all civilians who work at Edwards reside off base. Most live in the communities of Lancaster, Palmdale, Rosamond, Mojave, California City, North Edwards, Boron, Tehachapi, Bakersfield, Barstow, Victorville, and adjacent areas. The socioeconomic region of influence (ROI) for Edwards is the area within approximately an 81 km (50 mi) radius of the Main Base area. The estimated 1994 ROI population is 444,214 persons (EAFB 1994C). The X-33 Program would produce only one test spaceplane at an existing aerospace manufacturing plant (Lockheed-Martin Skunk Works, Palmdale, California). In addition, a portion of the hardware would be developed at other locations around the country. The Program is expected to employ no more than 200 to 250 people on-site at EAFB, the majority of whom would be current residents. The number of dependents is estimated to be approximately 588 (assuming an average of 2.94) for a total of 788 persons. Based on these estimates, the X-33 Program would contribute less than 0.1 percent to the ROI population; therefore, impacts would be minimal.

Approximately 100 to 150 employees would be present during site preparation activities and 200 to 250 for operational activities. Site preparation activities are expected to last 18 months or less. The duration of the flight test program would be approximately 12 months. Edwards employed 13,443 persons in 1995 (EAFB 1995D), creating approximately 16,375 secondary jobs off base. Total aggregate employment for the ROI was 25,337 jobs. The unemployment rate was 9.3 percent. The result would be a small, short-term increase in employment of

approximately 0.8 percent, providing a minimal short-term positive economic impact to the surrounding area.

4.1.15 Land Use

All X-33 Program activities are similar to past and current Edwards operations. Site preparation activities are relatively small as described in Section 2.1.4. Edwards has also reserved areas for future expansion; therefore, minimal impacts on land use are anticipated.

The Environmental Management, Natural Resources Section (AFFTC/EMXC) is developing an Integrated Natural Resources Management Plan at Edwards. This plan would integrate all aspects of natural resources management with each other and the Base mission. Currently, there is no natural resource management unit designated at the Space Port 2000 site. A majority of the Haystack Butte site is located in Zone 1 Management Area for desert tortoise and was designated by the U.S. Fish and Wildlife Service as critical habitat in 1994.

4.1.16 Snow Avalanche

No snow avalanche-prone areas have been identified in the vicinity of either proposed launch site or initial trajectories in California. Therefore, no impact is expected.

4.2 Proposed Landing Sites

4.2.1 Silurian Lake, California

Up to three X-33 landings would occur at this site over a four-month period to flight test the vehicle at a speed of Mach 4 (2,900 mph). Also required would be the landing of the Boeing 747 to air ferry back the X-33 to Edwards. No refueling of the Boeing 747 would be required in such a short distance. The exact size of the lake bed used would depend on the conditions at the time of landing and the status of the vehicle. Proposed layout for X-33 landing operations is provided in Appendix I. A 3,050 m (10,000 ft) by 92 m (300 ft) landing area would be delineated to the maximum extent possible on a hardened, level, and contiguous area of the lake bed to minimize leveling and compaction requirements and provide landing conditions suitable for the weights and touchdown pressures on landing of the X-33 and Boeing 747 and also the weight of the two aircraft mated together on takeoff. All leveling and fill of substandard areas of the landing and takeoff area as well as minor impacts in staging and tracking areas would be detailed in a Section 404 permit application to the U.S. Army Corps of Engineers through the Bureau of Land Management. Approximately 10 to 15 percent of the landing area may require minimal leveling, fill and/or compaction. However, it is expected that substantially less area of the lake bed would require disturbance. Fill from external areas to the lake bed would be minimized or eliminated by redistributing lake bed sediments. Up to 75 on-site personnel would be required to conduct X-33 landing activities.

Two to seven days in advance of landings preparation of temporary support infrastructure would be required such as: (1) positioning of ground support equipment; (2) mobile tracking stations and command center consisting of four trailers with appropriate equipment, generators, antennae and other communications transmitting/receiving equipment; two mobile cranes for lifting and mating the X-33 to the back of the Boeing 747; tow truck; staging area for general purpose equipment, LH_2/LOX venting equipment, high pressure cylinders of inert helium gas, and monitors, generators, lighting; portable human support services, potable water, portable toilets, etc.; temporary striping of the lake bed with a nontoxic paint to facilitate safe landing of the Boeing 747; activation of the 24-hour security surveillance for a 8 km (5 mi) radius of the lake bed (no road closure); landing and securing of the Boeing 747; and positioning of minimum emergency equipment such as ambulance(s) and fire truck(s). A 3 by 3 m (10 by 10 ft) concrete slab to support the 4 m (12 ft) radar antenna would be required for the mobile range tracking equipment. Approximately 8 other areas requiring 0.1 ha (0.3 ac) of level hard-packed or gravel preparation for placement of tracking equipment would be required. The area to be affected would cover up to 1.0 ha (2.5 ac), scattered over approximately 27 ha (68 ac) as shown in Appendix I.

Approximately one hour in advance of the scheduled landings with coordination and permission of the California Department of Transportation, security perimeters would be expanded to block all cars, trucks, and other vehicles not authorized for egress by the X-33 Program. Also up to five helicopters would be used to verify the secured area. Road closure would be at the junction of State Highway 127 and Saratoga Springs Road, to the north of Silurian Lake, and extend for approximately 40 km (25 mi) beginning at a point just north of Baker, California, 24 km (15 mi) south of the lake bed and would remain in force 1.5 to 4 consecutive hours. A smaller section of

the road (approximately 1.6 km (1 mi)) in the immediate vicinity of the lake bed would be closed for 15 to 30 minutes in order to land and takeoff the Boeing 747. Escorts for critical needs such as medical emergencies and perishable commodities would be available at both the north and south roadblocks. At the conclusion of the short-range test flights, all semi-permanent fixtures would be removed and area restoration and cleanup performed.

The following assumptions have been made in determining the level of impact associated with Silurian Lake. Due to the preliminary and conceptual design of landing site operations, the assumptions below are intended to provide conservative determination of the level of impacts:

- 50 to 75 onsite personnel
- personnel onsite for up to three 1-week intervals over a 4-month period
- baselined for 3 landing/retrieval operations requiring approximately 12 hours of intensive use of the lake bed per operation
- X-33 would land with up to 680 kg (1,500 lb) of residual LH_2 and up to 340 kg (750 lb) of residual LOX
- no refueling of the 747 ferry aircraft necessary for return to Edwards
- approximately 10 to 15 percent of the landing area could be subject to grading.

4.2.1.1 Site Infrastructure

Preparation of support infrastructure would be required beginning 2 to 7 days in advance of landing. Permission for the use of the lake bed and adjacent areas for landing the X-33 would be sought through application by Lockheed Martin through NASA for a "Right of Way Reservation" addressing requirements of Section 507 of Federal Land Policy and Land Management Act. The application would be submitted to BLM. Advance operations include:

- positioning of ground support equipment: support equipment would be staged on the west side of the lake bed and moved to the south portion of the lake bed after the vehicle has landed; the exact size of the lake bed to be used would depend on the conditions at the time of landing and the status of the vehicle
- mobile tracking station and command center consisting of four trailers with appropriate equipment, generators, and antennae and other communications transmitting/receiving equipment
- two mobile cranes for lifting and mating the X-33 to the back of Boeing 747
- tow truck
- staging area for general purpose equipment, LH_2/LOX venting equipment, high pressure cylinders of inert helium gas, and monitors, generators, lighting
- portable human support services, potable water, portable toilets, etc.
- temporary striping of the lake bed with a nontoxic paint to facilitate safe landing of the Boeing 747
- activation of 24-hour security surveillance at the immediate area of the lake bed (no road closure)
- landing and securing of the Boeing 747

- positioning of minimum emergency equipment such as ambulance(s) and fire truck(s).

Approximately 1 hour in advance of scheduled landing, the security zone clear of non-X33 personnel would be expanded to block all cars, trucks, and other vehicles not authorized for egress on State Highway 127, due to its proximity to the lake bed by the X-33 Program. An encroachment permit issued by the California Department of Transportation would be required in order to restrict traffic on this highway.

Closure of State Highway 127 would extend for approximately 40 km (25 mi), beginning at a point just north of Baker, California, 24 km (15 mi) south of the lake bed to a site approximately 16 km (10 mi) north of the lake bed. Up to five helicopters would be used to verify security. The X-33 Program anticipates that this level of security, including road closure, would remain in force for 1.5 to 4 hours per landing.

Landing operations would include:

- landing of the X-33 with up to 680 kg (1500 lb) of residual LH_2 and up to 340 kg (750 lb) of residual LOX
- venting of residual LH_2/LOX
- inert gas purging of X-33 tanks with helium for final safing
- towing the Boeing 747 to area for lifting X-33 and mating operations
- towing the Boeing 747 with X-33 to takeoff position
- takeoff of the Boeing 747 with X-33 for return to Edwards.

As soon as the X-33 lands, autosafes, and is towed to a place on the lake bed away from the road, the road would be reopened. The road would also be closed for 15 minutes twice for landing and takeoff of the Boeing 747. Closure for this activity would only occur for approximately a one mile segment of the road immediately in the vicinity of the lake bed. All equipment would be packed and expeditiously returned to Edwards. Temporary fencing and semi-permanent fixtures would be left until the X-33 Program has evaluated flight data and determined that use of the lake bed is no longer required. From preparation of first flight until determination of final flight is anticipated to last no longer than 4 months.

At conclusion of use, all semi-permanent fixtures would be removed and area restoration and cleanup performed in accordance with the BLM requirements. The X-33 Program would strive to minimize disturbance and restore the site to its original state as practical and feasible. Therefore, impact is expected to be minimal.

Landing Area

A 3,050 m (10,000 ft) by 91 m (300 ft) landing area would be delineated to the maximum extent possible on a hardened, level, and contiguous area of the lake bed to minimize leveling and compaction requirements and provide landing conditions suitable for the weights and touchdown pressures on landing of the X-33 and Boeing 747 and weight of the two aircraft mated together on takeoff. All leveling and fill of substandard areas of the landing and takeoff area as well as minor

impacts in staging and tracking areas would be detailed in a 404 permit application to the U.S. Army Corps of Engineers. It is anticipated at this time that approximately 10 to 15 percent of the landing area may require minimal leveling, fill and/or compaction. Substantially less disturbance is currently expected due to the current condition of the lake bed. Fill from areas external to the lake bed would be minimized or eliminated by redistributing suitable lake bed sediments.

Support equipment would be staged along the western portion of the lake bed. The equipment would be moved to the southern portion of the lake bed after the X-33 vehicle has landed and safing operations have begun (see Figure 2-17). The exact size and location of the area where preparation activities for hoisting the X-33 onto the Boeing 747 aircraft and related operations would vary depending on the condition of the vehicle. However, all such operations would occur solely on the lake bed. No other features would be affected.

The mobile range tracking equipment would be staged on the eastern edge of the lake bed, just off the lake bed itself (see Figure 2-17). Staging includes placement of a 3-m by 3-m (10 ft by 10 ft) concrete slab to support the 4 m (12 ft) radar antenna. This slab would be removed following completion of the X-33 Program. The area to be affected would cover less than 0.2 ha (0.5 ac). The habitat type affected would be creosote bush scrub. Given the small size of the affected area and the proximity to the lake bed, the impact to this habitat type within the Silurian Valley is considered minimal. Approximately 8 other areas requiring 0.1 ha (0.3 ac) of level hard-packed or gravel preparation for placement of tracking equipment would be required. The area affected would cover up to 1.0 ha (2.5 ac) scattered over approximately 27 ha (68 ac) as shown in Appendix I.

The lake bed area would be vacated prior to the next rainy season, allowing for natural ponding and sedimentation to occur and final restoration of the lake bed through this natural cycle of rainwater and runoff ponding, drying and hardening. Uneven spots are also filled in annually through the natural process of wind transporting and depositing soils from the surrounding area. Therefore, the X-33 Program is expected to have a minimal impact on the lake bed during operations, and through natural processes, the lake bed would be restored to its natural state.

Water Supply and Distribution

Approximately 8,520 L (2,250 gal) per day of potable water would be transported by tanker truck to the site for employee consumption and use everyday that X-33 employees are stationed on site. Vehicle cleaning for preparation of return of the X-33 and Boeing 747 may require an additional volume of 284,000 L (75,000 gal) of potable-quality water for cleaning, dust control, etc.

Wastewater

Portable tanks would be available to capture any water used in cleaning operations that may be contaminated with materials undesirable for release on the lake bed. The tanks would be transported to the nearest suitable waste disposal facility. This procedure is considered a precautionary measure, and it is not anticipated that the wastewater would contain hazardous

materials or chemicals requiring dispensation through manifesting and disposal under the Resource Conservation and Recovery Act procedures for hazardous waste.

Electricity

Portable generators would be brought in for supplying electrical power needs. Use of the equipment would be required for a maximum period of 9 days per flight. See Section 4.2.1.4 for further details of air quality impacts and descriptions of equipment.

Communications

Portable range control, X-33 tracking and telemetry equipment would be stationed at various places along the X-33 flight path. These portable stations would be housed in vans and similar vehicles that would be parked along existing roadways during test flights. Portable communications equipment would be used for communications at Silurian Lake and to off-site Program personnel. This equipment would be installed in the same disturbed area along with the tracking equipment. Therefore, minimal impact is expected.

Fuel

No refueling of the Boeing 747, X-33, helicopters, or vehicles would be required at the lake bed. Approximately 416 L (110 gal) of diesel fuel may be maintained at the lake bed for refueling generators. The diesel fuel would be stored in barrels within temporary diked areas to contain 110 percent of the maximum volume in case of spills. The dikes would be made of plastic cover and sandbags which would be removed and the area visually surveyed for verification before final conclusion of the project. Therefore, minimal impact is expected from fuel operations.

4.2.1.2 Hazardous Materials and Hazardous Waste

The primary hazardous materials associated with the X-33 landing would be the residual LH_2 and LOX. Safing activities would be accomplished by gradually venting the propellants to the atmosphere followed by purging of the tanks with inert helium gas. All three gases are normal constituents of the atmosphere.

Generation of hazardous waste at Silurian is not projected. However, provisions for small quantities would be made available at the site should the need arise and manifesting, transportation, and disposal would be accomplished using vendors permitted through proper State regulatory authorities for compliance with the Resource Conservation and Recovery Act. Therefore, minimal impact is expected.

Propellant Safety

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, the safing and propellant venting operations would be sited in accordance with the explosive safety quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. Any visitors would be restricted to safe areas.

Transportation of Hazardous Materials

All transportation of hazardous materials required for landing site operations would use approved containers and procedures conforming to Resource Conservation and Recovery Act, Department of Transportation, and applicable state regulations. Transportation of hazardous materials are expected to use trucks and surface roads. Therefore, no impacts would be expected.

Contamination

There is no known or existing contamination at Silurian Lake. Therefore, no impacts are expected.

4.2.1.3 Solid Waste

Minimal amounts of solid waste in the form of wastepaper, food refuse, etc., are expected to be generated at Silurian. The X-33 Program personnel would conscientiously keep all trash and refuse picked up and containerized in waste drums for transportation and disposal at nearest permitted solid waste landfill. The Fort Irwin Land Treatment Site, located on Fort Irwin Road near Fossil Bed Road, appears to be the closest suitable landfill for these wastes. Therefore, minimal impact is expected.

4.2.1.4 Air Quality

A Conformity Analysis, provided, in Appendix C was prepared for projected activities on and around Silurian Lake for proposed X-33 activities to determine whether or not proposed activities would potentially be in nonconformance with the State Implementation Plan required by the Clean Air Act. The conformity analysis was based on two landings. The emissions presented in this section have been extrapolated to accommodate the new baseline of three potential landings. A comparison of the X-33 emissions projections for 1997 through 1999 with *de minimis* regulatory threshold levels is provided in Table 4-8. All projected emissions are less than these thresholds, and thus no conformity determination is required, and minimal impact to air quality is expected. Air permits for operation of portable internal combustion equipment would be obtained as required by the respective air quality district. Site preparation of the lake bed which may including grading, smoothing, and hardening could result in the additional release of 0.12 metric tons per year (0.13 tpy) of PM_{10}, particulates, in 1999. The additional PM_{10} releases to those attributable to operations would not affect the conformity determination.

Table 4-8. Emissions Summary for Silurian Lake.

Year	Estimated Emissions metric tons/year (tons/year)		
	Nitrogen Oxides (NO_X)	Volatile Organic Compounds (VOC's)	Particulate Matter (PM_{10})
1997	N/A	N/A	no activity
1998	N/A	N/A	no activity
1999	N/A	N/A	11.1 (12.26)
de minimis regulatory threshold	N/A	N/A	91.0 (100) *
Conformity Determination Required?	NO	NO	NO

Classification: O_3 (attainment); PM_{10} (moderate non-attainment)
Note: Conformity determination regulations not applicable (N/A) for "attainment" classification areas.
*13.7 (15) - Standards imposed for reasonably available control measures used by BLM and required by the Emissions Control Strategy in the California State Implementaion Plan.

4.2.1.5 Airspace and Air Traffic

The Silurian Lake flight path originates within the R-2515 military restricted airspace, achieving 18,300 m (60,000 ft) in altitude when 8.8 km (5.5 mi) downrange of the launch pad. Acceleration would continue until the X-33 achieves an altitude of approximately 32,000 m (105,000 ft) when it is at a downrange distance of approximately 30 km (18 mi). The X-33 would not re-enter airspace under 18,300 m (60,000 ft) and under control of the FAA until it is 20.8 m (13 mi) from landing (see Appendix D starting at page D-21 for trajectory details).

Flight tests to Silurian Lake would affect the military restricted airspaces of R-2515 for ascent and R-2502N (Ft. Irwin) and the Shoshone MOA for descent. Flight tests to Silurian Lake would re-enter the Shoshone MOA at an altitude of less than 18,300 m (60,000 ft) and descend in a pattern to reduce energy and speed until the X-33 safely lands on the dry lake bed. Trajectory details and flight test airspace zones which would be cleared of all aircraft is provided in Appendix D (specifically starting on p. D-21). Airspace zones recommended for clearing of all aircraft were based on a corridor whose width and length are 150 percent of the maximum zone in which the X-33 would manuever under 18,300 m (60,000 ft) on its approach to the lake bed, plus the length of the lake bed and extending 4.8 km (3 mi) beyond to accomodate a safety buffer.

General and commercial aviation can use the Military Operating Areas (MOAs) as needed using visual/instrument flight rules as described in Section 3.1.6. The X-33 would overfly the Panamint MOA and require a small zone of the Shoshone MOA to be temporarily sterile, void of all aircraft, during landing operations at Silurian Lake.

Sterile airspace, void of aircraft, from the FAA would be applied for by the X-33 Program (specifically, Lockheed Martin) in order to be able to have clear airspace at Silurian Lake during landings. The temporary restriction on this airspace would be imposed beginning one hour prior to launch time and remain in effect until the X-33 has completed its test flight. A test flight would require approximately 10 minutes. Once the X-33 is readied for launch, the launch would occur no later than two hours from scheduled launch time or the flight would be delayed a minimum of 24 hours. Therefore, restriction on aviation in the vicinity of Silurian would be approximately 1.5

to 4 hours per launch. The temporary sterile airspace would be activated one or more times (estimated no more than three) per launch for up to three launches. The AFFTC would coordinate approval of use of affected military restricted and shared use airspace.

If the FAA approves the application for sterile airspace, NOTAMs or Altitude Reservations would be issued. The application for the NOTAMs or Altitude Reservations would provide the FAA and military all pertinent information related to the test flights, such as dates and times, duration, altitudes along entire flight path, exact route, landing points, speeds; and latitude and longitude of start, apex, and stop points. The NOTAMs or Altitude Reservations would affect several Air Route Traffic Control Centers. Therefore, early coordination would be important. Upon FAA approval, the affected state aviation representatives would be notified. Other contacts who would also be notified would include the Aircraft Owners and Pilots Association and the Air Transport Association (ATA). Impact to airspace is expected to minimal.

4.2.1.6 Biological Resources

Vegetation

Silurian Lake has no existing infrastructure and several temporary structures and areas would be established on or near the lake bed. The lake bed is flat, with extremely saline or alkaline soil, and little vegetation. The area surrounding the lake bed is classified as Mojave creosote bush scrub. Impacts include the loss of scrub habitat to development of the landing support areas, and disturbance associated with the preparation of the lake bed for X-33 landings. Given that landing site preparation would be confined to the lake bed as much as possible, and the paucity of vegetation in the lake bed, these effects are expected to be be minimal.

Wetlands and Floodplains

The Silurian dry lake bed is at a lower elevation than the surrounding landscape. Runoff water temporarily collects on the lake bed after heavy rains, bringing with it a deposition of fine silts, clays, salts, and minerals. The lake bed has not been formally evaluated and classified as a jurisdictional wetland by the U.S. Army Corps of Engineers. Due to the time and effort required to make a formal determination, the X-33 Program has elected to assume that the lake bed would be a jurisdictional wetlands and apply for a Section 404 Permit under the Clean Water Act for any disturbance and fill of the lake bed. The permit would be prepared by Lockheed Martin and submitted to the U.S. Army Corps of Engineers through BLM. Grading the lake bed is not anticipated unless the condition of its surface becomes unsuitable for landing because of rain and use by off-road vehicles, leaving ruts. Some compaction of the sand would be done, particularly in the 46 m^2 (500 ft^2) staging area where the X-33 would be prepared for return to Edwards on the Boeing 747 (see figure 2-17).

The closest wetland area with permanent water is at Salt Creek, approximately 10 km (6 mi) northwest of the lake bed. It supports riparian vegetation and wildlife, and is a BLM-designated Area of Critical Environmental Concern. The X-33 project is not expected to impact this wetland because of its distance from the landing site.

Wildlife

The lake bed is essentially devoid of vegetation and does not provide permanent habitat for wildlife. There is occasional use of the area by large mammals and migratory birds after heavy rains, and some species would migrate across the lade bed with it is dry. The Mojave creosote bush scrub immediately adjacent to the lake bed may provide habitat for the wildlife species listed in Table 3-5. Impacts to the wildlife would involve the permanent loss and disturbance of scrub habitat from preparation of the landing support facilities.

Sonic booms from the X-33 at pressures between 0.02 an 0.53 kPa (0.5 and 11 psf) as discussed in Section 4.2.1.12 would occur along the flight track and descent of approximatley 64 km (40 mi). Impacts from sonic booms to wildlife in natural situations are extremely difficult to study or predict. In general, mammals and raptors do not panic when exposed to sudden intense noise; whereas, waterfowl are more likely to injure themselves or their young when suddenly frightened (Bowles 1997). After fewer than five exposures, most animals become habituated to the noise and show little response. Animals that are accustomed to other human disturbances are less likely to panic. In research conducted on pronghorn antelope, Rocky Mountain elk, and bighorn sheep, exposure to sonic booms caused a slight rise in heart rate after the initial disturbance (USAF 1992B). The startle responses decreased for subsequent booms and were soon less than those evoked by humans walking into the animal pens, or by bees and biting flies bothering the animals. In a study on cliff-nesting raptors exposed to the noise from underground nuclear explosions, damage to or desertion of nests was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). Although quantitative information for most species is lacking, the available data indicate that exposure to sonic booms in the pressure ranges expected from the X-33 would not likely have deleterious effects on wildlife populations.

4.2.1.7 Threatened, Endangered, and Sensitive Species

Vegetation

Six species of plants that could potentially occur in the habitat adjacent to the Silurian Lake bed have been designated for protection by the California Native Plant Society (CNPS). Three of these, the New York mountains cryptantha (*Cryptantha tumulosa*), the sand linanthus (*Linanthus arenicola*), and the small-flowered androstephium (*Androstephium breviflorum*) are federal species of concern. The other three species, Coso mountains lupine (*Lupinus magnificus var. glarecola*), striped horsebrush (*Tetradymia argyraea*), and California draba (*Draba california*), have no federal or state designation, but occur on the CNPS watch list. Impacts to these plant species may come from whatever habitat destruction occurs off of the lake bed to prepare the landing support structures. Given that construction would be confined to the lake bed as much as possible, these effects are expected to be minimal.

Wildlife

The creosote bush scrub surrounding the runway is potentially suitable to support the desert tortoise. Surveys at Silurian Lake for the desert tortoise were conducted in 1979-1980 and 1992. Density estimates for both surveys were very low, ranging from 0 to 8 tortoises per sq km (0 to 20 tortoises per sq mi) (BLM 1996). No tortoises, tortoise burrows, or other evidence of tortoises have been documented from the lake bed or immediately adjacent area (Egan 1997). The Bureau of Land Management recognizes that the lake bed lies within the known range of the desert tortoise, but because the local tortoise population is either very low or nonexistent, there is no emphasis on tortoise conservation in the land management plans for that area (Egan 1997). However, due to the potential desert disturbance described in section 4.2.1, NASA would implement the same desert tortoise mitigation and protection measures as described in section 5.6. Because tortoise densities are so low, minimal or no impacts to the desert tortoise population from facilities preparation are anticipated from the X-33 project.

Sonic boom impacts on the desert tortoise are expected to be minimal. Recent studies found that 14 tortoises exposed to a series of simulated sonic booms ranging from 0.012 to 0.29 kPa (0.25 to 6.0 psf) showed no startle responses or significant changes in heart rate (Bowles/Eckert/Startke 1997). The only response observed was a brief orienting of the animal toward the direction of the boom, after which normal activity quickly returned. In addition, no temporary hearing loss was noted until 5 tortoises were exposed to the cumulative energy equivalent to a 1.2 kPa (25.0 psf) sonic boom (Bowles/Francine/Matesic/Stinson 1997). Four of those animals recovered full hearing capabilities within 1 hour, and the fifth recovered within 48 hours. It must be noted that these tortoises had been exposed to upper respiratory tract disease (Berry 1997), and one showed clinical symptoms of the disease, but all of the tortoises exhibited normal hearing capabilities and reflexes prior to testing (Bowles/Eckert/Startke 1997). Further details can be found in the Biological Assessment provided in Appendix E. Minimal impact is expected.

4.2.1.8 Cultural Resources

Historic and archaeological sites documented on the lake shoreline and lake bed would be marked and avoided during all X-33 activities. Any undocumented sites that are discovered during X-33 operations would not be disturbed until the State Historic Preservation Officer has been contacted for guidance and resolution of the situation. Therefore, on the basis of the currently available information, no effect is projected.

4.2.1.9 Water Resources

All water would be transported and managed as described in Section 4.2.1.1. Therefore, no impacts are expected.

4.2.1.10 Geology and Soils

Land preparation, grading and site preparation activities would alter the topography of the Silurian Lake area as described in Section 4.2.1.1. Lake bed surface preparation would require compaction of some areas and grading of ruts or other obstructions. Mechanical or vehicular

disturbance of the upper dried clayey surface crust would expose underlying fine sediment to wind erosion. The hazard of dry soil blowing is very high (BLM 1996). Placement of all equipment and landings and takeoff would alter the ground surface, but should result in only minimal disturbance of the surficial geology.

4.2.1.11 Health and Safety

X-33 safing would be performed as described in Section 4.2.1.1. The calculated QD clear zone would extend for a radius of 137 m (450 ft). This zone must be maintained secure until safing is completed due to the explosive potential of the remaining LH_2 is 680 kg (1,500 lb) and 340 kg (750 lb) of LOX. All non-essential personnel would be prevented from entering safety-controlled zones until the LH_2 been vented and purged. At Silurian Lake, because there are no structures and the lake bed is uninhabited, there are no circumstances where the required QD clear zone cannot be met.

Once the vehicle has been vented to ambient pressure for the first time, other routine safing operations would begin. The vehicle is prepared for towing to a previously defined staging area at the landing site where additional safing operations would be performed. These operations include continued venting of the LH_2 tanks, purging the liquid-empty propellant tanks and lines with helium (supplied externally), and then performing LOX safing operations in a similar manner. Safing may require up to 12 hours to accomplish. The vehicle would then be prepared for ferry back to Edwards on the Boeing 747. It is expected that the staging area would have a temporary shelter or wind restraint to protect the vehicle from inclement weather.

Because of the remoteness of Silurian Lake, there are no hazards to structures or inhabited areas. It is anticipated that a 40 km (25 mi) stretch of Highway 127 would have to be closed during all advance operations through return of the X-33 and Boeing 747 to Edwards. Personnel supporting landing and recovery operations would be moved a substantial distance away from the lake bed to protect them from any possible catastrophic failure during landing. A Landing Site Safety Plan would be prepared Lockheed Martin Skunk Works with participation by NASA, and in consultation with BLM. The plan would be coordinated and approved by the AFFTC on Edwards. The plan would include provisions to use the vehicle's guidance system to deliberately bring the vehicle down into an unpopulated area if the tracking systems indicate that the vehicle would not safely land in the designated area and could potentially pose a threat to the public, a AFFTC sensitive area or facility. The decision to terminate flight in this manner would be made by the Range Safety Officer.

Transportation of hazardous materials required for landing site operations would use approved containers and procedures. Emergency response plans addressing failures and accident scenarios would be developed by Lockheed Martin with participation of NASA and BLM. Necessary emergency equipment to adequately respond to these scenarios would be available at the scene, and on-site personnel would be trained to respond to potential emergency situations. Based on these factors, there is a minimal potential for impacts to the health and safety of people and property resulting from X-33 landing operations on Silurian Lake.

4.2.1.12 Noise

See Section 3.1.13 for additional background information on noise and its effects.

Operational Noise

Landing the X-33 spaceplane and the 747 carrier aircraft at Silurian Lake are activities that would produce additional noise in the area. In addition, up to five helicopters may be in the area during landing operations for security reasons. Three flight demonstration tests are planned for landing at Silurian Lake. The X-33 spaceplane would be unpowered on landing, producing less noise than powered jet planes. The 747 carrier aircraft and helicopter noise would be similar to that currently experienced from military operations in the area. Personnel areas and security zones would be set at distances where the 115 dBA maximum sound level established for short exposure by the Department of Labor standards is not exceeded. The only other operation to be performed at Silurian Lake would be mounting the X-33 on the back of the 747 aircraft for return to Edwards. This activity would not contribute any measurable noise levels to current recreational and military activities. Therefore, only minimal impacts are expected.

Noise and Sonic Boom Footprints

Figure 4-31 shows footprints for the nominal trajectory to Silurian Lake. Most of the area receiving sonic booms would be subject to boom overpressures of 0.1 kPa (2 psf) or less. There is little probability of damage at these low overpressures; therefore, impact would be minimal for the majority of affected areas. Higher overpressures would occur in the focal zones seen in Figure 4-31. Some focus overpressures would be as high as 0.50 kPa (10 psf). Focusing would occur within small regions, typically less than 91 m (100 yd) wide, and would occur primarily in a small region of BLM-administered property between Edwards and China Lake Naval Air Weapons Station (Table 4-9; Figures 4-32 and 4-33). Impact potential would depend on the structures that are located in the focus regions. Because of the localized nature of the focal zones, overall impact is expected to be minimal.

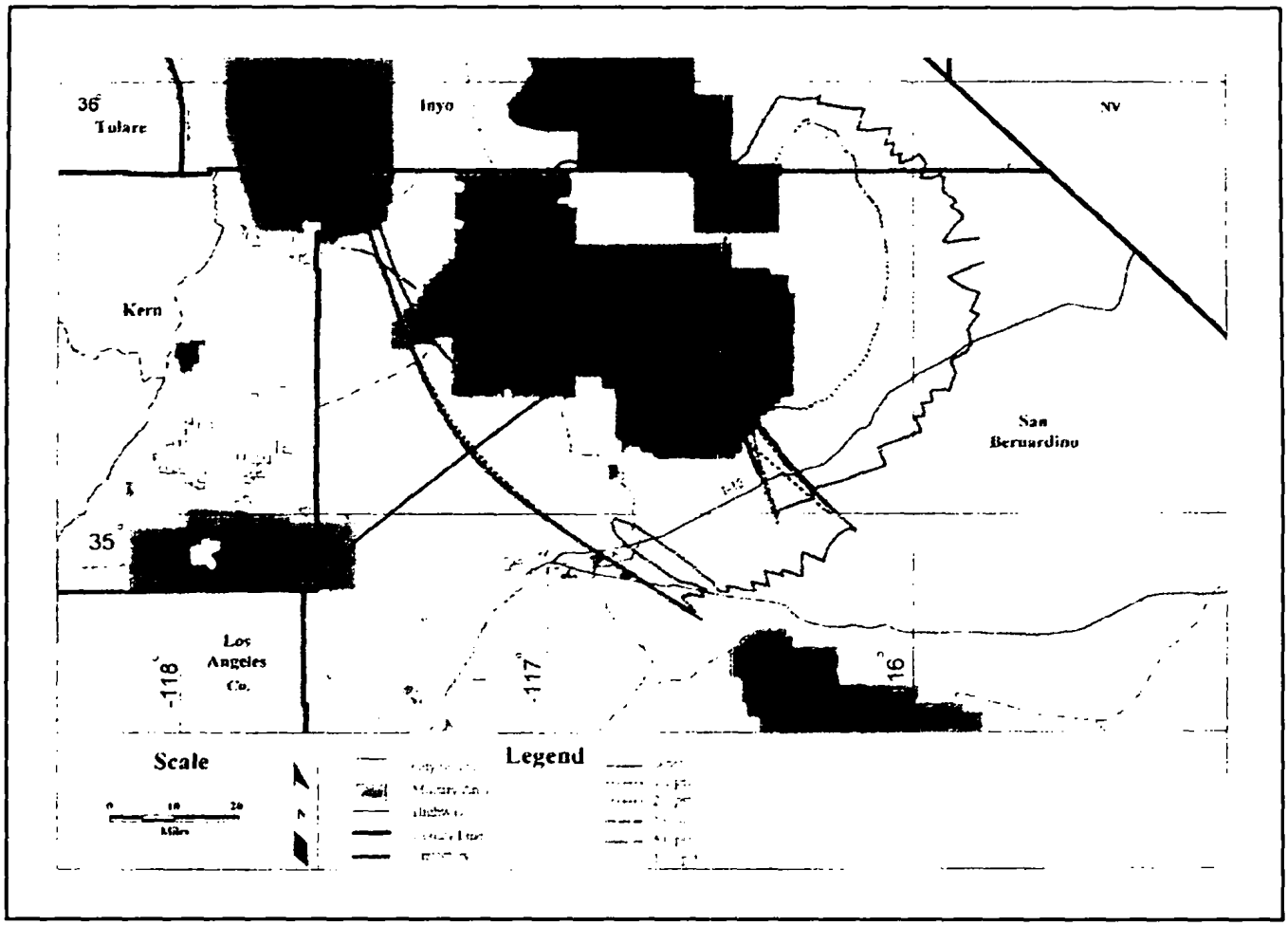


Figure 4-31. Sonic Boom Contours for Nominal Trajectory to Silurian Lake.

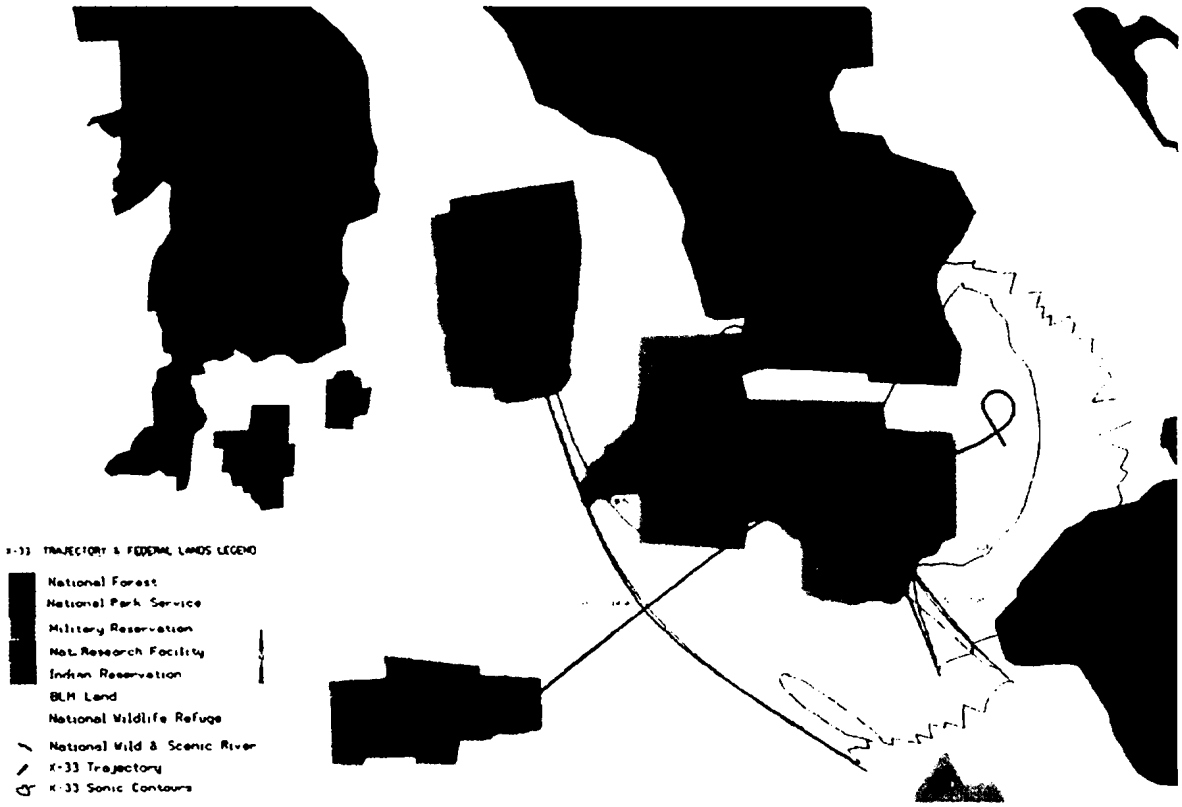


Figure 4-32. Federal and Private Lands Exposed to Focus Booms during Launch from Haystack Butte to Landing at Silurian Lake (National Geographic Society 1996).

Figure 4-33. Federal and Private Lands Exposed to Focus Booms duringLaunch from Space Port 2000 to Landing at Silurian Lake (National Geographic Society 1996).

Table 4-9. Impact on Special Status Lands Due to Sonic Booms from X-33 Launches from Edwards Air Force Base Landing at Silurian Lake, CA.

Launch Focus Boom		Landing Focus Boom		Landing Carpet Boom	
Area Affected	Expected kPa[1] (psf[2])	Area Affected	Expected kPa (psf)	Area Affected	Expected kPa (psf)
BLM[3] lands	up to 0.5 (10.0)	BLM lands	up to 0.53 (11.0)	BLM lands	up to 0.07 (1.5)
		Ft. Irwin NTC[4]	up to 0.53 (11.0)	China Lake NAWC[5]	up to 0.02 (0.5)
				Death Valley NationalPark	up to 0.05 (1.0)
				Ft. Irwin NTC	up to 0.10 (2.0)
				Mojave National Preserve	0.02 - <0.05 (0.5 - <1.0)

Key:
[1]*kPa = kilo Pascal*
[2]*psf = pounds per square foot*
[3]*BLM = Bureau of Land Management*
[4]*NTC = National Training Center*
[5]*NAWC = Naval Air Warfare Center*

The carpet boom increases as the vehicle descends toward the landing site, exceeding 1 psf when the vehicle descends through 34,000 to 27,000 m (110,000 to 90,000 ft) of altitude. Several parcels of federal property, including BLM lands, Death Valley National Monument and the Mojave National Preserve, would experience low-intensity carpet booms (Table 4-9; Figures 4-32 and 4-33). Most of the descents involve turns that cause maximum focus booms of 0.29 to 0.53 kPa (6 to 11 psf). Maximum focus booms are confined to very narrow focal zones, as discussed earlier. These are less than 91 m (100 yd) wide. X-33 landings at Silurian Lake are expected to produce focus booms over BLM lands and the Ft. Irwin National Training Center (Table 4-9; Figures 4-32 and 4-33). Outside of the focal zones, maximum overpressures for descent of the X-33 are in the 0.05 to 0.1 kPa (1 to 2 psf) range, comparable to the low-intensity carpet boom of the Space Shuttle for its descent over the Antelope Valley. Figure 4-34 shows a typical sonic boom footprint for a Space Shuttle descent into Edwards. Ascent noise and sonic booms for an X-33 launch are less than levels produced by the Space Shuttle upon ascent and, therefore, ascent comparisons of the two vehicles are not applicable.

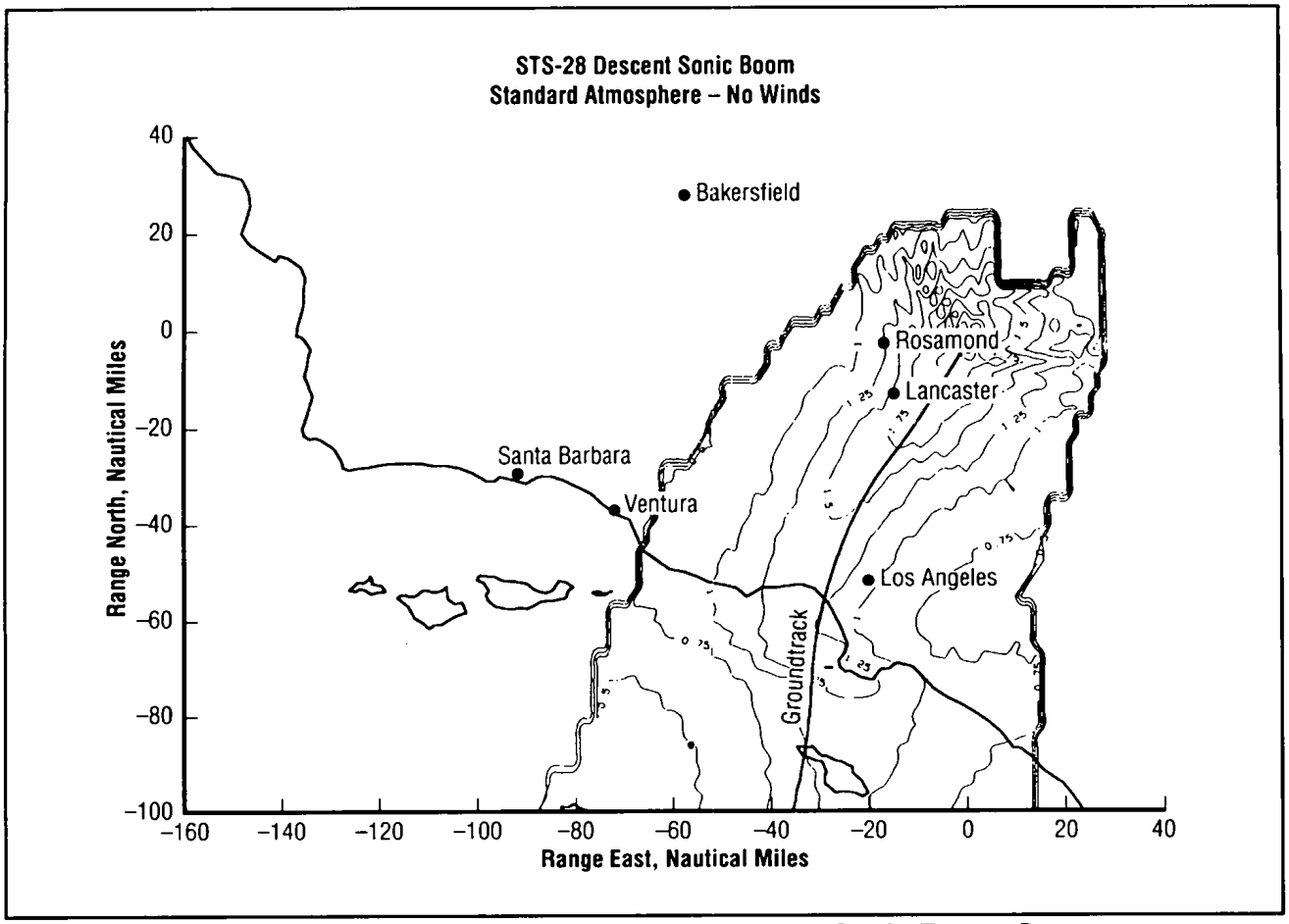


Figure 4-34. STS-28 Space Shuttle Orbiter Descent Sonic Boom Overpressure Contours. Overpressure Contours on the Above Map in the Range of 0.5 to 1.75 are in psf.

4.2.1.13 Transportation

To ensure the safety of both the public and the vehicle and also protect the fragile desert environment, the program would require that State Highway 127 be closed for 1.5 to 4 hours for each landing of the X-33 vehicle. Road closure would be in coordination with and approval of the California Department of Transportation. The closure points would be at the junction of State Highway 127 and Saratoga Springs Road to the north of Silurian Lake, and on State Highway 127 just north of Baker. These points have been selected due to their representing the last points to stop traffic at detour roads an/or public services prior to Silurian Lake. A smaller section of the road (approximately 1.6 km (1 mi)) in the immediate vicinity of the lake bed would be closed for 15 to 30 minutes in order to land and takeoff the Boeing 747.

During closures, the traffic normally using this route would be redirected or allowed to wait for the road to reopen. Two alternative routes are available; one which includes both paved and unpaved roads, and another which includes only paved roads. The first alternative route would run north from the closure point at the junction of Saratoga Springs Road and State Highway 127

(paved) to the town of Tecopa; east from Tecopa on Furnace Creek Road (paved part way) to the junction with Excelsior Mine Road near (unpaved) Horse Springs; south of Excelsior Mine Road (unpaved) to the junction with Kingston Road (unpaved) , which runs south to Interstate 15 (paved) near Valley Wells, and then west on Interstate 15 to Baker. This alternative route would extend the normal travel distance when traveling south, by approximately 39 km (25 mi) when counted from Tecopa, and 69 km (45 mi) when counted from the closure point at Saratoga Springs Road and State Highway 127. When traveling north, the distance would be extended by approximately 93 km (60 mi) for persons traveling to the beginning of Saratoga Springs Road and State Highway 127 from Baker. Depending on the travel speed, this detour would result in increased travel times of as much as 2 to 3 hours.

The second route, which contains only paved roads, would run north from the closure point at the junction of Saratoga Springs road and State Highway 127 to the town of Shoshone, east on State Highway 178 to the Nevada border where the road becomes State Highway 52; east to the town of Pahtrump and the junction of State Highway 16. East on State Highway 16 into the city of Las Vegas and the junction of Interstate Highway, then south of Interstate 15 to Baker. This alternative would extend the normal travel distance when traveling south, by approximately 203 km (126 mi) when counted from Shoshone and 235 km (146 mi) when counted from Saratoga Springs Road and State Highway 127. When traveling north, the distance would be extended by approximately 235 km (146 mi) for persons traveling to the beginning of Saratoga Springs Road and State Highway 127 from Baker. Depending on the travel speed, this detour would result in increased travel times of as much as 3 to 5 hours.

Although these closures would be few (1 to 3) and short duration, they would impact private and commercial traffic. To mitigate these impacts, the X-33 Program would widely advertise each planned closure in newspapers, radio, and television announcements, and provide alternate routing information as part of the announcements. Highway signs at detour routes would be temporarily placed. Escorts for critical needs such as medical emergencies and perishable commodity (milk and other agricultural products, etc.) deliveries would be available at both the north and south road blocks. In addition, an Enroachment Permit from the California Department of Transportation (Caltrans) will be required for this road closure. Application/permit will be sought in a timely manner prior to the first launch and landing of the X-33 vehicles. Details of the conditions required to close this road will be part of the permit.

4.2.1.14 Population and Employment

Approximately 50 to 75 personnel would be temporarily stationed in the vicinity of Silurian Lake. Therefore, no impact is expected.

4.2.1.15 Land Use

Silurian Lake is under management of the BLM. It is open to the public for recreational activities. It is also used for various commercial purposes such as filming of movies. Landing the X-33 spaceplane, mounting it on back of the ferry aircraft, and transporting it back to Edwards would impact these uses during launch, landing, and servicing operations of the X-33 because the dry lake bed would be closed for other uses during that time. These closures would be up to

4 consecutive hours for each landing. In addition, an area approximately 8 km (5 mi) in radius of the lake bed would be cleared of all non-program personnel starting 24 hours in advance of the planned launch time and terminating immediately after landing of the X-33. Potential interference with commercial uses would be coordinated with BLM to ensure minimal impacts. The use of the lake bed as a landing area would constitute a temporary change in land use. No permanent closure or encumbrance upon future use of Silurian Lake will be imposed. After all landings projected for Silurian Lake are accomplished, the land use would revert to its present designation.

The proposed landing and associated facility sites do not contain prime or unique farmland and are not located on or adjacent to Areas of Critical Environmental Concern (ACEC). There are no designated or study inventory rivers in the Wild and Scenic Rivers System in the vicinity. There are no designated wilderness areas or Native American Religious areas in the immediate vicinity. No effects would be anticipated on prime or unique farmlands, wild and scenic rivers, wilderness, or Native American Religious areas as the result of the X-33 landings at Silurian Lake.

Impacts to land use at Silurian Lake are expected to be minimal because use of the area would be of short duration, and no major modifications would be required.

To the extent that 49 USC Section 303 (formerly Section 4(f) of the Department of Transportation Act) may be interpreted to apply, the only potential effects of the proposed X-33 operations on parks, recreation areas, and wildlife/waterfowl refuges would be from occasional noise associated with vehicle launches. However, these impacts would be minor and would not substantially impact the use of these areas. For details of impacts, if any, for the environments of the launch and landing site, please see Chapters 3 and 4 of this Final EIS, specifically the particular area of interest (i.e., for Silurian Lake, Cultural Resources, see Section 4.2 at subsection 4.2.1.8) (FAA, July 1997).

4.2.1.16 Snow Avalanche

No ski areas or mountain passes are located along the proposed flight path or within the area expected to receive sonic boom overpressure. Therefore, no increased danger of injury or structural damage resulting from snow avalanche are anticipated as a result of flight operations to the Silurian Lake landing site.

4.2.2 China Lake Naval Air Weapons Station, California

Up to three X-33 landings at this site would occur to flight test the vehicle at a speed of Mach 4 (2900 mph). Also required would be landing of the Boeing 747 to air ferry the X-33 back to Edwards. Refueling of the Boeing 747 at China Lake would not be necessary. An existing runway and infrastructure are in place to support X-33 activities. A field crew of 50 to 75 would be on China Lake for approximately one week at each landing. Equipment for venting of LH_2 and LOX would be brought in for each landing. Safing activities would be accomplished by gradually venting the residual propellants to the atmosphere and purging with inert gaseous helium. Safing and venting locations would be sited in accordance with the explosive safety quantity distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Navy, and NASA instructions.

4.2.2.1 Site Infrastructure

Runway

There are three intersecting runways at China Lake. Runway 3-21, which is 3,048 m (10,000 ft) long by 61 m (200 ft) wide was identified as a reasonable alternative for X-33 landings (see Figure 2-12). Adequate aircraft parking space is limited, since part of the hangar parking apron lies inside Runway 14-32 primary surface. No modifications to runways would be required, and no impacts are expected.

Water Supply and Distribution

The extensive network of deep wells and reservoirs noted in Section 3.2.2.1 have excess capacity. No modifications to existing water systems would be required to provide the estimated 8,520 LPD (2,250 GPD) for each day that X-33 personnel are on site. Vehicle cleaning and preparation would require approximately 284,000 L (75,000 gal) for each landing/retrieval operation The existing supply and distribution system currently serves an onsite population of about 6,700 civilian and military personnel. No impacts to existing supplies would be expected.

Wastewater

Wastewater from the X-33 would consist of approximately 8,520 LPD (2,250 GPD) of domestic wastewater resulting from 50 to 75 additional X-33 personnel. Industrial wastewater would be approximately 284,000 L (75,000 gal) resulting from washing down the spaceplane and the 747 after landing. The amount of extra wastewater involved for each of the approximately 1-week landing/retrieval operations is minimal compared to the normal daily wastewater flows from current onsite operations and the 6,700 civilians and military personnel working at China Lake. The wastewater treatment system has an average daily burden of 52 percent of design capacity and can treat up to an additional 8.0 MLD (2.1 MGD). Therefore, minimal impact to wastewater treatment facilities is expected.

Electricity

Current electrical demand on the Inyokern substation is approximately 50 percent of capacity. The electrical demands from X-33 activities would be very small and temporary. Therefore, no impact to the system is expected due to minor requirements for a short, temporary line.

Communications

Telephone and radio networks in place are adequate to accommodate X-33 Program needs. Therefore, the existing communications system would not be adversely impacted.

Fuel

The 747, with the X-33 piggyback, would not need to be refueled in order to fly back to Edwards. Fuel-related impacts from motor vehicles, aircraft operations, and retrieval of the X-33 spaceplane would be minimal. Equipment for off-loading and venting of residual liquid hydrogen and oxygen propellants would be brought in as part of landing preparations by the X-33 workforce. Therefore, no impact is expected.

4.2.2.2 Hazardous Materials and Hazardous Waste

The primary hazardous materials associated with X-33 landing and retrieval operations would be the residual propellants onboard the X-33 (up to 680 kg (1,500 lb) of LH_2 and 340 kg (750 lb) of LOX). Safing activities would be accomplished by gradually venting these propellants to the atmosphere and purging with the inert gas helium. No adverse impacts would be associated with defueling since all three gases are normal constituents of the atmosphere.

Generation of hazardous waste at China Lake is not projected. Should the need arise to manage and dispose of hazardous waste, the hazardous waste would be managed through China Lake's existing hazardous waste management system on a reimbursement basis with the X-33 Program. Overall impact is expected to be minimal.

Propellant Safety

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, safing and venting of the residual propellants would be conducted in an area that would accomodate the explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions and allow normal flight operations to resume. See Section 4.2.2.11 for further details.

Transportation of Hazardous Materials

Hazardous materials required for landing retrieval operations would be minimal and transported to and from the landing site in approved containers. No impacts to transportation systems are expected.

Contamination

X-33 landing/retrieval operations would not be conducted in any known areas of existing contamination. All landing/retrieval operations activities would be conducted in accordance with existing base requirements for the prevention of releases to the environment. No impacts are expected.

4.2.2.3 Solid Waste

Minimal amounts of solid waste in the form of paper, food refuse, etc., are expected to be generated. All solid waste would be containerized for disposal at the permitted landfill through Kern County. Minimal impact is expected.

4.2.2.4 Air Quality

An air conformity analysis provided in Appendix C was prepared for all projected activities on and around China Lake for proposed X-33 activities to determine whether or not proposed activities, according to the federal general conformity regulations, could potentially be in nonconformance with the State Implementation Plan. The Conformity Analysis was based on two landings. The emissions presented in this section have been extrapolated to accommodate the new baseline of three potential landings. A comparison of the X-33 emissions projections for 1997 through 1999 with *de minimis* regulatory threshold levels is provided in Table 4-10. All projected emissions are less than these thresholds, and thus no formal conformity determination is required. Minimal impact to air quality is expected. Air permits for portable generators and other internal combustion equipment used for X-33 landing operations would be obtained through appropriate air district authorities.

Table 4-10. Emissions Summary for China Lake.

Year	Estimated Emissions metric tons/year (tons/year)		
	Nitrogen Oxides (NO_X)	Volatile Organic Compounds (VOC's)	Particulate Matter (PM_{10})
1997	no activity	no activity	no activity
1998	no activity	no activity	no activity
1999	4.1 (4.6)	1.1 (1.3)	3.1 (3.4)
de minimis regulatory threshold	45.4 (50.0)	45.4 (50.0)	91.0 (100)
Conformity Determination Required?	NO	NO	NO

Classification: O_3 (serious non-attainment); PM_{10} (moderate non-attainment)

4.2.2.5 Airspace and Air Traffic

The China Lake flight path is approximately 80 km (50 mi) long. Ascent would occur in R-2515 and descent under 18,300 m (60,000 ft) within R-2505. Intervening airspace governed by MOAs would be overflown at altitudes exceeding 18,300 m (60,000 ft) subject to NOTAMs informing general aviation of the X-33 flight plan and other pertinent information. The total flight time would be approximately 10 minutes. The X-33 along this nominal trajectory would overfly the

Isabella MOA (see Section 3.1.6 for description) that permits restricted use of this airspace by civilian and commercial aircraft. Minimal impact to military, commercial, and general aviation would be expected.

4.2.2.6 Biological Resources

Vegetation

There would be no land disturbance necessary to support X-33 landings at China Lake; therefore, no effects to vegetation are expected to occur.

Wetlands and Floodplains

The nearest wetland to the runway is 7 km (3 mi) and would not be impacted by X-33 activities. The vicinity of the runway, however, is encompassed in the 100 yr floodplain. No construction is required for landing the X-33, and no X-33 activities could be conducted if flooding conditions existed. Therefore, no impacts to wetlands are expected from the X-33 project.

Wildlife

Sonic booms from X-33 landings are expected to produce maximum overpressures of 0.25 to 0.50 kPa (5 to 10 psf) in a small area approximately 24 km (15 mi) north of the runway. Less intense sonic boom overpressures in the range of 0.05 to 0.10 kPa (1 to 2 psf) would be experienced at the distances of approximately 16 km (10 mi) in all directions of the runway. The impacts from sonic booms to wildlife in natural situations are difficult to study or predict. In general, mammals and raptors do not panic when exposed to sudden intense noise; whereas, waterfowl are more likely to injure themselves or their young when suddenly frightened (Bowles 1997). After fewer than five exposures, most animals become habituated to the noise and show little response. Animals that are accustomed to other human disturbances are less likely to panic. In research conducted on pronghorn antelope, Rocky Mountain elk, and bighorn sheep, exposure to sonic booms caused a slight rise in heart rate after the initial disturbance (USAF 1992B). The startle responses decreased for subsequent booms and were soon less than those evoked by humans walking into the animal pens, or by bees and biting flies bothering the animals. In a study on cliff-nesting raptors exposed to noise from underground nuclear explosions, damage to or desertion of nests was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). Although quantitative information for most species is lacking, available data indicate that exposure to sonic booms in the pressure ranges expected from X-33 would not impact wildlife populations.

4.2.2.7 Threatened, Endangered, and Sensitive Species

Vegetation

Lane Mountain milk-vetch (*Astragalus jaegerianus*) is a vine-like perennial ground cover that uses other plants as a lattice for climbing (Laye 1977). It is currently approved for federal listing and is classified as a proposed species. Its distribution is very limited and restricted to the

foothills of the Mojave desert between 900 to 1,200 m (3,000 to 4,000 ft). The milk-vetch has not been documented on China Lake Naval Air Weapons Station, but there is suitable habitat on the base (Williams 1997).

Thirteen species of plants identified on China Lake have been classified as sensitive by the state of California. None are these plants endemic to China Lake. Two species of particular management concern on China Lake are the Mojave fishhook cactus (*Sclerocactus polyancistrus*) and Charlotte phacelia (*Phacelia nashiana*). Neither of these species have populations located near the airfield. No effects to any plant species are expected from the X-33 project.

Wildlife

Nine federally protected wildlife species could potentially occur at China Lake (Woodman/ Kohfield/Bagley 1996) (Table 4-11). Of these, one fish, reptile, and bird are considered to have the potential to be affected by the X-33 project. The other six species, all birds, are not considered to be of concern to this project, because they occur very infrequently or have never been documented on base, and they are non-nesting migrants or there is no suitable nesting habitat on base (Laye 1997; Williams 1997).

Table 4-11. Federally Listed Wildlife Species Potentially Occurring at China Lake X-33 Proposed Landing Site.

Species	Scientific Name	Status[1]
Mohave tui chub	*Gila bicolor mohavensis*	FE
brown pelican	*Pelecanus occidentalis californicus*	FE
American peregrine falcon	*Falco peregrinus anatum*	FE
southwestern willow flycatcher	*Empidonax traillii extimus*	FE
least Bell's vireo	*Vireo bellii pusillus*	FE
desert tortoise	*Gopherus agassizii*	FT, CH
bald eagle	*Haliaeetus leucocephalus*	FT
Inyo California towhee	*Pipilo crissalis eremophilus*	FT
Western snowy plover	*Charadrius alexandrinus rivosus*	FE

[1]***Key***:
FE = federally endangered
FT = federally threatened
CH = critical habitat

The Mohave tui chub (*Gila bicolor mohavensis*) is small minnow-like fish that is federally protected as endangered. This fish is native to the Mojave River in southern California, but was in danger of becoming extinct, because of hybridization with the non-native arroyo chub (*Gila orcutti*). In 1971, China Lake Naval Air Weapons Station was chosen as a recipient site, and 400 Mohave tui chubs were introduced to the Lark Seep wetlands area in a last-ditch effort to save the subspecies (USN 1989). Lark Seep is an artificial wetlands created by years of percolation from the evaporation percolation ponds at the sewage treatment plants. Unlike other Mohave tui chub introduction projects, the one at China Lake was very successful and the population at Lark Seep grew to over 10,000 by 1990 (USN 1989). The population has spread into several drainages and the G-1 Seep.

The only anticipated impacts on the Mohave tui chub may be from sonic booms and these are expected to be none or minimal, because of the sound attenuation afforded by being under water. For noise within the range of human hearing (125 to 4,000 Hz.), the acoustic absorption coefficients of water are between 0.008 and 0.025 (Sutherland 1968). These rates are much lower than for common building materials such as wood, plaster, or brick, and infers that most of the sound waves traveling from air to the water would be reflected.

Suitable habitat for the federally threatened desert tortoise occurs throughout much of the south range of the China Lake complex, which has been designated as a Tortoise Critical Habitat Management Area by the United States Fish and Wildlife (USN 1989; Williams 1997). Density estimates range between 0 to 19 tortoises per sq km (0 to 5 per sq mi) (Kiva 1991). There is little suitable habitat in the north range and the highest densities are estimated to be 8 tortoises per sq km (20 per sq mi) (Kiva 1991).

The only anticipated impacts on the desert tortoises may be from sonic booms and these are expected to be minimal. Recent studies found that 14 tortoises exposed to a series of simulated sonic booms ranging from 0.01 to 0.29 kPa (0.25 to 6.0 psf) showed no startle responses or significant changes in heart rate (Bowles/Eckert/Starke 1997). The only response observed was a brief orienting of the animal toward the direction of the boom, after which normal activity quickly returned. In addition, no temporary hearing loss was noted until five tortoises were exposed to the cumulative energy equivalent to a 1.20 kPa (25.0 psf) sonic boom (Bowles/Fracine/Matesic/ Stinson 1997). Four of those animals recovered full hearing capabilities within 1 hour, and the fifth recovered within 48 hours. It must be noted that these tortoises had been exposed to upper respiratory tract disease (Berry 1977), and one showed clinical symptoms of the disease, but all of the tortoises exhibited normal hearing capabilities and reflexes prior to testing (Bowles/Eckert/Starke 1997).

The Inyo California towhee (*Pipilo crissalis eremophilus*) is a small sparrow-like bird which is federally listed as threatened. The total population size is estimated to be 250 to 300 birds, although a range-wide population survey has not been done since 1979 (BioSystems 1994; LaBerteaux 1994; LaBerteaux 1997). Its distribution is entirely restricted to the Argus mountain range in southwest Inyo County, California. Riparian scrub and the adjacent hillsides have been designated as critical habitat for the towhee. This area includes approximately 1,700 ha (4,200 ac) on China Lake Naval Air Weapons Station, where there is an estimated population of 100 to 150 birds (LaBerteaux 1994; LaBerteaux 1997). The towhee nesting season extends from late March through early July, and peaks during mid to late April. The time from egg-laying to fledging is about 20 days. If the first nesting attempt is unsuccessful, the towhees would typically immediately make a second nesting attempt (BioSystems1994; LaBerteaux 1994).

The Inyo California towhee habitat at China Lake is anticipated to experience sonic booms between 0.02 and 0.07 kPa (0.5 and 1.5 psf). If X-33 landings occur during the nesting season, there could potentially be an impact to individual birds or nesting pairs. Damage to eggs or young could be inflicted if the adult bird is startled off the nest by the noise, or if the adults abandon the nest due to the noise disturbance. The local population of towhees is currently exposed to sonic booms approximately once per month (Williams 1997). No data are available to predict the

response of the towhees to the sonic booms, but it is unlikely that they would abandon their nests (LaBertaux 1997). Landings at China Lake would be scheduled to occur early in the X-33 Program, which would coincide with the beginning of the towhee nesting season. If losses did occur, there would be adequate time remaining in the nesting season for affected pairs to renest (LaBertaux 1997). Therefore, the impact of X-33 sonic booms to the Inyo California towhee population is expected to be minimal.

A California species of special concern and former federal candidate species, the Mohave ground squirrel (*Spermophilus mohavensis*), has been documented on China Lake and may experience sonic booms in pressure ranges between 0.01 to 0.06 kPa (0.2 to 1.2 psf). Generally, mammals do not panic when exposed to sudden intense noise and habituate rapidly (Bowles 1997). Because of the short duration of the X-33 project at China Lake, no impacts to the Mohave ground squirrel population are expected. Overall impact to wildlife is expected to be minimal.

4.2.2.8 Cultural Resources

There are no plans to construct or modify any facilities at China Lake to support the X-33 Program. Therefore, no impacts are expected.

4.2.2.9 Water Resources

Impacts to water resources due to X-33 could result from demands to meet the domestic needs of employees and industrial uses of water for washdown of the vehicles, if required. Water resource demands are expected to be minimal and would be of short duration; therefore, no impacts from this source are expected.

4.2.2.10 Geology and Soils

The proposed action would result in no impacts to the geology and soils at the China Lake landing site.

4.2.2.11 Health and Safety

Upon landing, there would be minor residual amounts of LH_2 and LOX as previously described (see Section 4.2.2.2).

At the landing site, following wheel stop, the vehicle would automatically perform subsystem safing functions and reduce power consumption to minimize safety risks to personnel after approximately one hour from wheel stop, the vehicle would be towed to the staging area for final safing.

The calculated quantity-distance clear zone that would be maintained due to the explosive potential of the remaining LH_2 and LOX is 137 m (450 ft). Non-essential personnel would be kept outside of this area until the LH_2 and LOX have been totally vented and purged. China Lake would be able to meet the required clear zone within the 4,452 ha (11,000 ac) of the airfield.

All sites used by the X-33 Program at China Lake would have to meet base safety requirements and be approved by China Lake Safety and command.

Venting of LH_2 tanks would be accomplished in a cyclic, controlled process until no LH_2 is left in the tanks. The gaseous residual hydrogen would then be purged with helium delivered by tube trailers to render the vehicle "safe" from any hydrogen explosive potential. A similar safing operation for residual LOX would be performed before the vehicle would be determined to be "safe."

Since China Lake is a fully operational military airfield, significant emergency response capability is already in place with highly trained personnel available. A Landing Site Safety Plan including emergency response plans addressing failures and accident scenarios would be developed by Lockheed Martin with participation of NASA, and coordinated with and approved by the AFFTC on Edwards and the China Lake Range Safety Office. Flight safety and flight termination are discussed in Section 4.3.

Based on these factors, there is expected to be minimal potential impact to the health and safety of people and private property resulting from X-33 landing operations on China Lake.

4.2.2.12 Noise

See Section 3.1.13 for additional background information on noise and its effects.

Operational Noise

Personnel exposure levels in industrial shops and processing facilities at China Lake are routinely monitored for compliance with standards established by Occupational Safety and Health Administration. Three flight demonstration tests are planned for landing at Armitage Airfield. The eastern approach path of the X-33 complies with the rules adopted by China Lake to avoid populated areas. Actions taken as a result of the Air Installation Compatible Use Zone study have reduced the noise effects on adjacent communities. The landing noise of the 747 aircraft carrier would be similar to current aircraft operations at the airfield. The X-33 would be unpowered on landing, thus producing less noise than powered jet planes. Personnel areas and security zones established by China Lake for current flight operations, that meet the 115 dBA maximum sound level established for short exposure by the Department of Labor standards, would not be exceeded by X-33 or the Boeing 747 landing or takeoff. The only other operation to be performed at China Lake—mounting the X-33 on the back of the 747 aircraft for return to Edwards—would not contribute any measurable noise levels to current recreational and military activities. Therefore, only minimal impacts are expected.

Flight Noise and Sonic Boom

Figure 4-35 shows sonic boom footprints for the nominal trajectory to China Lake. The carpet boom would increase as the vehicle descends toward the landing site, exceeding 0.05 kPa (1 psf) when the vehicle descends through 34,000 to 27,000 m (110,000 to 90,000 ft) of altitude. Low-intensity carpet booms would be anticipated for BLM lands, Death Valley National Park, and

lands administered by the National Forest Service (see Table 4-12; Figures 4-36 and 4-37). Descent would involve turns that cause maximum focus booms of 0.29 to 0.53 kPa (6 to 11 psf). Maximum focus booms are confined to very narrow focal zones as discussed earlier, less than 91 m (100 yd) wide. Focus booms from landings at China Lake would be confined to Navy property (Table 4-12; Figures 4-36 and 4-37). These are less than 91 m (100 yd) wide. Outside of the focal zones, the maximum overpressures would be in the 0.05 to 0.1 kPa (1 to 2 psf) range, comparable to the Space Shuttle. Figure 4-34 shows a typical sonic boom footprint for a Space Shuttle descent into Edwards. Ascent noise and sonic booms for the Space Shuttle are not applicable.

Due to the low level carpet booms, low probability exists to potentially cause minor structural damage, mainly in the form of cracked windows. Windows that crack at these low overpressure would generally have to be stressed by some previous activity. The higher overpressures associated in the focal zone could potentially damage even new windows (see Table 4-6). However, due to the small number of flights with low probability of damage potential from carpet booms and small focal zone, minimal impact is expected.

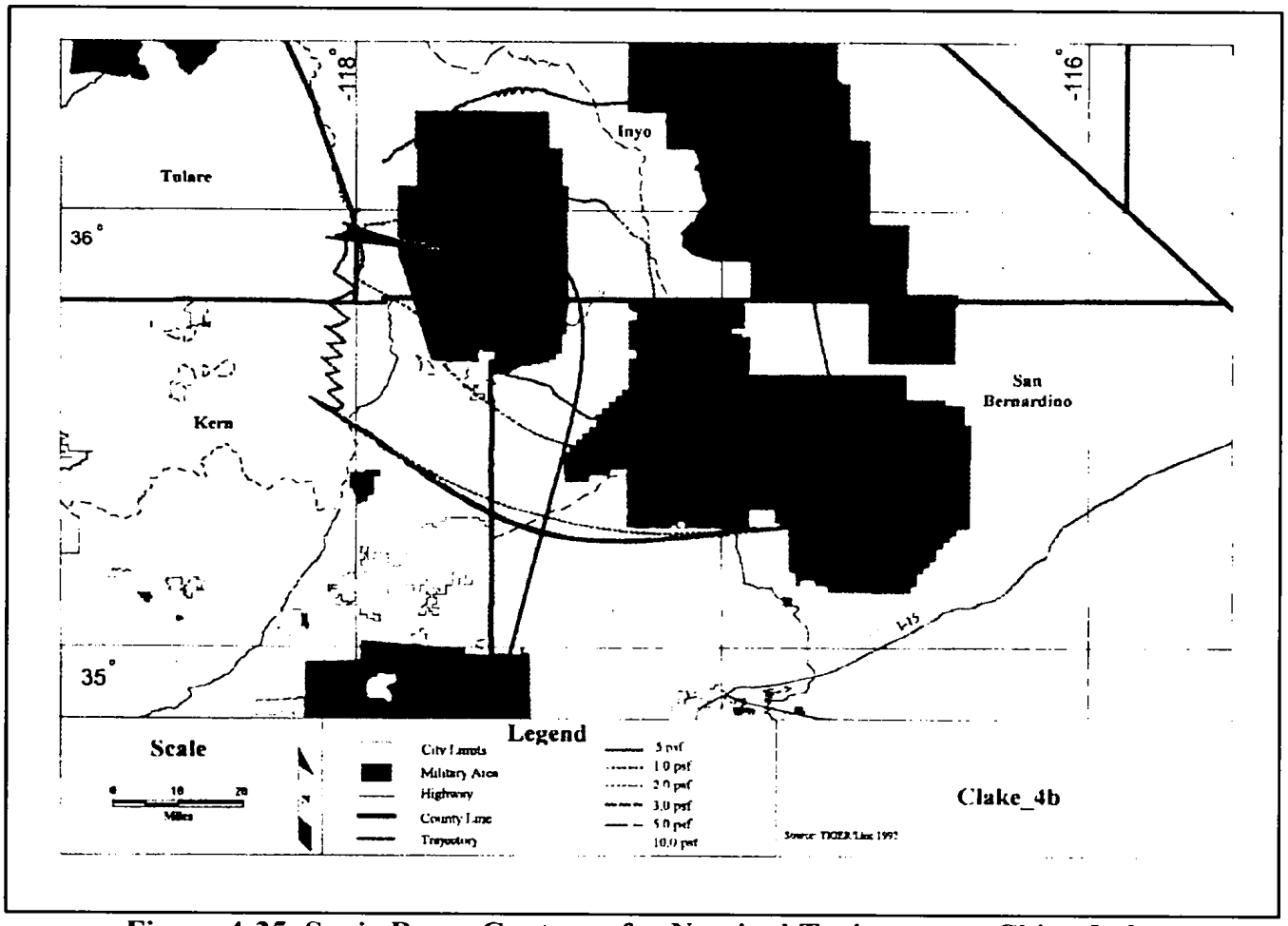


Figure 4-35. Sonic Boom Contours for Nominal Trajectory to China Lake (National Geographic Society 1996).

Table 4-12. Impact on Special Status Lands Due to Sonic Booms from X-33 Launches from Edwards Air Force Base Landing at China Lake NAWS[1].

Launch Focus Boom		Landing Focus Boom		Landing Carpet Boom	
Area Affected	**Expected kPa[2] (psf[3])**	**Area Affected**	**Expected kPa (psf)**	**Area Affected**	**Expected kPa (psf)**
BLM[4] lands	up to 0.5 (10.0)	China Lake NAWS	up to 0.53 (11.0)	BLM lands	0.02-0,07 (0.5-1.5)
				China Lake NAWC	up to 0.10 (2.0)
				Death Valley Nat'l. Park	0.02-<0.05 (0.5-<1.0)
				Ft. Irwin NTC[5]	0.02 (0.5)
				Nat'l Forest lands	0.02 (0.5)

Key:
[1]NWC = Naval Air Weapons Station
[2]kPa = kilo Pascal
[3]psf = pounds per square foot;
[4]BLM = Bureau of Land Management
[5]NTC = National Training Center

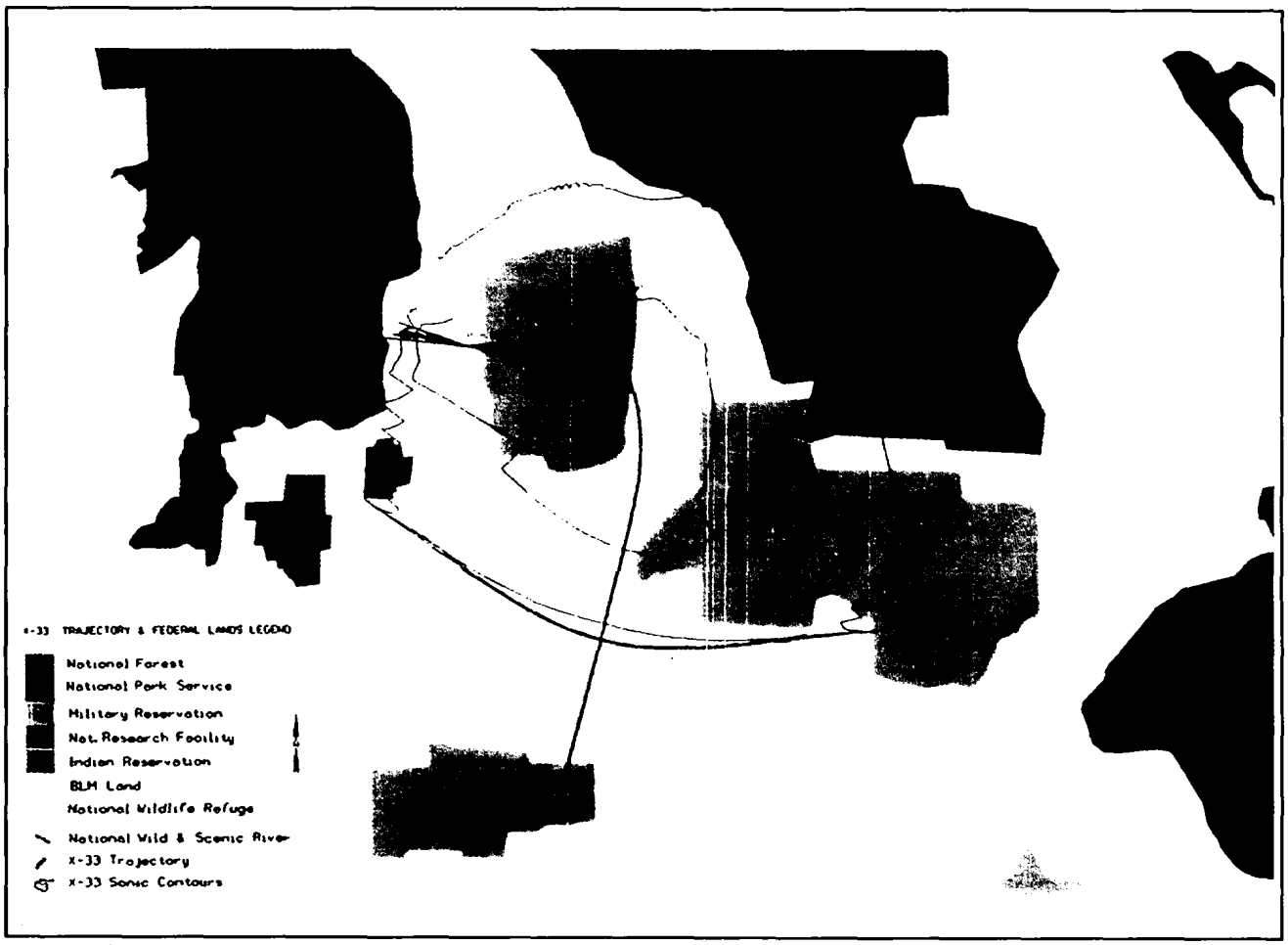


Figure 4-36. Federal and Private Lands Exposed to Focus Booms during Launch from Haystack Butte to Landing at China Lake (National Geographic Society 1996).

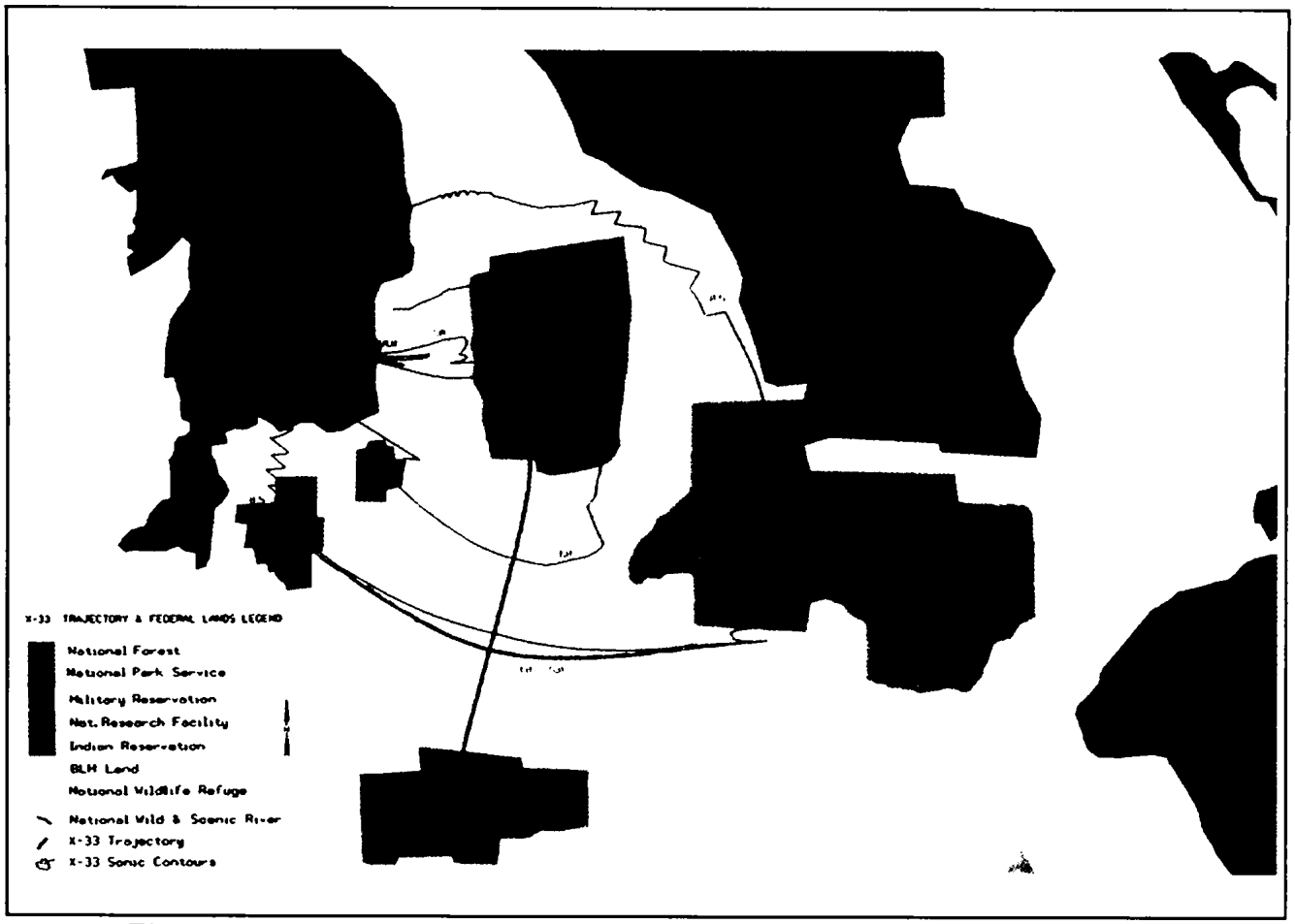


Figure 4- 37. Federal and Private Lands from Space Port 2000 Exposed to FocusBoomsduring Launchto China Lake (National Geographic Society).

4.2.2.13 Transportation

Personnel an private citizen transportation by private automobile or commercial bus via state and U.S. highways. No road closures are expected to be necessary for X-33 landings. With the small number of employees, transportation systems would not be impacted.

4.2.2.14 Population and Employment

Operations are expected to have small effects, since the proposed landing site would be staffed only during flight test operations with 50 workers. Up to three landings are planned at China Lake and they would occur in the early timeframe of the flight test program. Therefore, impacts are expected to be minimal.

4.2.2.15 Land Use

China Lake Naval Air Weapons Station is currently zoned for and performs operations similar to those to be undertaken by the X-33 Program. Therefore, its land use designations are compatible

with the missions of the Program. No site preparation would be required. Therefore, the X-33 Program would not impose any changes in or impacts on land use at China Lake (USN 1989).

4.2.2.16 Snow Avalanche

No ski areas or mountain passes are located along the proposed flight path or within the area expected to receive sonic boom overpressure. Therefore, no increased danger of injury or structural damage resulting from snow avalanche is anticipated as a result of flight operations to the China Lake landing site.

4.2.3 Michael Army Airfield Within Dugway Proving Ground, Utah

Approximately seven X-33 landings at this site with a 7-day turnaround period would occur to flight test the vehicle at speeds of Mach 9 to 12 (6,600 to 8,800 mph). Also required would be the landing of the Boeing 747 to air ferry back the X-33. Refueling of the 747 would be required and handled by existing facilities. Existing runway and infrastructures are in place to support the X-33 landings and operations (approximately 24 hours each); therefore, no site preparation or ground disturbance would be required. Approximately 50 to 75 on-site personnel would be required to support these activities. The field crew would be on Dugway approximately one week for each landing. Equipment for venting of LH_2 and LOX would be brought in as part of landing preparation. Safing activities would be accomplished by gradually venting these propellants to the atmosphere and purging with inert gaseous helium. Safing and venting locations would be sited in accordance with the explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions.

4.2.3.1 Site Infrastructure

Runway

Michael Army Airfield has a hard surface runway 4,000 m (13,124 ft) long by 61 m (200 ft) wide. There are approximately 7 proposed test flights into Dugway with a 7-day turnaround period. The runway can accommodate both landings of the X-33 and Boeing 747 vehicles and takeoff of the 747/X-33 configuration without modifications; therefore, no impacts are expected.

Water Supply and Distribution

The X-33 workforce would require water for both potable and sanitary uses. Each retrieval operation would utilize approximately 284,000 L (75,000 gal) of water to wash down the vehicles, if required. The additional X-33 employees represent a small increase to the population currently on-base. No modifications to existing water systems would be required to provide the estimated 8,520 L (2,250 gal) for each day that X-33 operations are conducted on site. Combined with the temporary nature of the X-33 workforce presence, X-33 is expected to have a minimal impact on the water supply at Dugway.

Wastewater

Wastewater from the X-33 would consist of approximately 8,520 LPD (2,250 GPD) of domestic wastewater resulting from 50 to 75 additional personnel. Industrial wastewater would be approximately 284,000 L (75,000 gal) resulting from washing down the spaceplane and the 747 after landing. The amount of extra wastewater involved for each landing/retrieval operation is minimal compared to the normal daily wastewater flows from current onsite operations. The exact amount of excess wastewater treatment capacity was not available. However, the wastewater volumes anticipated to be generated for the temporary X-33 landing activities are very small. Therefore, X-33 is expected to have a minimal impact on the wastewater systems at Dugway.

Electricity

The relatively short duration of each of the landing/retrieval operations, and the lack of any electric power-intensive activities during retrieval, would be expected to have minimal impacts upon electricity demand at the landing site.

Communications

Telephone and radio networks are in place and adequate to cover X-33 Program needs; therefore, overall impact would be none.

Fuel

Michael Army Airfield is equipped with aircraft fueling facilities and supplies. Refueling of the 747 would be required for each of the return flights back to Edwards. Fuel-related impacts from X-33 motor vehicles, aircraft operations, and processing of the X-33 spaceplane and 747 would be minimal. Equipment for off-loading and venting of LH_2 would be brought in as part of landing preparation.

4.2.3.2 Hazardous Materials and Hazardous Waste

The primary hazardous materials associated with the X-33 landing and retrieval operations would be residual propellants in the vehicle (up to 680 kg (1,500 lb) of LH_2 and up to 340 kg (750 lb) of LOX). Safing activities would be accomplished by gradually venting these propellants to the atmosphere and purging with the inert gas helium. No adverse impacts would be associated with defueling since all three gases are normal constituents of the atmosphere.

Generation of hazardous waste at Dugway is not projected. Should a small need arise, the hazardous waste would be managed through Dugway's existing hazardous waste management system. Overall impact is expected to be minimal.

Propellant Safety

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, the safing and venting location would have to be sited in accordance with the explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. See Section 4.2.3.11 for further details.

Transportation of Hazardous Materials

Hazardous materials required for landing retrieval operations are anticipated to be small in volume (liters (gal)) and would be transported to and from the landing site in approved containers. The small hazardous material usage would result from operation such as small field cleaning and servicing of equipment. No impacts to transportation systems are expected.

Contamination

X-33 landing/retrieval operations would not be conducted in any known areas of existing contamination. All landing/retrieval operations activities would be conducted in accordance with existing base requirements for the prevention of releases to the environment. No impacts are expected.

4.2.3.3 Solid Waste

Nonhzardous solid waste generated by the X-33 Program would consist of a relatively minimal amount of debris and waste generated by Program personnel during normal operations. All solid waste would be containerized for disposal. Minimal impact is expected.

4.2.3.4 Air Quality

Dugway is located in an area designated as attainment for all of the criteria pollutants; therefore, there are no conformity issues to be addressed according to the federal general conformity regulations. Air emissions for landing support activities would be 2.3 times greater than those for China Lake because of 7 landings baselined for Dugway versus 3 for China Lake provided in Table 4-10 of Section 4.2.2.4. Air emission releases for 1999, the only year of potential impact, would be: (1) for NO_2, 9.5 mtpy (10.5 tpy); (2) for VOC's, 2.5 mtpy (3.0 tpy); and (3) for PM_{10}, 7.1 mtpy (7.9 tpy). Contributions of the ground support equipment required to return the X-33 to Edwards for the approximate number of landings in 1 year are expected to be minimal.

4.2.3.5 Airspace and Air Traffic

Significant portions of proposed flights of the X-33 from Edwards to Michael Army Airfield on Dugway Proving Ground would involve overflight or flight through restricted military airspace which would be coordinated and approved in advance by the Air Force Flight Test Center with Nellis Air Range and the Utah Test and Training Range (Figure 4-38). Total estimated flight time from Edwards to Dugway would be 13 minutes. When active, no civil or commercial flight operations are allowed to occur within these military restricted zones. All air traffic within the X-33 approach zone, approximately 19 km (12 mi) wide by 34 km (21 mi), and including the air field would need to be restricted in time to clear aircraft from the airspace prior to launch until the X-33 lands or launch is delayed. This airspace could be restricted from 1.5 to 4 hours per landing.

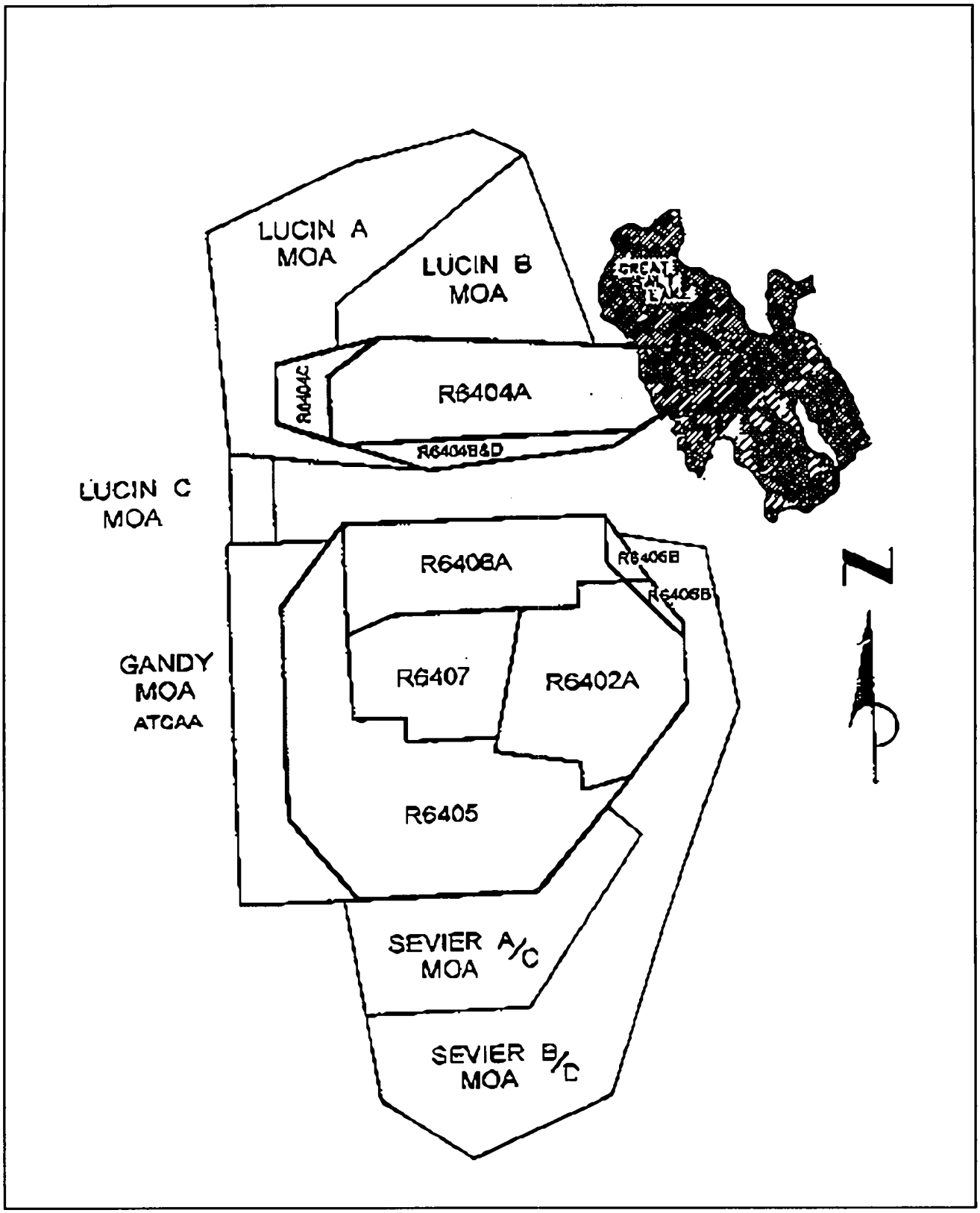


Figure 4-38. Utah Test and Training Range (UTTR) Restricted and Controlled Airspace (AFFTC 1994).

There are also four high altitude (5,500 m to 18,300 m altitude (18,000 ft to 60,000 ft)) and low altitude (surface to 5,500 m (18,000 ft)) flight sectors that would be influenced by the Michael Army Airfield flight track, with the busiest day being Thursday, affecting approximately 1,887 flights during a 24-hour period, while Monday being the least busy, totaling 346 flights during a 24-hour period. Further details of air traffic within the Class A airspace of the Federal Aviation Administration (FAA) are provided in Appendix D. Even though three sectors have no reported data for certain days, it appears that the least traveled times by commercial and general aviation aircraft range from 1 a.m. to 6 a.m., local time. X-33 flights are expected to be conducted in daylight hours with the most probable times of launch being near 6 a.m. Pacific Standard Time (PST).

Overflight of the FAA-controlled airspace would require issuance of NOTAMs which would contain information (not known sufficiently in advance to publicize by other means) concerning the establishment or change in any component (facility, service, or procedure of, or hazard) in the National Airspace System, the timely knowledge of which is essential to personnel concerned with flight operations. Procedures for implementing NOTAMs are described in FAA Advisory Circular No. 150/5200-28B, "Notices to Airmen (NOTAMs) for Airport Operators."

Because ascent and descent of the X-33 will occur within military restricted airspace for these purposes and no request for sterile airspace, void of aircraft, for temporary restriction of FAA Class A airspace within the National Airspace System would be required, minimal impact to air space and air traffic is expected. Flight safety issues are discussed separately in Section 4.3.

4.2.3.6 Biological Resources

Vegetation

Existing facilities would be used at Michael Army Airfield for X-33 activities, and no site preparation or ground disturbance or construction is required or planned. No impacts to vegetation would be anticipated from the X-33 project.

Wetlands and Floodplains

None of Dugway's 989 ha (2,444 ac) of jurisdictional wetlands or 17,046 ha (42,121 ac) of designated waters of the U.S. are located near the airfield. The runway is not in the 100-yr floodplain. Therefore, no effects from the X-33 landings would be expected on wetlands and floodplains.

Wildlife

Sonic booms from X-33 landings are expected to produce maximum overpressures of 0.10 to 0.40 kPa (2 to 8 psf) in a small area approximately 24 km (15 mi) west of the runway. Less intense sonic boom overpressures in the range of 0.05 to 0.10 kPa (1 to 2 psf) would be experienced at the distances of approximately 16 km (10 mi) in all directions of the runway. There are 1 amphibian, 12 reptile, 199 bird, and 39 mammal species documented on Dugway (DPG 1996B; DPG 1996C; DPG 1996D). Sonic booms from the X-33 at pressures between

0.01 and 0.06 kPa (0.2 to 1.2 psf) are expected to occur when the vehicle is approximately 97 km (60 mi) from the landing strip. Impacts from sonic booms to wildlife in natural situations are extremely difficult to study or predict. In general, mammals and raptors do not panic when exposed to sudden intense noise; whereas, waterfowl are more likely to injure themselves or their young when suddenly frightened (Bowles 1997). After fewer than five exposures, most animals become habituated to the noise and show little response. Animals that are accustomed to other human disturbances are less likely to panic. In research conducted on pronghorn antelope, Rocky Mountain elk, and bighorn sheep, exposure to sonic booms caused a slight rise in heart rate after the initial disturbance (USAF 1992B). Startle responses decreased for subsequent booms and were soon less than those evoked by humans walking into the animal pens, or by bees and biting flies bothering the animals. In a study on cliff-nesting raptors exposed to the noise from underground nuclear explosions, damage to or desertion of nests was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). Although quantitative information for most species is lacking, the available data indicate that exposure to sonic booms in the pressure ranges expected from X-33 would not likely have deleterious effects on wildlife populations.

4.2.3.7 Threatened, Endangered, and Sensitive Species

Vegetation

Existing facilities would be used at Michael Army Airfield, and no site preparation or ground disturbance is planned. Therefore, no impacts to vegetation are anticipated from the X-33 project.

Wildlife

The federally endangered peregrine falcon (*Falco peregrinus*) and the state-protected ferruginous hawk (*Buteo regalis*) have been documented nesting in the mountain cliffs located on Bureau of Land Management's property adjacent to Dugway. Nesting raptors may be exposed to sonic booms less than 0.05 kPa (1 psf) during landings. Short-term startle effects are expected to be minimal, as raptors appear to have little susceptibility to nest losses caused by sudden noise (Bowles 1997). In a study on cliff-nesting raptors exposed to the noise from underground nuclear explosions, damage to or desertion of nests of red-tailed hawks (*Buteo jamaicensis*) and golden eagles (*Aquila chrysaetos*) was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). In a different study, of six pairs of nesting peregrine falcons (12 birds total) exposed to sonic booms, half showed no response to the noise and half showed a mild alarm response. None of the adults that were incubating or brooding exhibited behavior that would endanger eggs or young in the nest (Ellis/Mindell 1991). Nestling and fledgling responses were either insignificant or mild, and no young were injured or killed. Long-term effects from X-33 sonic booms are also expected to be absent or minimal. Since 1990, bald eagles nesting on the Kennedy Space Center have been exposed to 15 sets of twin sonic booms produced by the Space Shuttle landings. The number of nests during those years steadily increased from 4 in 1990 to 10 in 1997, and the number of fledged young per year ranged from 5 to 13 (Whaley 1997). At Dugway, no damage to peregrine nests, eggs, or young from rocks falling as a result of sound waves is expected, because of their habit of placing the nest under

shelter. In addition, the likelihood of a noise-induced rockslide at the low pressure expected over the mountain ranges is very small. Given the low density of nesting peregrine falcons and ferruginous hawks in the vicinity, and the short duration of the X-33 project at the site, it is not likely that X-33 activities would adversely affect either population.

Two other wildlife Utah species of special concern, which occur near Michael Army Airfield on Dugway, are the western burrowing owl (*Speotyto cunicularia*) and the kit fox (*Vulpes macrotis*). Impacts from sonic booms to wildlife in natural situations are extremely difficult to study or predict. In general, mammals and raptors do not panic when exposed to sudden intense noise; whereas, waterfowl are more likely to injure themselves or their young when suddenly frightened (Bowles 1997). After fewer than five exposures, most animals become habituated to the noise and show little response. Animals that are accustomed to other human disturbances are less likely to panic. In research conducted on pronghorn antelope, Rocky Mountain elk, and bighorn sheep, exposure to sonic booms caused a slight rise in heart rate after the initial disturbance (USAF 1992B). The startle responses decreased for subsequent booms and were soon less than those evoked by humans walking into the animal pens, or by bees and biting flies bothering the animals. In a study on cliff-nesting raptors exposed to the noise from underground nuclear explosions, damage to or desertion of nests was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). Although quantitative information for most species is lacking, the available data indicate that exposure to sonic booms in the pressure ranges expected from X-33 would not likely have deleterious effects on wildlife populations.

4.2.3.8 Cultural Resources

There are no plans to construct or modify any facilities at Dugway to support the X-33 Program. Therefore, no effects to cultural sites or facilities are expected.

4.2.3.9 Water Resources

Impacts to water resources from X-33 would be due to water demands to meet the domestic needs of employees and industrial uses of water for potential wash down of the vehicles. Since only 50 to 75 additional workers would be employed, demand for water would be expected to increase by the same volumes as estimated for waste water in Section 4.2.3.1 which is a minimal amount in comparison to water usage in support of normal operations; therefore, impacts are expected to be minimal.

4.2.3.10 Geology and Soils

The proposed action would result in no impacts to the geology and soils at the Dugway landing site since no construction would be required to support the X-33 landings, and associated activities in order to return the vehicle to Edwards.

4.2.3.11 Health and Safety

Upon landing, there will be minor residual amounts of LH_2 and LOX as previously described (see Section 4.2.3.2). At the landing site, following wheel stop, the vehicle would automatically perform subsystem safing functions and reduce power consumption to minimize safety risks to personnel. After approximately one hour from wheel stop, the vehicle would be towed to the staging area for final safing.

The calculated quantity-distance clear zone that would be maintained due to the explosive potential of the remaining LH_2 and LOX is 137 m (450 ft). Non-essential personnel would be kept outside of this area until the LH_2 and LOX has been totally vented and purged. Dugway would be able to meet the required clear zone at an area in the vicinity of the runway as approved by Dugway safety and other base authorities. Safing operations would require up to 12 hours.

Landings would be from the northwest toward the southeast. The Ditto Area, which contains office and laboratory facilities, is at the southern end of the runway. In the unusual circumstance that the vehicle uses the entire runway, it would stop within 305 m (1,000 ft) of the Ditto Area. The runway is 4,000 m (13,000 ft) long and the X-33 would require 2,400 m (8,000 ft) to land. A Landing Site Safety Plan discussed below would be developed to ensure an adequate personnel clear zone is maintained.

The X-33 Program plans to use the northwest decontamination pad for staging and safing. This area is a concrete pad (92 by 92 m (300 by 300 ft)) set over 152 m (500 ft) from the runway with a significant surrounding buffer zone.

Venting of LH_2 tanks would be accomplished in a cyclic, controlled process until no LH_2 is left in the tanks. The gaseous residual hydrogen would then be purged with helium delivered by tube trailers to render the vehicle "safe" from any hydrogen explosive potential. A similar safing operation for residual LOX would be performed before the vehicle was rendered totally "safe."

In addition to the Ditto Area, another area of concern is an ammunition storage facility approximately 1.6 km (1.0 mi) from the runway. Since Michael Army Airfield is a fully operational military airfield, significant emergency response capability is already in place with highly trained personnel available. A Landing Site Safety Plan including emergency response plans addressing failures and accident scenarios would be developed by Lockheed Martin Skunk Works with participation of NASA and coordinated with and approved by the Edwards Range Safety Office, UTTR Range Safety, and Dugway Safety Office. Flight safety and flight termination are discussed in Section 4.3.

Based on these factors, it is expected that there would be a minimal potential for impacts to the health and safety of people and property resulting from X-33 landing operations on Michael Army Airfield.

4.2.3.12 Noise

See Section 3.1.13 for additional background information on noise and its effects.

Operational Noise

Personnel exposure levels in industrial shops and processing facilities at Dugway are routinely monitored for compliance with standards established by Occupational Safety and Health Administration. Seven flight demonstration tests are planned for Michael Army Airfield. The landing noise of the 747 aircraft carrier would be similar to current aircraft operations at the airfield. The X-33 would be unpowered on landing, thus producing less noise than powered jet planes. Personnel areas established by Dugway for current flight operations that meet the 115 dBA maximum sound level established for short exposure by the Department of Labor standards is not exceeded by X-33 or Boeing 747 landings or takeoffs. The only other operation to be performed at the landing site—mounting the X-33 on the back of the 747 aircraft for return to Edwards—would not contribute any measurable noise levels to current recreational and military activities. Therefore, minimal impacts are expected.

Noise and Sonic Boom Footprints

Figure 4-39 shows sonic boom footprints for the nominal trajectory to Michael Army Air Field. The carpet boom increases as the vehicle descends toward the landing site, exceeding 0.05 kPa (1 psf) when the vehicle descends through 34,000 to 27,000 m (110,000 to 90,000 ft) in altitude. Special status properties anticipated to experience low-intensity carpet booms from landings at Michael Army Airfield include Fish Springs National Wildlife Refuge, Great Basin National Park, various National Forest Service lands, and the Skull Valley Indian Reservation (see Table 4-13; Figures 4-40 through 4-42). Most of the descents involve turns that cause maximum focus booms of 0.29 to 0.53 kPa (6 to 11 psf). Maximum focus booms are confined to very narrow focal zones, as discussed earlier. These are less than 91 m (100 yd) wide. Focus booms produced from landings at Michael Army Airfield are expected to be confined to Dugway Proving Ground property (see Table 4-13; Figure 4-42). Outside of the focal zones, the maximum overpressures are in the 0.05 to 0.10 kPa (1 to 2 psf range), comparable to those produced by the Space Shuttle as it descends over Antelope Valley on its approach to landing at Edwards Air Force Base. Figure 4-34 shows a typical sonic boom footprint for a Space Shuttle descent into Edwards. Carpet booms from X-33 would produce potentially very minor damage. The focus booms could crack windows and contribute to other structural damage, but the focal zone is very small and is expected to impact a remote area on Dugway. Therefore overall impact is expected to be minimal.

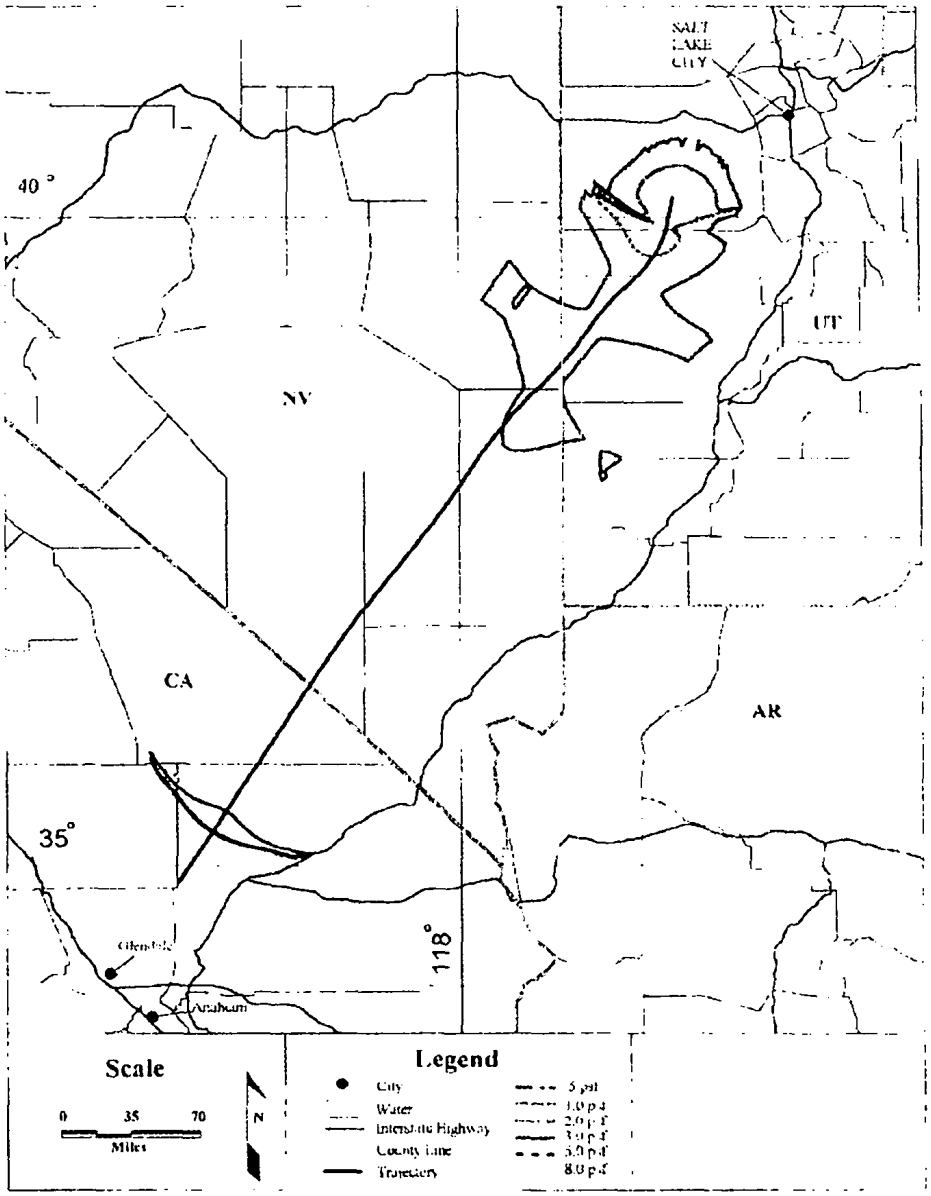


Figure 4-39. Sonic Boom Contours for Nominal Trajectory to Dugway.

Table. 4-13. Impact on Special Status Lands Due to Sonic Booms from X-33 Launches from Edwards Air Force Base Landing at Dugway Proving Ground, Utah.

Launch Focus Boom		Landing Focus Boom		Landing Carpet Boom	
Area Affected	Expected kPa[1] (psf[2])	Area Affected	Expected kPa (psf)	Area Affected	Expected kPa (psf)
BLM[3] lands	up to 0.5 (10.0)	Dugway PG[4]	up to 0.53 (11.0)	Fish Spring NWR[5]	0.05 (1.0)
				Great Basin Nat'l Park	0.02 (0.5)
				Nat'l Forest lands	up to 0.05 (1.0)
				Skull Valley Indian Reservation	0.02 - <0.05 (0.5 - <1.0)

Key:
[1] *kPa = kilo Pascal*
[2] *psf = pounds per square foot*
[3] *BLM = Bureau of Land Management*
[4] *PG = Proving Ground*
[5] *NWR - National Wildlife Refuge*

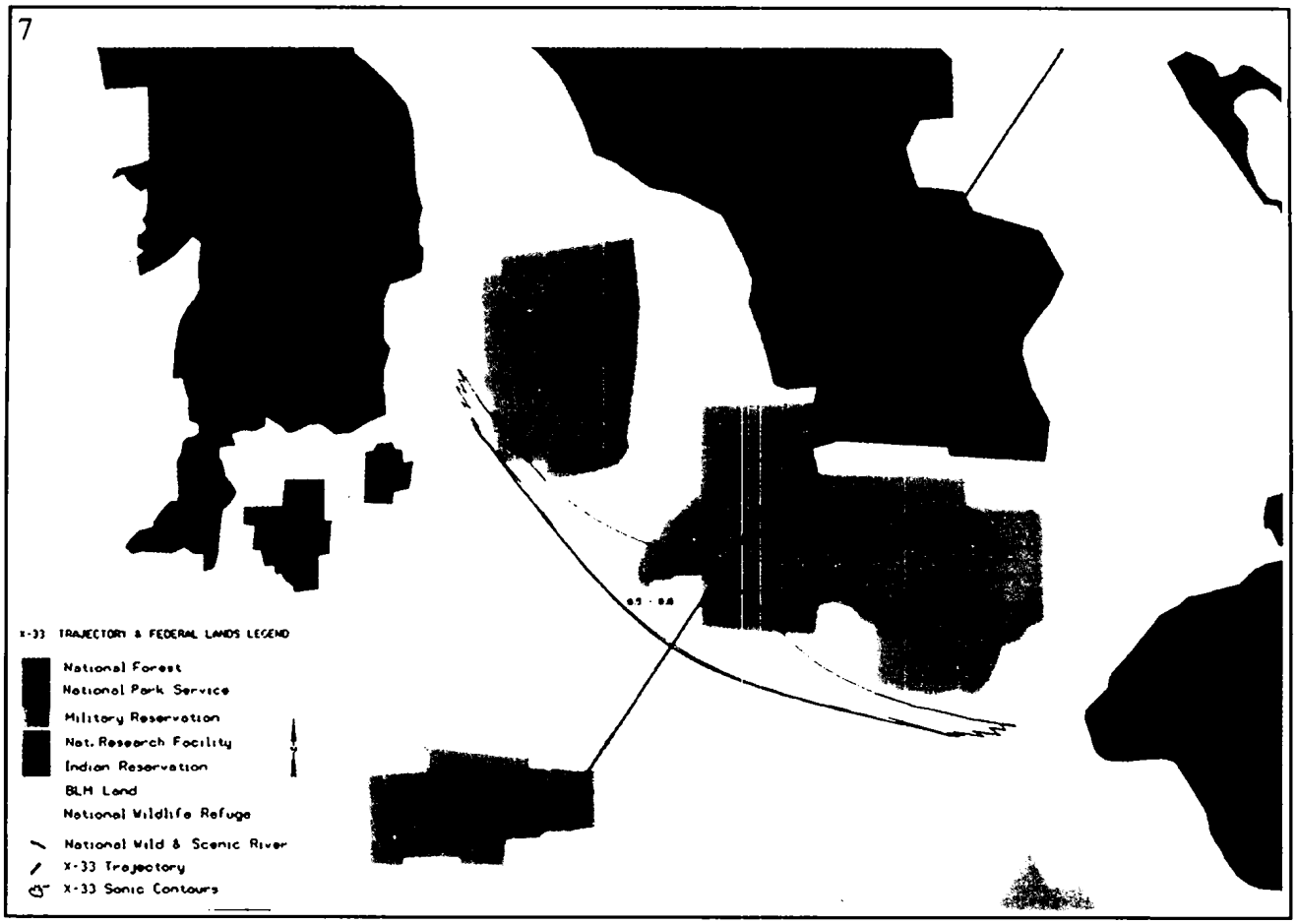


Figure 4-40. Federal and Private Lands at Haystack Butte Exposed to Focus Booms during Launch for flight to Dugway (National Geographic Society 1996).

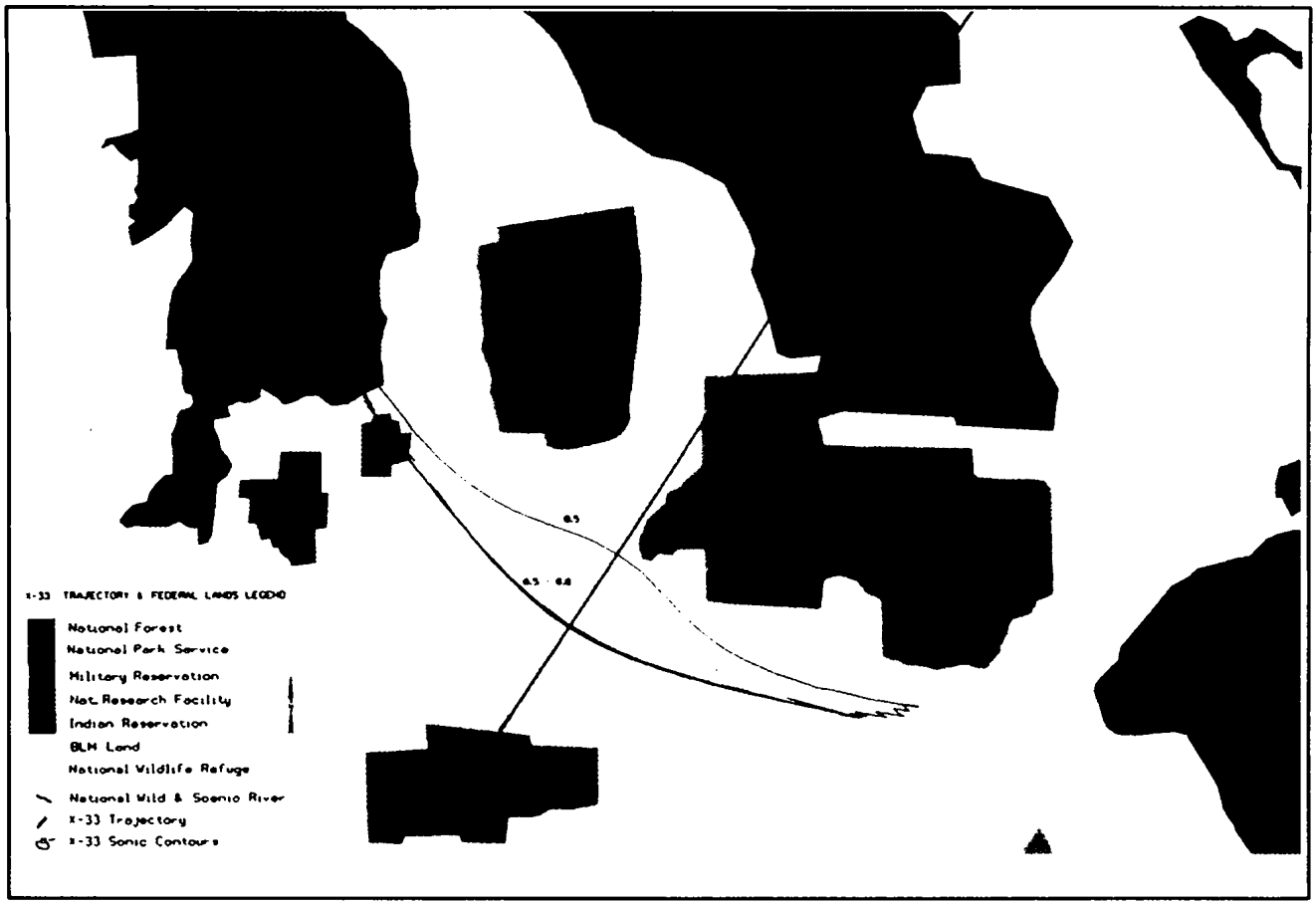


Figure 4-41. Federal and Private Lands at Space Port 2000 Exposed to Focus Booms during Launch for flight to Dugway (National Geographic Society 1996).

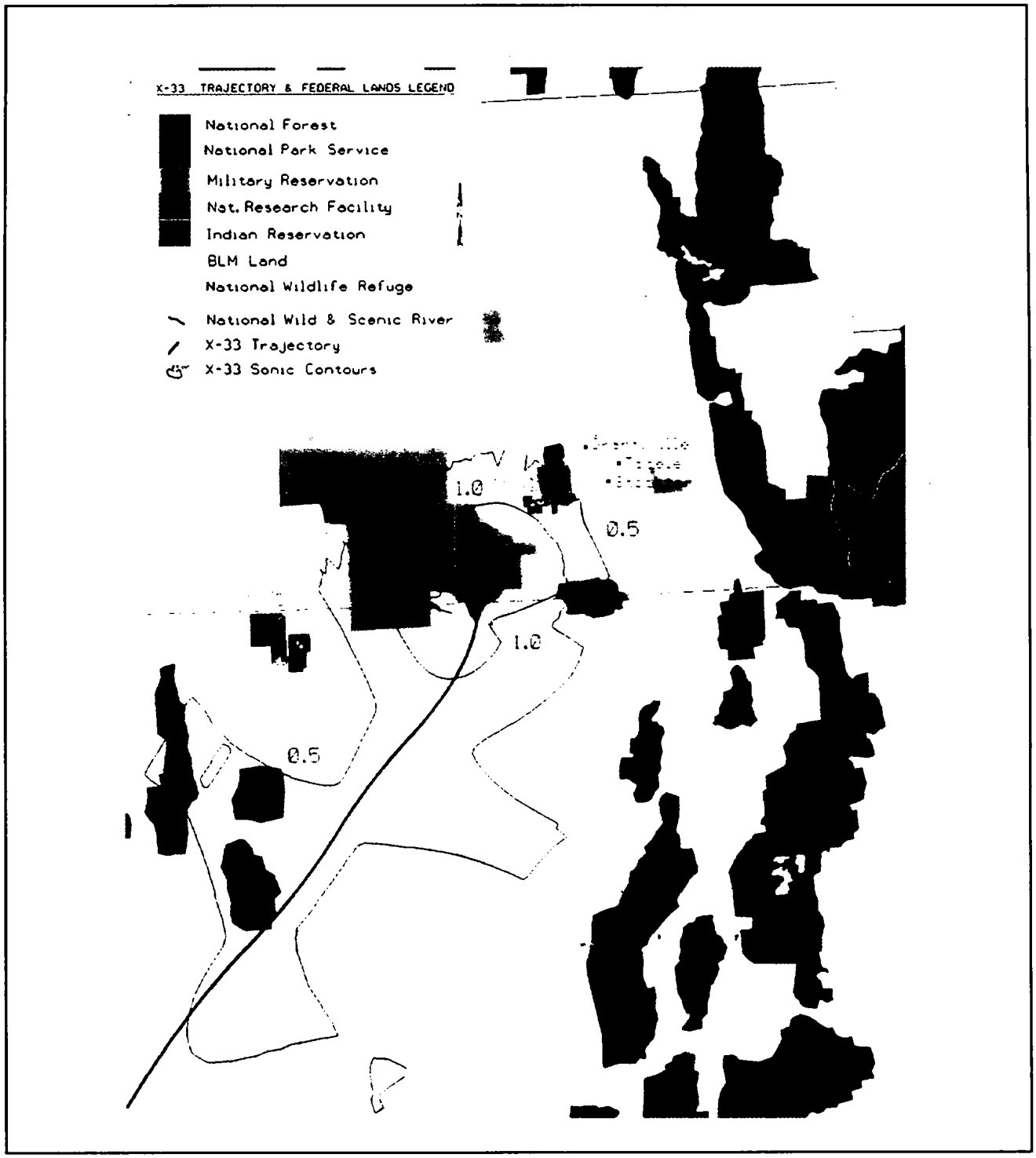


Figure 4-42. Federal and Private Lands at Dugway Exposed to Sonic Booms during landing (National Geographic Society 1996).

4.2.3.13 Transportation

Roadway capacity into Dugway is adequate for existing traffic although slowdowns can occur at gates during morning rush hours. No roadway closures are contemplated. The number of people

involved in the test program would have very little effect on road congestion at any time. Therefore, minimal roadway impact is expected.

4.2.3.14 Population and Employment

Placement of special test equipment at the proposed landing site would be expected to last 6 months or less. Operations would be expected to have an even smaller effect since the proposed landing sites would be staffed only during flight test operations with a small contingent of approximately 50 to 75 personnel. The X-33 Recovery Team employees would not be hired from the local area, but would be part of the existing Program workforce. Up to seven landings are planned at Dugway and would occur in mid-1999. Therefore, impacts are expected to be minimal.

4.2.3.15 Land Use

The Army at Dugway and Air Force at Hill Air Force Base work cooperatively when property of Dugway is involved to accomplish DOD missions. Missions include testing and evaluating unmanned aerospace vehicles (UAV's) and UAV launch and recovery systems. They support testing of weapons systems; training for operational aircrews and other combat units; maintain and operate a variety of aircraft; schedule and monitor flight activities; and provide range support and air traffic control. Dugway and UTTR operations are compatible with the mission of the X-33 Program. Therefore, no impacts are expected on land use at Dugway.

4.2.3.16 Snow Avalanche

Figure 4-39 shows the peak sonic boom overpressures expected to result from normal flight operations from Edwards to the proposed landing site at Michael Army Airfield. Five mountain passes, but no ski areas, are located on or near the proposed flight path. None of the mountain passes are expected to receive sonic boom overpressure of 0.02 kPa (0.5 psf) or higher as a result of X-33 flight operations (refer to Section 3.2.5.17 for details on criteria). Therefore, no increased danger of injury or structural damage resulting from snow avalanche is anticipated as a result of flight operations to Michael Army Airfield.

4.2.4 Malmstrom Air Force Base, Montana

A maximum of five X-33 landings at this site would take place to reach the Mach 15 (11,000 mph) goal of the test flight program. Also required would be the landing of the Boeing 747 to ferry back the X-33. Refueling of the Boeing 747 would be required and handled by existing facilities. The runway would require maintenance to repair deterioration due to freeze/thaw cycles occuring after 1996 closure and proposed used. Flight support equipment required to support the X-33 and Boeing 747 would be accommodated with mobile equipment. The X-33 program would ensure that the runway and associated facilities and navigation systems that are needed are maintained in good operating condition through the life of the program. Approximately 50 to 75 on-site personnel would be required to support flight activities up to five 1-week intervals over about 5 months. Safing activities would be accomplished by gradually venting propellants to the atmosphere and purging with the inert gaseous helium. Safing and venting locations would be sited in accordance with the explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. Malmstrom would be able to meet the required clear zone. A Special Use Permit for restricting all aircraft in a zone 33.6 km (21 mi) long and 19.2 km (12 mi) wide, issued by the FAA, would be required for landing at the base. A temporary restricion of 1.5 to 4 hours would be imposed by NOTAM on the airspace.

4.2.4.1 Site Infrastructure

Runway

The X-33 Program would ensure that the runway and any facilities or systems used or placed at Malmstrom that are no longer there are maintained in good operating condition through the life of the Program. Therefore, the Program would have a major positive impact on these facilities.

Water Supply and Distribution

No modifications to existing water systems would be required to provide the estimated 8,520 L (2,250 gal) for each day the X-33 personnel are on site. Vehicle cleaning and preparation would require approximately 285,000 L (75,000 gal) of water for each landing/retrieval operation. The capacity of the existing water supply is sufficient to meet these temporary demands. No adverse impacts to the existing water supply and distribution system is expected.

Wastewater

Wastewater from the X-33 Program would consist of approximately 8,520 LPD (12,250 GPD) domestic wastewater and approximately 285,000 L (75,000 gal) for each landing/retrieval operation. The impacts to the existing 5.7 MLD (1.5 MGD) treatment facility would be minimal.

Electricity

The electrical capacity of the existing distribution system (lines, transformers, voltage regulators, etc.) is adequate. Therefore, no impact to the system is expected due to the minor and temporary requirements for X-33 Program.

Communications

Telephone and radio networks in place are adequate to accommodate the X-33 Program needs. Therefore, the existing communications system would not be impacted.

Fuel

There is significant excess fuel storage capacity at Malmstrom for the X-33 Program. Therefore, the impacts to fuel should be minimal.

4.2.4.2 Hazardous Materials and Hazardous Waste

The hazardous materials of concern associated with the X-33 landing and retrieval operations would be the residual propellants onboard the vehicle (up to 680 kg (1,500 lb) of LH_2 and up to 340 kg (750 lb) of LOX). Safing activities would be accomplished by gradually venting these propellants to the atmosphere and purging with the inert gas helium. No impacts would be associated with defueling since all three gases are normal constituents of the atmosphere.

Generation of hazardous waste is not expected. Should a need arise, the hazardous waste would be managed through the existing hazardous waste management system. Overall impact is expected to be minimal.

Propellant Safety

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, propellant safing and venting activities would be conducted in an area approved by Malmstrom safety and other base authorities that would accomodate the 160 m (524 ft) explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. See Section 4.2.4.11 for further details.

Transportation of Hazardous Materials

Hazardous materials required for landing retrieval operations are anticipated to be small in volume (liters (gal)) and would be transported to and from the landing site in approved containers. The small hazardous material usage would result from operation such as small field cleaning and servicing of equipment. No impacts to transportation systems are expected.

Contamination

Although there are several areas on th base contaminated by past activities as noted in Section 4.2.4.2, X-33 landing/retrieval operations would not be conducted in any of these known areas of

existing contamination. Landing/retrieval operations would be conducted in accordance with existing base requirements for the prevention of releases to the environment. No impacts are expected.

4.2.4.3 Solid Waste

The amount of solid nonhazardous waste generated by the small number of additional employees would be minimal compared to the waste produced daily by regular base operations; therefore, the impact would be minimal.

4.2.4.4 Air Quality

Malmstrom is located in an area designated as attainment for all of the criteria pollutants and therefore there are no general conformity issues to be addressed according to the federal general conformity regulations. Landing support activities would be essentially the same as those for China Lake. Air emmission rates would be 1.7 times greater than those rates expected for China Lake (see Table 4-10) because 5 landings are baselined for Malmstrom versus 3 landings at China Lake. Air emission releases for 1999, the only year of potential impact, would be: (1) for NO_2, 6.9 mtpy (7.9 tpy); (2) for VOC's, 1.9 mmtpy (2.2 tpy); and (3) for PM_{10}, 5.3 mtpy (5.8 tpy). Contributions of the ground support equipment to air quality for approximately 5 landings in 1 year would be expected to be minimal.

4.2.4.5 Airspace and Air Traffic

The Malmstrom Air Force Base flight path would originate within the R-2508 Complex and also transect the Nellis Air Range established for similar purposes. Overflight of 16 high and low altitude flight sectors within Class A airspace would occur along this flight track. The busiest day for commercial use of these flight sectors is Tuesday, with approximately 4,328 flights during a 24-hour period, while Monday is the least busy, totaling 346 flights during a 24-hour period. Further details are provided in Appendix D. Fifteen sectors have no reported data for Monday, Wednesday, Friday, and Sunday, while two sectors have no reported data at all. The least traveled times by commercial and general aviation aircraft range from 1 a.m. to 6 a.m. X-33 flights are expected to be conducted in daylight hours with the most probable time of launch being near 6 a.m. PST. NOTAMs for overflight of these Federal Aviation Administration Class A airspace areas would be required.

Small privately-owned aircraft such as those used in the agricultural industry and by local residents which use nearby grass fields to land and take off would be required to remain grounded, land at a facility or area outside of the restricted zone, or divert around the area when airspace restriction is in effect. Local notifications at least one week in advance of planned flight times besides NOTAMs would be made as recommended by local FAA and airport officials.

In addition, a sterile airspace, void of aircraft, would be required from FAA for temporarily clearing all aircraft from a zone 33.6 km (21 mi) long and 19.2 km (12 mi) wide along the final

flight track and encompassing the runway (see Appendix D, specifically starting at page D-21, for further details). All aircraft would be excluded from this zone for approximately 1.5 to 4 hours per launch. The estimated flight time from Edwards to Malmstrom is 17 min. Aircraft exclusion would be effected by NOTAM beginning one hour from the scheduled launch time. If the X-33 launch were delayed more than two hours from scheduled launch time, the launch would be rescheduled at least 24 hours later. The NOTAM would be obtained as described in Section 4.2.1.5.

The total number of flights referenced above were over a 24 hour period with the least number of flights occurring between 1 a.m. and 6 a.m. X-33 launch times would be scheduled at or very close to dawn when air traffic is low in density. The temporary restriction of airspace would occur beginning one hour prior to the scheduled launch time. Therefore, it is anticipated that X-33 test flights would most probably occur at a time when air traffic is light. Also, approximately 5 flights would be planned into Malmstrom if selected. This airfield has been closed, and its reopening, if approved through proper DOD authorities and/or Congressional action, would only be for NASA's temporary operations to support X-33 landings at the facility. No other use of this runway is known or anticipated.

Approximately 6 takeoffs and landings, each, would be expected daily from commercial airlines at the Great Falls International Airport from 5 a.m. till 11 a.m. General aviation use would also be anticipated during this same time period. The majority of flight services at the Great Falls International Airport are accommodated at 9:00 a.m. and later each day.

If the application for sterile airspace for Malmstrom is approved by FAA, overall impact is considered moderate. The Great Falls International Airport is approximately 14.4 km (9 mi) west of Malmstrom. The application for sterile airspace would not preclude the use of Great Falls International Airport. However, some flight paths and approaches might have to be modified for a short time in order to land and take-off at the airport.

4.2.4.6 Biological Resources

Vegetation

There would be no land disturbance necessary to support the X-33 landings. Therefore, no impacts to vegetation are expected.

Wetlands and Floodplains

There would be no wetland or floodplain disturbances necessary to support X-33 landings. Therefore, no impacts to wetlands or floodplains are expected.

Wildlife

Sonic booms from the X-33 landings are expected to produce overpressures of 0.01 and 0.06 kPa (0.2 to 1.2 psf) along the flight track in Idaho and Montana. No focus booms are expected. Although quantitative information for most wildlife species is lacking, the available data indicate

that exposure to sonic booms in the pressure ranges expected from the X-33 Program would not likely harm wildlife populations.

4.2.4.7 Threatened, Endangered, and Sensitive Species

Vegetation

No federally protected plant species or Montana Natural Heritage Program species of special concern have been documented at Malmstrom.

Wildlife

No federally protected or sensitive wildlife species have been documented as occurring on Malmstrom. The following bird species of concern nest at Benton Lake National Wildlife Refuge approximately 23 km (14 mi) north of the base: the black tern (*Chlidonias niger*); the largest Montana population (10,000 to 15,000 pairs in 1996) of Franklin's gulls (*Larus pipixcan*); ferruginous hawk (*Buteo regalis*); white-faced ibis (103 pairs in 1996) (*Plegadis cihi*); and western burrowing owl (*Speotyto cunicularia*) (Martin 1997). The anticipated landing schedule for X-33 at Malmstrom is November–December 1999, which is well after the avian nesting season has been completed. No impacts to these sensitive species are expected.

4.2.4.8 Cultural Resources

There are no plans to construct facilities at Malmstrom to support the X-33 Program. Therefore, no effects to cultural sites or facilities are expected.

4.2.4.9 Water Resources

Impacts to water resources as described in 4.2.4.1 would result from demands due to domestic needs of employees and industrial uses of water for vehicle washdown, if required. Site activities for the X-33 and 747 are expected to employ 50 to 75 personnel and be of short duration. Therefore, impacts are expected to be minimal.

4.2.4.10 Geology and Soils

There should be no impact to the geology and soils of Malmstrom from the proposed action.

4.2.4.11 Health and Safety

Upon landing, there would be minor residual amounts of LH_2 and LOX as previously described (see Section 4.2.4.2). At the landing site, following wheel stop, the vehicle would automatically perform subsystem safing functions and reduce power consumption to minimize safety risks to personnel. After approximately one hour from wheel stop, the vehicle would be towed to the staging area for final safing. The staging area would be approved by base safety.

The calculated quantity-distance clear zone that would be maintained due to the explosive potential of the remaining LH_2 and LOX is 137 m (450 ft). Non-essential personnel would be kept outside of this area until the LH_2 and LOX has been totally vented and purged. Malmstrom would be able to meet the required clear zone. From the runway, it is more than 366 m (1,200 ft) to the nearest structure, easily maintaining the clear zone following landing. Malmstrom has numerous stretches of taxiway and a remote "hot pad" which would meet staging area requirements. All of these areas can also meet clear zone requirements. The X-33 Program would coordinate explosive siting requirements with the AFB Explosive Ordnance Disposal Group and USAF Headquarters Space Command, HQ AFSPC/CEPX.

Venting of LH_2 tanks would be accomplished in a cyclic, controlled process until no LH_2 is left in the tanks. The gaseous residual hydrogen would then be purged with helium delivered by tube trailers to render the vehicle "safe" from any hydrogen explosive potential. A similar safing operation for residual LOX would be performed before the vehicle would be "safe."

The runway and associated support equipment at Malmstrom are no longer active, and the crash and rescue capability has been greatly reduced. Airfield closure has diminished the existing capability to respond to any anticipated contingencies. These deficiencies would be addressed in the emergency response plans discussed in Section 4.3. It is anticipated that additional fire and rescue vehicles and crews would be brought in to support landing operations.

Malmstrom is located adjacent to the city of Great Falls with the runway located 8.8 km (5.5 mi) from downtown and 0.8 km (0.5 mi) from the nearest non-military residential area. Other significant facilities in the vicinity of the runway include:

- Weapons Storage Area 305 m (1,000 ft) from the north end of the runway
- military barracks approximately 305 m (1,000 ft) west of the runway
- military housing area approximately 366 m (1,200 ft) west of the runway
- missile handling facility 183 m (600 ft) east of the runway
- day care center approximately 1.6 km (1 mi) from the runway.
- Highway 89 which runs perpendicular to the south end of the runway.

Protection of these facilities would be addressed in the Landing Site Safety Plan (see Section 4.3). The Landing Site Safety Plan would be prepared by Lockheed Martin with NASA participation and coordinated with and approved by AFFTC on Edwards, Malmstrom Safety Office, Headquarters, USAF (HQ USAF), and Headquarters, Air Force Space Command (HQ AFSPC).

Based on the above data, impacts are considered minor.

4.2.4.12 Noise

See Section 3.1.13 for additional background information on noise and its effects.

Operational Noise

Personnel exposure levels in industrial shops and processing facilities at Malmstrom are routinely monitored for compliance with standards established by Occupational Safety and Health Administration. Up to five flight demonstration tests are planned for landing at Malmstrom. Actions taken as a result of the Air Installation Compatible Use Zone study have reduced the noise effects on adjacent communities. Landing noise of the 747 aircraft carrier would be similar to previous aircraft operations at Malmstrom. The X-33 would be unpowered on landing, thus producing less noise than powered jet planes. Personnel areas established by Malmstrom for past flight operations that met the 115 dBA maximum sound level established for short exposure by the Department of Labor standards would not be exceeded by X-33 or Boeing 747 landings or takeoffs. The only other operation to be performed at the landing site—mounting the X-33 on the back of the 747 aircraft for return to Edwards—would not contribute any measurable noise level to current recreational and military activities. Therefore, only minimal impacts are expected.

Noise and Sonic Boom Footprints

Figure 4-43 shows sonic boom footprints for the nominal trajectory to Malmstrom. The carpet boom increases as the vehicle descends toward the landing site, exceeding 0.05 kPa (1 psf) (see Table 4-6) when the vehicle descends through 34,000 to 27,000 m (110,000 to 90,000 ft) in altitude. Special status areas anticipated to experience low-intensity carpet booms from landings at Malmstrom include Benton Lake National Wildlife Refuge, BLM lands, Lewis and Clark National Forest, other National Forest lands, and one section of the Missouri River that is part of the National Wild and Scenic River System (Table 4-14; Figure 4-46). The descent into Malmstrom, is not expected to produce a focus sonic boom, and the overpressure remains below 0.08 kPa (1.6 psf). The landing footprint is similar in character to that associated with Space Shuttle entry. Figure 4-34 shows a typical sonic boom footprint for a Space Shuttle descent into Edwards over the Antelope Valley. Due to low overpressure and no projected focus booms, impact is expected to be minimal.

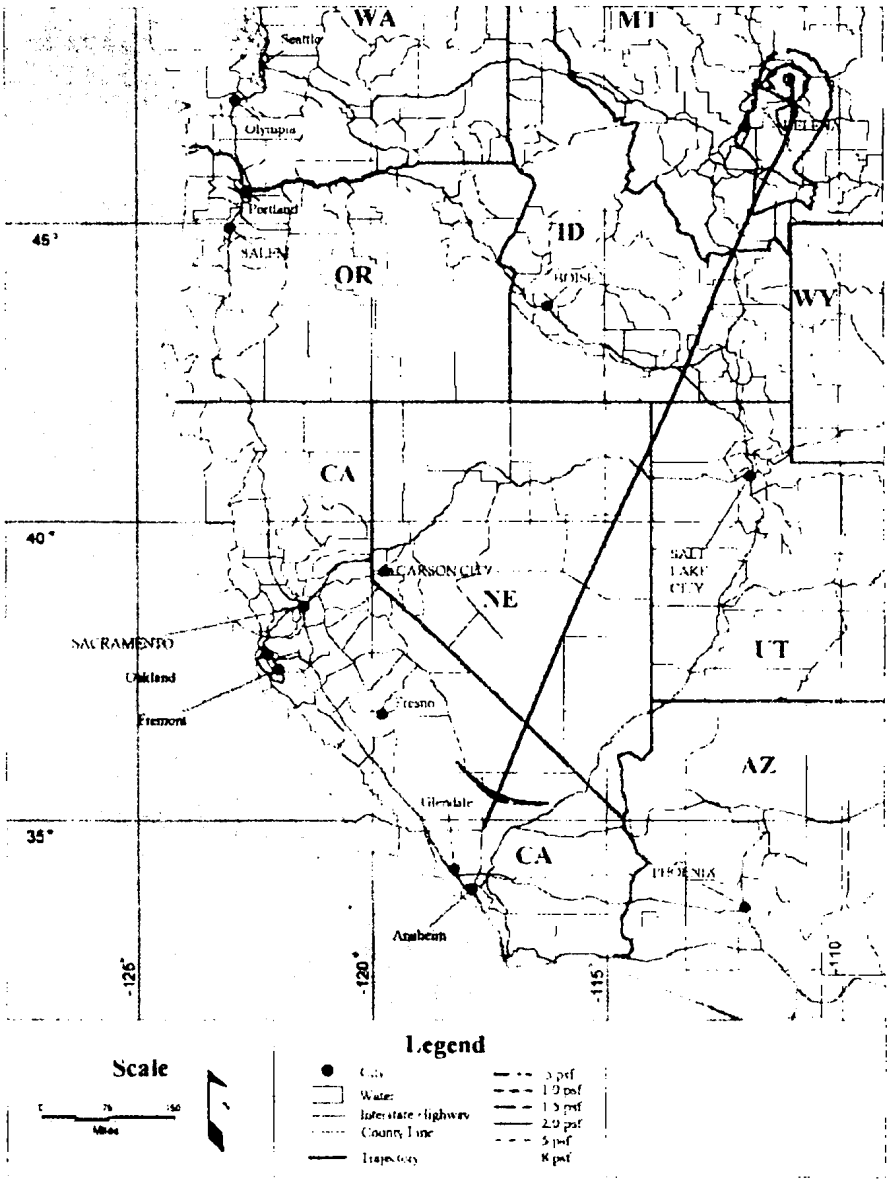


Figure 4-43. Sonic Boom Contours for Nominal Trajectory to Malmstrom.

Table. 4-14. Impact on Special Status Lands Due to Sonic Booms from X-33 Launches from Edwards Air Force Base Landing at Malmstrom Air Force Base, Montana.

Launch Focus Boom		Landing Focus Boom		Landing Carpet Boom	
Area Affected	**Expected kPa[1] (psf[2])**	**Area Affected**	**Expected kPa (psf)**	**Area Affected**	**Expected kPa (psf)**
BLM[3] lands	up to 0.5 (10.0)	none expected	none expected	Benton Lake NWR[4]	0.05 (1.0)
China Lake NAWC[5]	up to 0.5 (10.0)			BLM lands	0.02 - <0.05 (0.5 - <1.0)
				Lewis and Clark Nat'l Forest	0.02 - 0.05 (0.5 - 1.0)
				Nat'l Wild & Scenic River	0.05 (1.0)
				Other Nat'l. Forest lands	0.02 (0.5)

Key:
[1] *kPa = kilo Pascal*
[2] *psf = pounds per square foot*
[3] *BLM = Bureau of Land Management*
[4] *NWR = National Wildlife Refuge*
[5] *NAWC = Naval Air Warfare Center*

During ascent, focus booms would be generated approximately 32 km (20 mi) downrange of the launch pad. As shown in Figures 4-44 and 4-45 for trajectories originating at Haystack Butte and Space Port 2000, respectively. These sonic booms would be as high as 0.5 kPa (10.0 psf). Possible damage to structures could include cracked windows, cracked plaster, etc. See Table 4-6 for additional damage information.

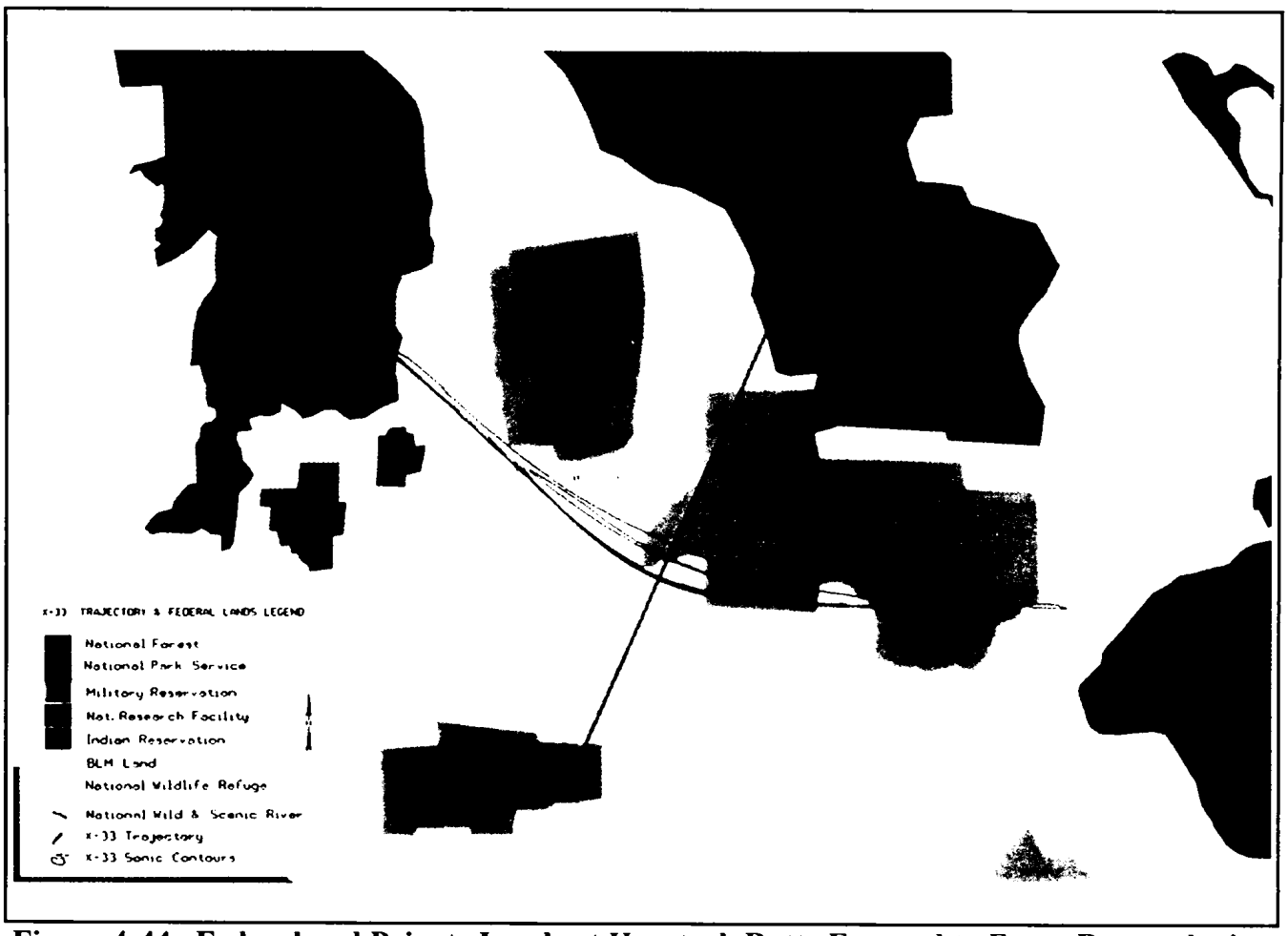


Figure 4-44. Federal and Private Lands at Haystack Butte Exposed to Focus Booms during Launch for flight to Malmstrom (National Geographic Society 1996).

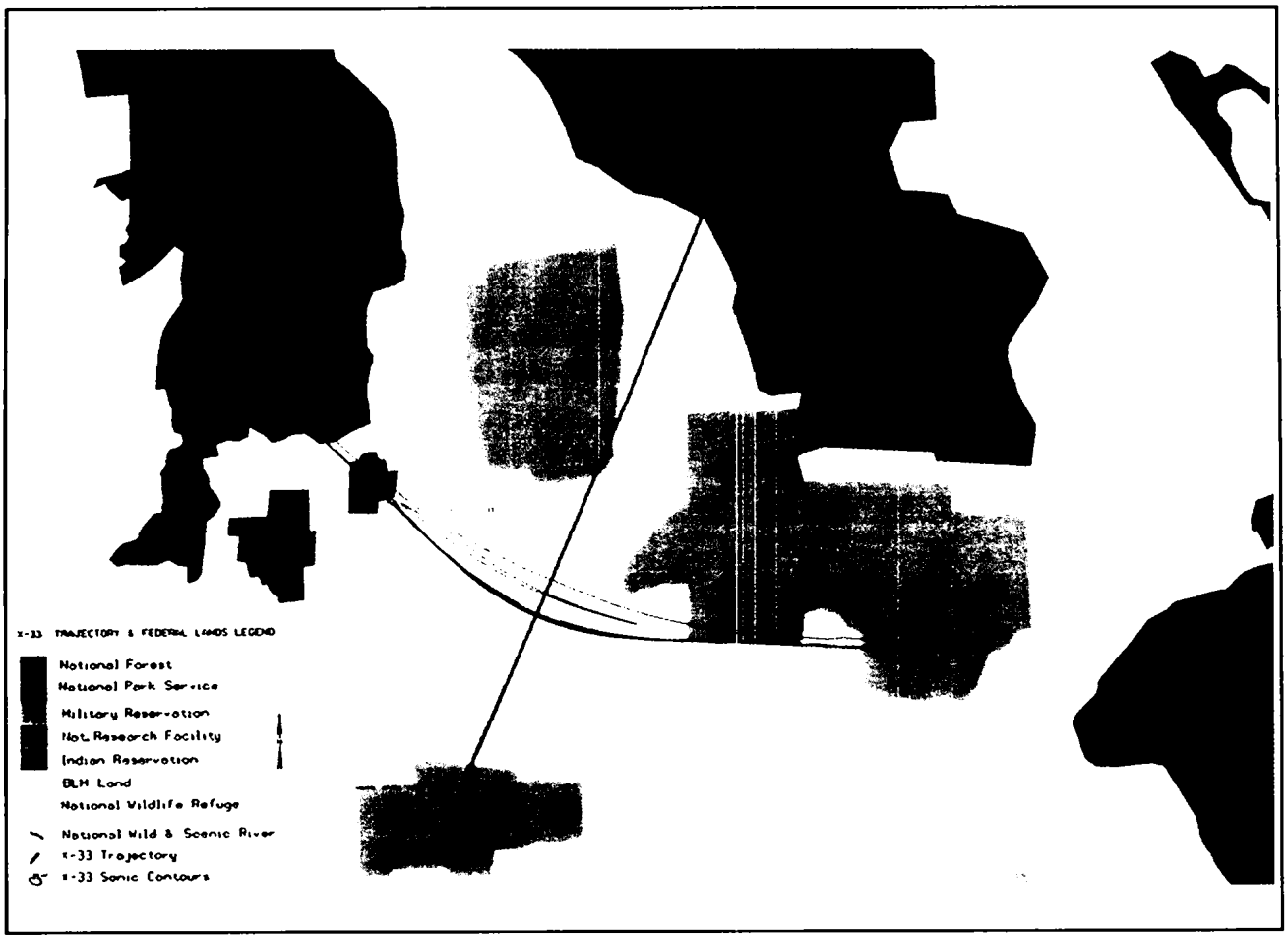


Figure 4-45. Federal and Private Lands at Space Port 2000 Exposed to Focus Booms during Launch for flightto Malmstrom (National Geographic Society 1996).

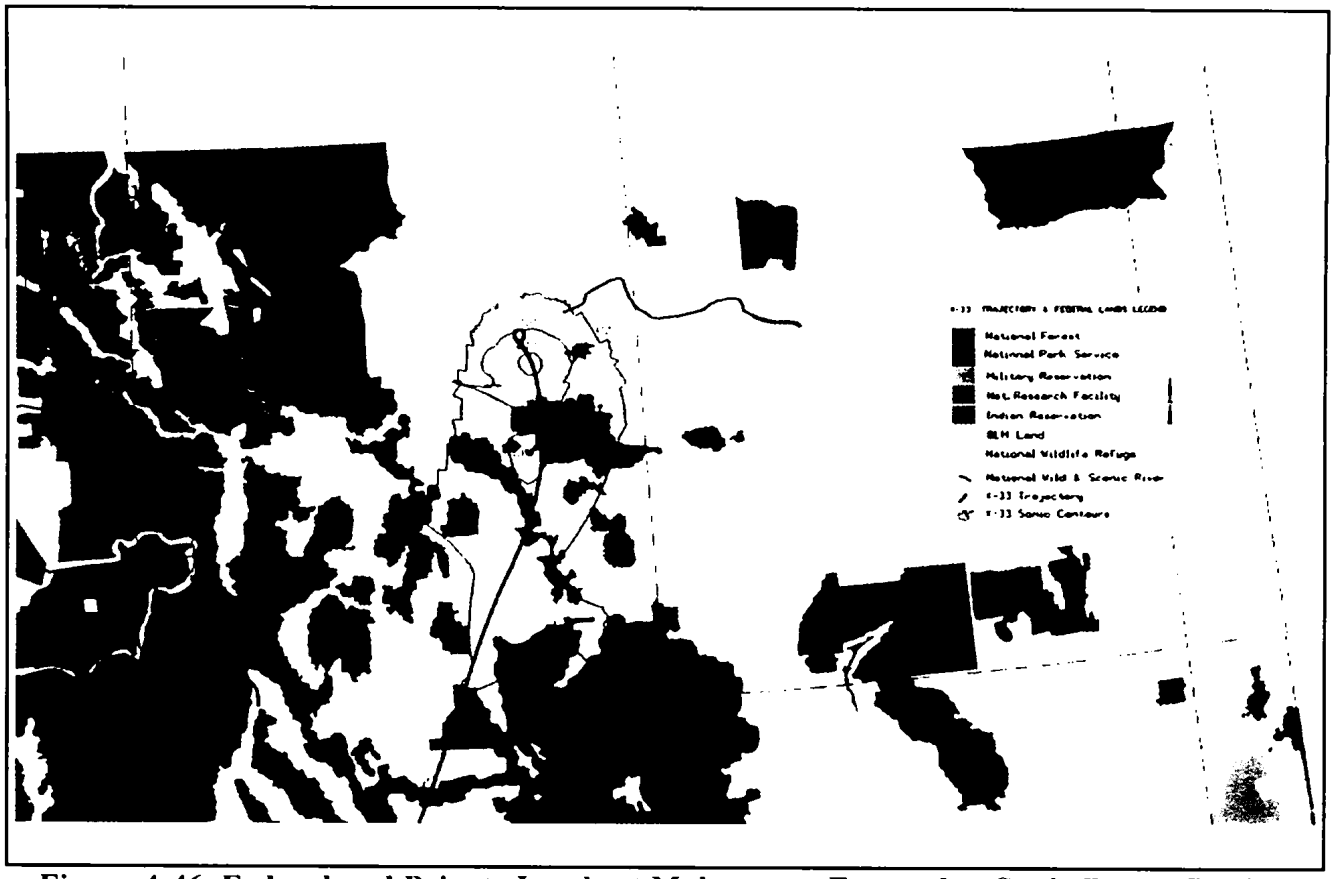


Figure 4-46. Federal and Private Lands at Malmstrom Exposed to Sonic Booms During Landing (National Geographic Society 1996).

4.2.4.13 Transportation

There are major roads as well as good internal roadway networks. No roadway closures are planned. Roadway capacity is adequate for existing traffic although slowdowns can occur at gates during morning rush hours. There is also adequate parking at Malmstrom except around the Command Center, but this situation is being addressed. The number of people involved in the test program would have very little effect on road congestion at any time; therefore, no roadway impact is expected.

4.2.4.14 Population and Employment

Operations are expected to have a small effect since the proposed landing sites would be supported only during flight test operations with 50 to 75 workers. X-33 Landing Team employees would not be hired from the local area, but would be part of the existing Program workforce. Therefore, impacts on population are expected to be minimal.

4.2.4.15 Land Use

The airfield is currently zoned for and has the ability to support operations similar to those to be undertaken by the X-33 Program. No new site preparation would be required; therefore, no impacts are expected to the land use at Malmstrom.

To the extent that 49 USC Section 303 (formerly Section 4(f) of the Department of Transportation Act) may be interpreted to apply, the only potential effects of the proposed X-33 operations on parks, recreation areas, and wildlife/waterfowl refuges would be from occasional noise associated with vehicle launches. However, these impacts would be minor and would not substantially impact the use of these areas. For details of impacts, if any, for the environments of the launch and landing site, please see Chapters 3 and 4 of this Final EIS, specifically the particular area of interest (i.e., for Malmstrom, Cultural Resources, see Section 4.2 at Subsection 4.2.4.8) (FAA, July 1997).

4.2.4.16 Snow Avalanche

During overflight of Nevada and Idaho of the X-33 on a flight path to Malmstrom, the X-33 would be at altitudes too high to cause sound overpressures from sonic booms that could conceivably cause snow avalanches. In the latter part of the flight, the X-33 would cause sound overpressures equivalent to a 16 km per hour (10 mph) wind gust which is an overpressure level experienced on a regular basis in winter in mountainous areas whether or not the X-33 overflights occurred. Winds of this speed and higher up to 40 km per hour (25 mph) are common in Montana. Please refer to climate and wind data provided in Section 3.2.4.4 of the Draft and Final EIS. Other factors such as thunder, wind gust, animal motion, and noise (e.g., birds or deer) are equally capable of triggering avalanches and occur much more frequently than X-33 overflights.

Figure 4-42 shows the peak sonic boom overpressures expected to result from normal flight operations from Edwards to the proposed landing site at Malmstrom. Eight mountain passes and five ski areas are located on or near the proposed flight path. One ski area (Showdown) and one mountain pass (Kings Hill) are expected to receive sonic boom overpressures greater than 0.02 kPa (0.5 psf) (Showdown 1997)(see Section 3.2.5.17 for criteria).

The Showdown ski area in Neihart, Montana, consists of 259 ha (640 ac) of skiable terrain that has a maximum elevation of 2,500 m (8,200 ft). Operation typically begins in late November and last until mid-April. Showdown employs snow-cutting as the primary method of artificial release. Periods of high avalanche danger typically occur during the first 10 to 15 days of operation. After this initial settling period, Showdown's three main snow slopes remain stable for the duration of the season (Showdown 1997). A potential for snow avalanche exists at the Showdown ski area for the proposed flight trajectory from Edwards to Malmstrom. To reduce the risk of injury or structural damage resulting from snow avalanche, X-33 flights to Malmstrom would be coordinated with Showdown. Showdown would be provided with the schedule for the X-33 flights indicating the time of day that the overflights would occur, thus allowing the ski area to complete avalanche control operations prior to anticipated X-33 overflights. X-33 launches would be delayed until avalanche clearing is verified.

At an elevation of 2,253 m (7,393 ft), Kings Hill Pass has snow conditions similar to those at the Showdown ski area. The state of Montana does not currently employ any avalanche prevention measures at its mountain passes (Montana 1997). Kings Hill Pass has no record of past problems with snow avalanche. Therefore, no additional risk of injury or damage resulting from snow avalanche at Kings Hill Pass is anticipated as a result of flight operations to Malmstrom.

4.2.5 Grant County Airport, Port of Moses Lake, Washington

A maximum of five X-33 landings at this site would take place to reach the Mach 15 (11,000 mph) goal of the test flight program. Also required would be the landing of the Boeing 747 to ferry back the X-33. Refueling of the Boeing 747 would be required and handled by existing facilities. Existing runway and infrastructures are in place to support X-33 landings and operations (approximately 12 hours each); therefore, no site preparation would be required. Approximately 50 on-site personnel would be required to support these activities up to seven 1-week intervals over about 5 months. Equipment for venting and purging of residual propellants would be brought in as part of landing preparation. Safing activities would be accomplished by gradually venting propellants to the atmosphere and purging with inert gaseous helium. Safing and venting locations would be sited in accordance with the explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. A Special Use Permit for restricting all aircraft in a zone 33.6 km (21 mi) long and 19.2 km (12 mi) wide, isssued by FAA, would be required for landing at the airport. A temporary restriction of 1.5 to 4 hours would be imposed by NOTAM on the airspace. The runway would have to be closed for a period of approximately one hour following landing.

4.2.5.1 Facilities and Infrastructure

Runway

The main runway at the Grant County Airport can easily handle both the X-33 and the 747 ferry vehicle; therefore, no impact to these facilities is expected.

Water Supply and Distribution

Grant County Airport elevated storage tanks were greatly enhanced in 1992 by a new 9.1 million L (2.4 million gal) tank installed in the residential area south of the airport. According to projections in the 1992 Comprehensive Water Plan, the airport and the city's demands as a whole may exceed capacity by the year 2002. Two additional wells, each with an assumed capacity of 9.5 MLD (2.5 MGD), have been recommended for the Grant County Airport system, and would provide sufficient capacity with some redundancy to cover breakdown and other out-of-service conditions.

The X-33 workforce would be onsite for about 1-week during each of the landing/retrieval operations. The potable water supply requirements would be 8,520 LPD (2,250 GPD) for the workforce. Each operation, in addition to the potable water demand of the workforce, would require approximately 284,000 L (75,000 gal) of washdown water for the vehicle. This short-term periodic demand is not expected to adversely impact the water supply system.

Wastewater

Wastewater from the X-33 would consist of approximately 8,520 LPD (2,250 GPD) of domestic wastewater resulting from additional personnel and approximately 5,700 LPD (1,500 GPD) industrial wastewater resulting from washing down the spaceplane and 747 after landing. Given

the small 50 to 75 person workforce, and the short-term duration of the landing/retrieval operations, impact upon the existing wastewater treatment system would be expected to be minimal.

Electricity

The short-term duration of each landing/retrieval operation, and the lack of any extraordinary electricity demand by those operations would produce minimal impact to existing supplies.

Communications

Overall impact to communications services is expected to be minimal.

Fuel

Local vendors supply aircraft and other fuels to the airport. Impacts on fuel supplies and the distribution system from motor vehicles servicing the X-33 and aircraft operations (including fueling of the 747) would be minimal.

4.2.5.2 Hazardous Materials and Hazardous Waste

The hazardous materials of concern associated with the X-33 landing and retrieval operations would be up to 680 kg (1,500 lb) of LH_2 and up to 340 kg (750 lb) of LOX. Safing activities would be accomplished by gradually venting these propellants to the atmosphere and purging with the inert gas helium. No adverse impacts would be associated with defueling since all three gases are normal constituents of the atmosphere.

Generation of hazardous waste at Moses Lake is not projected. Should a small need arise, the hazardous waste would be managed through the airport's existing hazardous waste management system. Overall impact is expected to be minimal.

Propellant Safety

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, propellant safing and venting activities would be conducted in an area that would accomodate the 160 m (524 ft) explosive safety/quantity-distance separation requirements of DOD 6055.9 and appropriate U.S. Air Force, U.S. Army, and NASA instructions. Any area used by the X-33 would be approved by the Grant County Airport authorities. See Section 4.2.5.11 for further details.

Transportation of Hazardous Materials

Hazardous materials required for landing retrieval operations are anticipated to be small in volume (liters (gal)) and would be transported to and from the landing site in approved containers. The small hazardous material usage would result from operation such as small field cleaning and servicing of equipment. No impacts to transportation systems are expected.

Contamination

X-33 landing/retrieval operations would not be conducted in any known areas of existing contamination. All landing/retrieval operations activities would be conducted in accordance with existing base requirements for the prevention of releases to the environment. No impacts are expected.

Hazardous Waste

Hazardous waste generated by X-33 onsite employees would be handled by existing systems at the airport and would result in minimal impact.

4.2.5.3 Solid Waste

Minimal amounts of nonhazardous solid waste in the form of wastewater, food refuse, etc., is expected to be generated. All solid waste would be containerized for disposal. The amount of solid waste generated would be minimal compared to the waste produced daily by regular base operations. Therefore, the impact would be minimal.

4.2.5.4 Air Quality

Grant County Airport is located in an area designated as attainment for all of the criteria pollutants; therefore, there are no conformity issues to be addressed according to the federal general conformity regulations. Landing support activities would be essentially the same as those for China Lake. Emission estimates would be 1.7 times greater than those provided in Table 4-10 of Section 4.2.2.4 due to a baseline of 5 landings versus 3 at China Lake. Air emission releases for 1999, the only year of potential impact would be: (1) for NO_2, 6.9 mtpy (7.9 tpy); (2) for VOC's, 1.9 mtpy (2.2 tpy); and (3) for PM_{10}, 5.3 mtpy (5.8 tpy). Impacts of the ground support equipment to air quality required to return the X-33 to Edwards for approximately 5 landings in 1 year are expected to be minimal. Permits for use of portable internal combustion equipment such as generators would be obtained if required.

4.2.5.5 Airspace and Air Traffic

The Moses Lake flight path would originate within the R-2508 Complex. The vehicle would fly over 16 high- and low-altitude flight sectors as described in Appendix D with the busiest day being Tuesday, with approximately 5,000 flights during a 24-hour period, and Sunday being the least busy, totaling approximately 2,941 flights during a 24-hour period. The least traveled times by commercial and general aviation aircraft range from 1 a.m. to 6 a.m. However, X-33 flights are expected to be conducted in daylight hours with the most probable time of launch being near 6:00 a.m. PST. NOTAMs for overflight of these Federal Aviation Administration Class A airspace areas would be required.

In a addition, sterile airspace, void of aircraft, would be required from FAA for temporarily clearing all aircraft from a zone 32 km (20 mi) long and 25.5 km (17 mi) wide along the final flight

track and encompassing the runway (see Appendix D, specifically Figure D-11. All aircraft would be excluded from this zone for approximately 1.5 to 4 hours per launch. The estimated flight time from Edwards to Moses Lake is 17 min. Aircraft exclusion would be effected by NOTAM beginning one hour from the scheduled launch time. If the X-33 launch were delayed more than two hours from scheduled launch time, the launch would be rescheduled at least 24 hours later. The NOTAM would be obtained as described in Section 4.2.1.5.

The X-33 Program plans to launch the vehicle at approximately 6 a.m. PST. From 6 a.m. to 10 a.m. PST, Grant County Airport provides daily service for two landings and takeoffs of small commuter aircraft providing commercial passenger service to Moses Lake. These two flights would be delayed from landing or takeoff from the airport for 1.5 to 4 hours causing a temporary, short-term delay in passenger service. Training flights would be delayed until the X-33 has landed and been towed to a staging area for final safing. Small privately-owned aircraft such as those used in the agricultural industry and by local residents would be required to remain grounded, land at a facility or area outside of the restricted zone, or divert around the area when the airspace restriction is in effect. Local notifications at least one week in advance of planned flight time besides NOTAMs would be made as recommended by local FAA and airport officials. Due to the need for temporary sterile airspace and the temporary disruption of commercial,private and pilot training aircraft operations, impact is considered moderate.

4.2.5.6 Biological Resources

Vegetation

Because no site preparation or development would be necessary to support X-33 landings, no impacts to vegetation are expected.

Wetlands and Floodplains

Because no site preparation or development would be necessary to support X-33 landings, no impacts to the one 0.8 ha (2 ac) wetland on the property or on floodplains are expected.

Wildlife

Sonic booms from X-33 landings are expected to produce maximum overpressures of 0.05 to 0.07 kPa (1 to 1.5 psf) in all directions of the runway. The impacts from sonic booms to wildlife in natural situations are extremely difficult to study or predict. In general, mammals and raptors do not panic when exposed to sudden intense noise; whereas, waterfowl are more likely to injure themselves or their young when suddenly frightened (Bowles 1997). After fewer than five exposures, most animals become habituated to the noise and show little response. Animals that are accustomed to other human disturbances are less likely to panic. In research conducted on pronghorn antelope, Rocky Mountain elk, and bighorn sheep, exposure to sonic booms caused a slight rise in heart rate after the initial disturbance (USAF 1992B). The startle responses decreased for subsequent booms and were soon less than those evoked by humans walking into the animal pens, or by bees and biting flies bothering the animals. In a study on cliff-nesting raptors exposed to the noise from underground nuclear explosions, damage to or desertion of

nests was caused by displacement of the ground and not the startled adults flying off the nest (Stahlecker/Alldredge 1976). Although quantitative information for most species is lacking, the available data indicate that exposure to sonic booms in the pressure ranges expected from X-33 would not likely have deleterious effects on wildlife populations.

4.2.5.7 Threatened, Endangered, and Sensitive Species

Vegetation

No protected or sensitive plant species have been documented on airport property or are expected to occur in the surrounding shrub-steppe vegetation community.

Wildlife

Sonic booms from the X-33 could potentially affect nesting birds near the runway, but the anticipated landing schedule for X-33 at Grant County Airport is during the latter stages of the project. Avian nesting season would be completed and no impacts to these sensitive species are expected.

4.2.5.8 Cultural Resources

There are no plans to construct facilities at Moses Lake to support the X-33 Program. Therefore, no effects to cultural sites or facilities are expected.

4.2.5.9 Water Resources

Impacts to water resources due to X-33 would result from demands to meet domestic needs of employees and industrial uses of water for washdown, and discharges to ground and surface waters. Preparation activities for the X-33 and 747 are expected to require approximately 50 to 75 employees temporarily coming in form other locations and would be of short duration; therefore, impacts would be minimal.

4.2.5.10 Geology and Soils

The proposed action would result in no impacts to the geology and soils at the Moses Lake landing site.

4.2.5.11 Health and Safety

Upon landing, there would be minor residual amounts of LH_2 and LOX as previously described (see Section 4.2.5.2).

At the landing site, following wheel stop, the vehicle would automatically perform subsystem safing functions and reduce power consumption to minimize safety risks to personnel. After approximately one hour from wheel stop, the vehicle would be towed to the staging area for final safing.

The calculated quantity-distance clear zone that would be maintained due to the explosive potential of the remaining LH_2 and LOX would be 137 m (450 ft). Non-essential personnel would be kept outside of this area until the LH_2 and LOX have been totally vented and purged. Moses Lake would be able to meet the required clear zone which would be an area approved by Grant Count Airport authorities. The control tower is the only structure within 305 m (1,000 ft) of the runway at Moses Lake. Maintaining the clear zone on the runway poses no issues. Moses Lake has significant flexibility for designation of the staging area. All staging areas being considered are capable of meeting the 305 m (1,000 ft) clear zone.

Venting of LH_2 and LOX tanks would be accomplished in a cyclic, controlled process until no LH_2 and LOX is left in the tanks. The gaseous residual hydrogen would then be purged with helium delivered by tube trailers to render the vehicle "safe" from any hydrogen explosive potential. A similar safing operation for residual LOX would be performed before the vehicle was rendered totally "safe."

A Landing Site Safety Plan including emergency response plans for failures and accident scenarios would be developed by Lockheed Martin with NASA participation and coordinated with and approved by AFFTC on Edwards. Grant Count Airport authorities would have final approval of all plans pertaining to this facility. Flight safety and flight termination is discussed in Section 4.3.

Based on the above plans, it is expected that there would be minimal potential for impacts to the health and safety from landing the X-33 at Grant County Airport.

4.2.5.12 Noise

See Section 3.1.13 for additional background information on noise and its effects.

Operational Noise

Personnel exposure levels in industrial shops and processing facilities at Grant County Airport are routinely monitored for compliance with the Washington Administrative Code. Areas beyond the airport boundaries are zoned to be compatible with aircraft noise. Up to five flight demonstration tests over a period of approximately four months may be planned for landing at Moses Lake. The landing noise of the 747 aircraft carrier would be similar to current aircraft operations at Moses Lake. The X-33 would be unpowered on landing, producing less noise than powered jet planes. Personnel areas and security zones would be set at distances such that the 115 dBA maximum sound level established for short exposure by the Department of Labor standards is not exceeded. The only other operation to be performed at the landing site—mounting the X-33 on the back of the 747 aircraft for return to Edwards—would not contribute any measurable noise level to current recreational and military activities. Therefore, only minimal impacts are expected.

Noise and Sonic Boom Footprint

Figure 4-47 shows the sonic boom footprints for the nominal trajectory to Moses Lake. The carpet boom increases as the vehicle descends toward the landing site, exceeding 0.05 kPa (1 psf) when the vehicle descends through 34,000 to 27,000 m (110,000 to 90,000 ft) in altitude. Several parcels of federal property, including five National Wildlife Refuges and two Indian Reservations, would be expected to experience very low-intensity (0.02 kPa (0.5 psf)) carpet booms from X-33 landings at Moses Lake (Table 4-15; Figures 4-48 through 4-50). The Hanford Site, administered by Fluor Danielfor the Department of Energy, would also be exposed to carpet booms of pressure less than or equal to 0.02 kPa (0.5 psf) (Table 4-15). This site is currently undergoing restoration and management of the radioactive and hazardous wastes generated there during nearly 50 years of defense production. Most of the descents involve turns that cause maximum focus booms of 0.29 to 0.53 kPa (6 to 11 psf). The descent into Moses Lake is not expected to produce a focus sonic boom and the overpressure remains below 0.08 kPa (1.6 psf). The landing footprint is similar in character to that associated with Space Shuttle entry. Figure 4-34 shows a typical sonic boom footprint for a Space Shuttle descent over the Antelope Valley into Edwards.

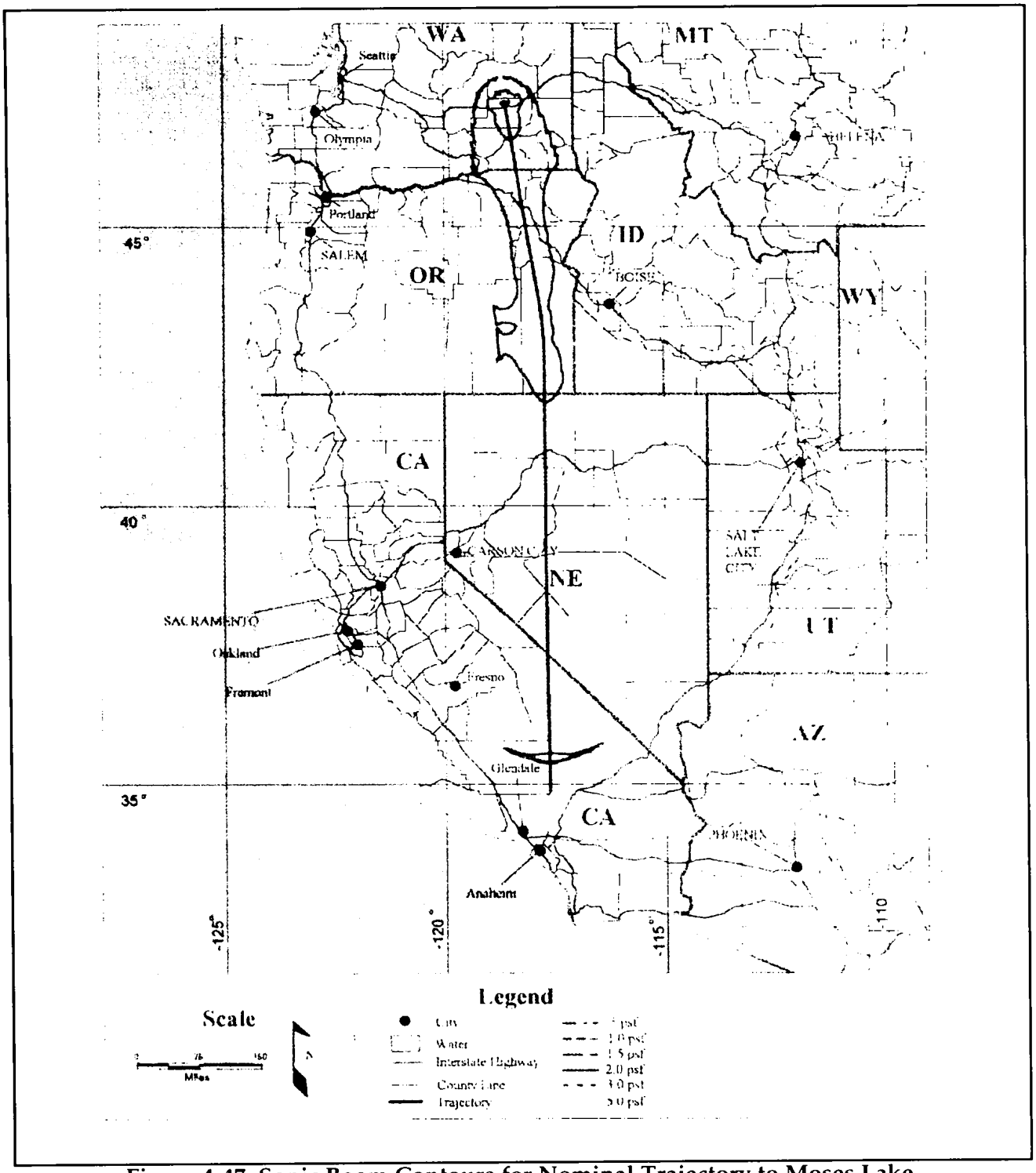


Figure 4-47. Sonic Boom Contours for Nominal Trajectory to Moses Lake.

Table. 4-15. Impact on Special Status Lands Due to Sonic Booms from X-33 Launches from Edwards Air Force Base Landing at Grant County Airport at Moses Lake, WA.

Launch Focus Boom		Landing Focus Boom		Landing Carpet Boom	
Area Affected	Expected kPa[1] (psf[2])	Area Affected	Expected kPa (psf)	Area Affected	Expected kPa (psf)
BLM[3] lands	up to 0.5 (10.0)	none expected	none expected	BLM lands	0.02 (0.5)
China Lake NAWS[4]	up to 0.5 (10.0)			Cold Springs NWR[5]	0.02 (0.5)
				DOE[6] Hanford Site	0.02 (0.5)
				Ft. McDermitt Indian Resrvation	0.02 (0.5)
				Malheur NWR	0.02 (0.5)
				McKay Creek NWR	0.02 (0.5)
				Nat'l. Forest lands	0.02 (0.5)
				Nat'l Park Service lands	0.02 (0.5)
				Nat'l Wild & Scenic River	0.02 (0.5)
				Saddle Mt. NWR	0.02 (0.5)
				Umatilla Indian Resrv.	0.02 (0.5)
				Umatilla NWR	0.02 (0.5)

Key:
[1]*kPa = kilo Pascal*
[2]*psf = pounds per square foot*
[3]*BLM = Bureau of Land Management*
[4]*NAWC = Naval Air Weapons Station*
[5]*NWR = National Wildlife Refuge*
[6]*DOE = Department of Energy*

Figure 4-48. Federal and Private Lands at Haystack Butte Exposed to Sonic Booms during Launch for Flight to Moses Lake (National Geographic Society 1996).

Figure 4-49. Federal and Private Lands at Space Port 2000 Exposed to Focus Booms during Launch for Flight to Moses Lake (National Geographic Society 1996).

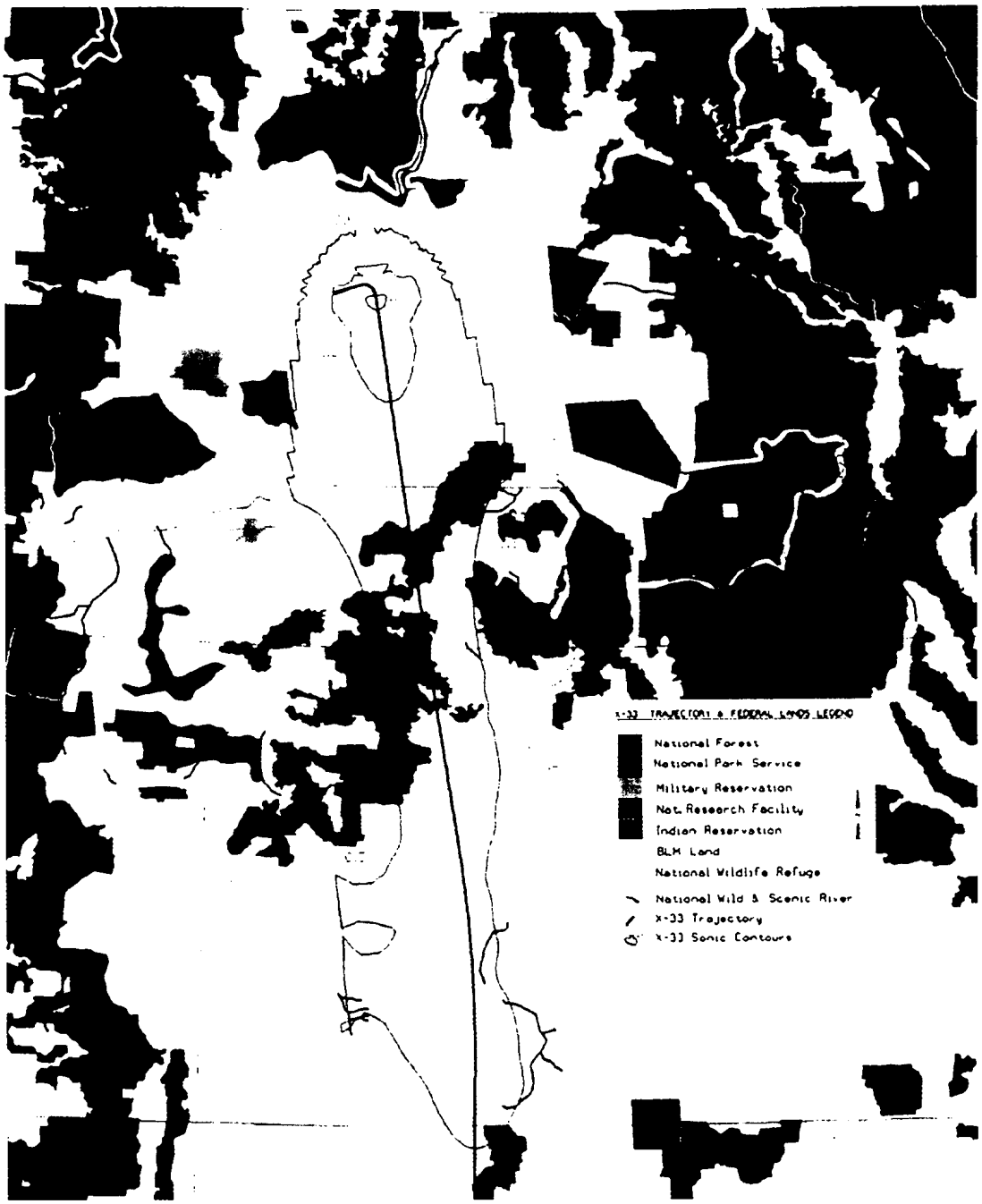


Figure 4-50. Federal and Private Lands at Moses LakeExposed to Sonic Booms during landing (National Geographic Society 1996).

4.2.5.13 Transportation

Roadway capacity is adequate for existing traffic although slowdowns can occur during morning rush hours. No roadway closures are expected. The number of people involved in the test program would have very little effect on road congestion at any time. Therefore, no roadway impact would be expected.

4.2.5.14 Population and Employment

Operations are expected to have a small effect since the proposed landing site would be used during flight test operations with 50 to 75 personnel. In addition, the X-33 Landing Team employees would not be hired from the local area, but would be part of the existing program workforce. Impacts on population are expected to be minimal.

4.2.5.15 Land Use

The airport is already zoned for and supports aircraft testing and operations, Boeing 747 takeoffs and landings are common day-to-day activities. However, the use of this airport for landing the X-33, a unique aerospace test vehicle, would constitute a new use of the facility. Due to the temporary nature of this program, the change in land use would be minimal. Therefore, impacts on land use at Moses Lake are expected to be minimal.

To the extent that 49 USC Section 303 (formerly Section 4(f) of the Department of Transportation Act) may be interpreted to apply, the only potential effects of the proposed X-33 operations on parks, recreation areas, and wildlife/waterfowl refuges would be from occasional noise associated with vehicle launches. However, these impacts would be minor and would not substantially impact the use of these areas. For details of impacts, if any, for the environments of the launch and landing site, please see Chapters 3 and 4 of this Final EIS, specifically the particular area of interest (i.e., for Moses Lake, Cultural Resources, see Section 4.2 at Subsection 4.2.5.8) (FAA, July 1997).

4.2.5.16 Snow Avalanche

Figure 4-47 shows the peak of sonic boom overpressures expected to result from normal flight operations from Edwards to the proposed landing site near Moses Lake. Eight mountain passes and two ski areas are located on or near the proposed flight path. One ski area would be expected to receive sonic boom overpressures greater than 0.02 kPa (0.5 psf) (Spout Springs 1997) (see Section 3.2.5.17 for criteria).

Located near Tollgate, Oregon, the Spout Springs ski area consists of 61 ha (150 ac) of skiable terrain at a maximum elevation of 1,650 m (5,400 ft). Operation typically begins in mid-November and lasts until early April. Spout Springs has no record of historical avalanche activity (Spout Springs 1997). Snow conditions are surveyed regularly by ski patrol members and no action has been required to stabilize the main ski slope (Spout Springs 1997).

There is the theoretical possibility that the proposed flight trajectory from Edwards to Moses Lake may trigger a snow avalanche at Spout Springs (see Section 4.1.16 for more details on criteria). To reduce the risk of injury or structural damage resulting from snow avalanche, X-33 flights to Moses Lake would be coordinated with Spout Springs. Spout Springs would be provided with the schedule of X-33 flights indicating the time of day that overflights would occur. This notice would allow ski patrol members to complete their surveys of snow conditions prior to anticipated X-33 overflights and communicate snow conditions to the X-33 Launch Control Center.

4.3 Flight Safety

The national range system, established by Public Law (PL) 81-60, was originally sited based on two primary concerns: location and public safety. Thus, Range Safety, in the context of national range activities, is rooted in PL 81-60 and DODD 3200.11, Use, Management, and Operation of Department of Defense Major Range and Test Facilities, that provide the framework under which the national ranges operate and provide services to range users. To provide for the public safety, the ranges, using a Range Safety Program, shall ensure that the launch and flight of launch vehicles present no greater risk to the general public than that imposed by overflight of conventional aircraft.

Range Safety is intrinsic to the range mission of providing range users the facilities, instrumentation, and infrastructure to support launch vehicles during prelaunch and launch operations. Significant hazards and risks are inherent to launch vehicle tests and operations; therefore, all reasonable precautions would be taken to minimize these risks with respect to life, health, and property. The mutual goal of the ranges and range users is to launch the X-33 safely and effectively with commitment to public safety. The ranges are working with NASA and Lockheed Martin Skunk Works to develop a Range Safety Program "tailored" to the X-33 vehicle and flight test program. The X-33 Range Safety Program would use the standards that, through experience, ensures a prudent level of public safety protection is provided during launch and flight operations. The range safety requirements would be issued by the Air Force Flight Test Center (AFFTC) for the X-33 Program. Included in these requirements would be definitions (by position) of responsibilities and authorities; approvals of all flight safety activities from design through test; vehicle checkout; and system safety including the flight termination system.

It is the policy of the Edwards Range to ensure that risk to the public, to personnel at the launch area, and to national resources is minimized to the greatest degree possible. This policy would be implemented by employing risk management in the categories of Public Safety, Launch Area Safety, and Landing Area Safety. The range users (NASA and Lockheed Martin Skunk Works) are required by Edwards Range Safety to endeavor and demonstrate through risk modeling that the lowest risk possible is achieved, consistent with mission requirements and AFFTC launch risk guidance. The AFFTC Chief of Safety would have responsibility for approving the proposed flight plan, flight termination system(s), and flight safety criteria. The AFFTC Commander would have final authority and responsibility for the safety of the X-33 flight tests.

The Range Commander may vary from these criteria for the X-33 Program or missions based on geography, weather, and national need; however, the basic standard is no more risk than that voluntarily accepted by the general public in normal day-to-day activities. Risk guidance established under the Range Commanders Council Standard would be used by AFFTC. This guidance is based on a standard of a collective per-flight risk level of not more than 30 casualties (harm) in 1 million (30×10^{-6}) for the general public and not more than 300 casualties in 1 million (300×10^{-6}) for essential launch area personnel. The basic standard for the general public is not more than the risk voluntarily accepted in normal day-to-day activities. The figure of 30×10^{-6} would be used by the range as a level defining "acceptable launch risk without high management (Range Commander) review (USAF 1995A and B; Range Commanders Council 1997A and B)."

In order to put this risk level in perspective, Table 4-16 lists the individual risk of fatality from several common causes.

Table 4-16. Calculated Individual Risk of Fatality by Various Causes in the United States (NASA 1996).

Accident Type	Number of Fatalities[a]	Approximate Individual Risk Per Year
Motor Vehicle	43,500	1.7×10^{-4}
Homicide	22,909	9×10^{-5}
Falls	12,200	4.8×10^{-5}
Poison	5,600	2.2×10^{-5}
Drowning	4,600	1.8×10^{-5}
Fires	4,200	1.7×10^{-5}
Suffocation	2,900	1.1×10^{-5}
Firearms and Explosives	1,400	5.5×10^{-6}
Manufacturing	800	2.7×10^{-6}
Electrocution	714	2.8×10^{-6}
Air Travel	700	2.7×10^{-6}
Water Transport	700	2.7×10^{-6}
Railway	400	1.5×10^{-6}
Lightning	74	2×10^{-7}

[a]Based on 1991 data

Another way of interpreting risk is to convert each risk estimate into a probability of occurrence simply by dividing each estimate into 1. A risk of 30×10^{-6} equates to a probability of 1 in 33,000 that an injury would occur. This probability does not mean that 1 out of every 33,000 people would be injured, but that if 33,000 flights of the X-33 were to occur, one injury to the public would be expected. A risk of 300×10^{-6} equates to a probability of 1 in 3,300. Flight paths have been analyzed to determine proposed trajectories (launch to landing) with lowest risk possible, consistent with mission requirements, and in consonance with AFFTC launch risk guidance (see Appendix G). As summarized in Appendix A, History of X-Planes, the intensive and effective risk management procedures developed by the ranges over the last 50 years have minimized risk to the public.

This analysis took into account areas of population densities as well as debris patterns resulting from inflight breakup of the vehicle on a nominal flight path, and significant environmental and cultural sites along the flight path that could be affected. The identified flight paths are shown in Figure 1-3. Note that the exact flight path may vary slightly due to the effect of winds. The onboard guidance system would make appropriate flight path corrections to overcome wind effects.

A risk analysis using debris estimations and patterns from inflight breakup or explosion during powered mode and population databases for Edwards and the general public along proposed

flight tracks was prepared and details are provided in Appendix G. Using historical failure rates for powered flight mode and engineering reliability factors for main engine cut off through landing, the maximum downrange risk value and probability of occurrence for launches from Haystack Butte range from 19×10^{-6} (1 in 53,000) to 5.0×10^{-6} (1 in 200,000) on a collective (total) per flight risk basis over the entire trajectories. The maximum values of launch through main engine cut off for launches from Space Port 2000 are 21×10^{-6} and 1 in 48,000. Due to necessary flight tracks from Space Port 2000, the total risks are expected to be higher than from Haystack Butte. In the near vicinity of the launch pad, the maximum risk and probability of occurrence for launches from Haystack Butte are 5.9×10^{-6} and 1 in 170,000, respectively. Using the historical failure rate would be considered to produce conservative risk projections. The historical failure rate was derived from launch failure rates of expendable launch vehicles (Atlas, Delta, and Titan II) and the Space Shuttle's LH_2/LOX engines. A complete summary of risk and probability can be found in Tables G-3 through G-6 of Appendix G. Risk assessments would be periodically updated and a final risk assessment prepared prior to first flight. Following first flight, actual flight data would be evaluated after each flight and, as appropriate, risk projections will be updated. Updated data would be used for successive launch decisions.

While the X-33 would not have a flight crew, it is being built to reliability standards comparable to those that would be required for a piloted spacecraft. High reliability design would be accomplished through the use of high reliability components, double and triple redundant critical systems, and extensive testing beyond what would be required for an unpiloted system. The X-33 flight test plan is based on an incremental expansion of the flight envelope with initial flights being conducted with speeds and stresses on the vehicle well under its maximum design specifications before progressing to maximum speed flights. Data would be evaluated flight to flight and risk assessments updated. Current data would be used for successive launch decisions.

Hazards resulting from an uncontrolled situation would include: (1) on or near launch pad explosion; (2) high-altitude explosion downrange of the launch site while the vehicle is still in powered flight; and (3) loss of vehicle control resulting in either vehicle breakup or a whole body impact. The debris zone in the vicinity of the launch pad due to an explosion at or immediately after liftoff would impact an area up to 640 m (2,100 ft) in radius or 126 ha (311 ac). Overpressures throughout this zone would pose some risk to light structures and windows. A high-altitude explosion on the trajectory to Silurian Lake or China Lake would produce a maximum debris zone of approximately 21 km (13 mi) in diameter and 32 km (20 mi) downrange.

If the vehicle undergoes a mid-air breakup and explosion during powered mode on flight to Dugway, debris would continue to move forward as it falls. If vehicle failure occurred close to its maximum speed, the leading edge of the debris pattern could fall approximately 400 km (250 mi) from Dugway. Debris would potentially fall along the flight track for up to 160 km (100 mi) long and 32 km (25 mi) wide due to the high energy achieved upon accelerating from Mach 9 to 12. At the maximum speed of Mach 15 which is needed to reach Malmstrom or Moses Lake, the elliptical debris pattern from a breakup of the vehicle could fall along the flight track for up to 250 km (160 mi) long and 64 km (40 mi) wide. The leading edge of the debris field could be as far as approximately 1,100 km (700 mi) downrange of Edwards (400 km (250 mi)) from Malmstrom. For all landings, potential debris zones would decrease in size as the vehicle loses speed and

altitude, eventually converging on landing to the smallest potential debris field of approximately 4 ha (10 ac) if the vehicle crashes nose down short of the runway. If the vehicle were to crash in any area as a whole body with only residual propellants, the debris field would be confined to 4 ha (10 ac). Risk factors were based on debris projection and footprints to determine trajectories meeting range safety criteria for powered and unpowered flight mode. Trajectory risk analysis would continue to be performed based on final design and risk projections specific to landing determined in order to refine energy management maneuvers and final approaches to landing sites. To mitigate hazards, proposed flight paths maximized overflight of federally-owned property, as shown in Figure 4-51 and Appendix G, Tables G-5 (A-E).

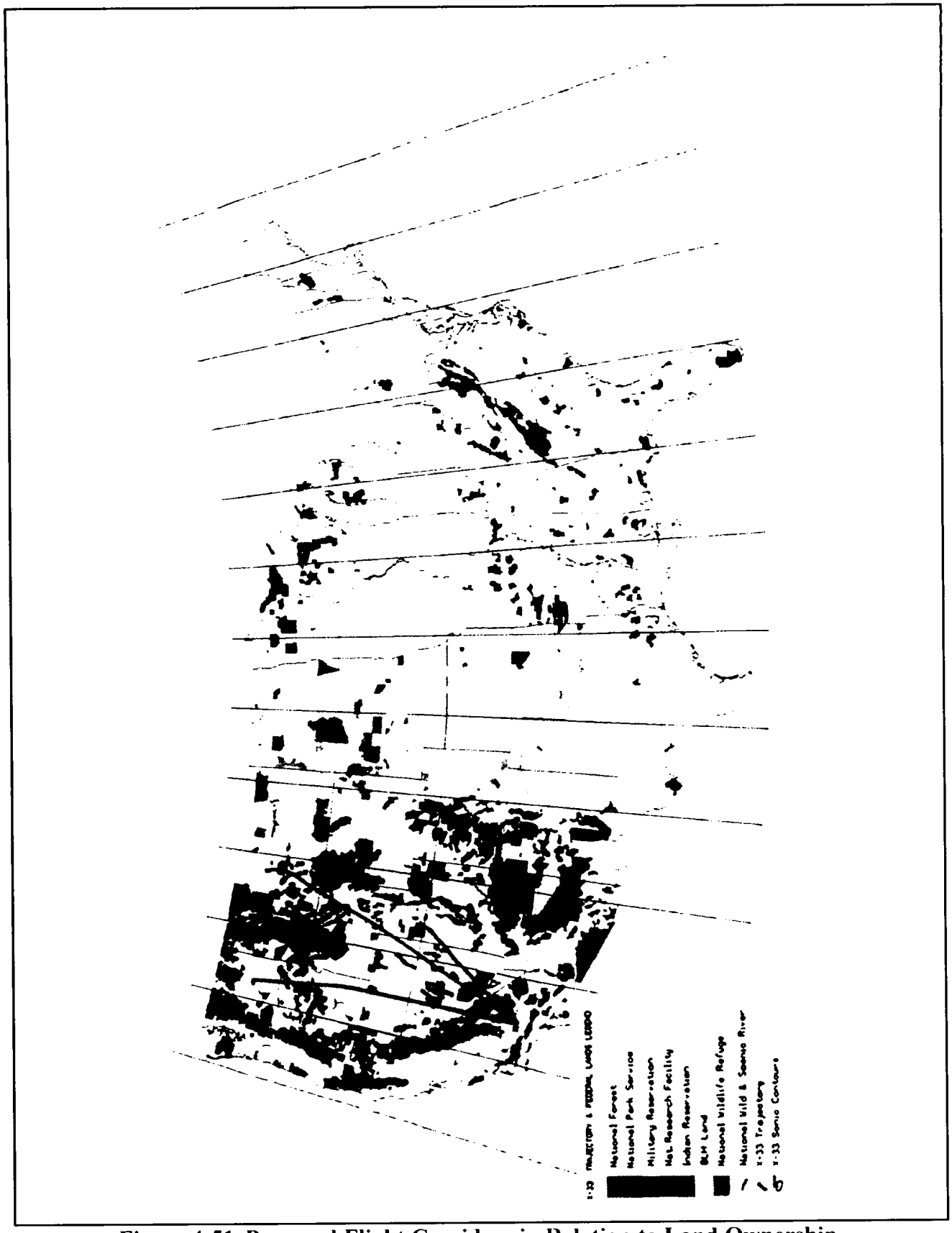


Figure 4-51. Proposed Flight Corridors in Relation to Land Ownership.

After main engine cutoff and depletion of fuels, the vehicle would be gliding in extremely thin atmosphere, similar to a satellite or a Space Shuttle Orbiter during its long descent from space. Until reentering denser atmosphere at approximately 30,500 m (100,000 ft), atmospheric loads on the vehicle would be significantly less than the design capability of the vehicle precluding the possibility of physical breakup.

The vehicle would be monitored by the AFFTC Range Safety Officer throughout the course of its flight. If a non-recoverable condition or a condition that is threatening population or property occurs, the Range Safety Officer would activate the flight termination system to end the flight and potentially break up the vehicle. The currently proposed flight termination system does not use ordnance (explosives). Once activated, the proposed flight termination system would perform the following:

- If fuel valves are open (i.e., powered flight), the fuel valves would be closed.
- Flap(s) on the vehicle would be deployed, which would cause the vehicle to tumble. (Note: If the flight is above 30,500 m (100,000 ft) at the time, tumbling might not occur until the vehicle returns to a lower altitude where aerodynamic control is regained.)
- The onboard flight controllers would be disabled allowing tumbling to occur without the computers trying to automatically stabilize the vehicle.

If AFFTC Range Safety determines the flight termination system would require more assurance to control a flight anomaly, a system utilizing ordnance may be required. The flight termination system would be fully operational throughout the flight.

In the event of vehicle breakup in flight or destruction on ground impact, remaining LH_2 and LOX fuel is expected to ignite, resulting in a localized fire and/or explosion on the ground. As a precaution, emergency response personnel should remain up wind of any fire or fumes. The vehicle's composite materials are carbon graphite fibers bonded with epoxy resin which may pose a health hazard similar to asbestos fibers. Emergency response plans would include procedures for minimizing health risks and environmental damage due to possible release of respirable fibers in the event of vehicle breakup or impact. "Waxing" of debris is one procedure used for stabilizing potential fiber release. This involves spraying a waxy material on the areas containing debris to reduce the potential for fibers to become airborne.

Emergency response plans would be prepared by Lockheed Martin with NASA participation and coordinated with and approved by AFFTC. Local and state emergency response organizations would be involved in preparation of these plans. In addition, these plans would be coordinated with and approved by the landing sites where applicable to their respective installation or authority. These plans would include applicable Material Safety Data Sheets for toxic or potentially toxic chemicals that might be formed and released as a result of an accident involving destruction of the vehicle and fire. Lockheed Martin would ensure that all county and state emergency organizations along each flight track would receive one prior to flight. Special response needs, precautions, training and/or equipment would be the responsibility of Lockheed Martin.

Debris from a vehicle explosion or breakup would disperse over a large area. After the debris enters the denser part of the atmosphere heavy pieces would continue moving forward as well as down at a rate of approximately 9,100 m/min (30,000 ft/min) and light debris would fall essentially straight down at a rate of approximately 3,000 m/min (10,000 ft/min) (Meade 1997). Debris as the result of an explosion or physical breakup at altitudes of 76,200 m (250,000 ft), 61,000 m (200,000 ft), 45,800 m (150,000 ft), and 30,500 m (100,000 ft) would descend below 18,300 m (60,000 ft) in approximately 2.5, 2.1, 1.75, and 1.25 min, respectively, for heavy pieces. At a lower altitude of 3,000 m (10,000 ft) where smaller aircraft generally fly, heavy debris would enter this airspace in approximately 4.2, 3.8, 3.5, and 3 min respectively.

Jet aircraft using the higher altitudes would fly at average speeds of 640 km/hr (400 mph) or 10.7 km/min (6.7 mi/min) to 800 km/hr (500 mph) or 13.3 km/min (8.3 mi/min). Small aircraft at the lower altitudes would fly at average speeds of 160 km/hr (100 mph) or 2.7 km/min (1.7 mi/min). In 1.75 to 2.5 min (time for heavy debris to fall below 18,300 m (60,000 ft), jet aircraft could travel 18.7 to 26.9 km (11.7 to 16.8 mi). In 3 to 4.2 min, small aircraft could travel 8.2 to 11.4 km (5.18 to 7.1 mi). Maximum debris ellipse widths for mid- and long-rang flights were estimated to be 32 km (25 mi) and 64 km (40 mi), respectively. Aircraft would have to fly up to half these width distances in order to clear the potential debris zone in the event of X-33 failure. For mid- and long-range flights maximum flight tracks for all aircraft would be 16 km (12.5 mi) and 32 km (20 mi), respectively. Therefore, small aircraft in the event of X-33 failure at altitudes of approximately 18,300 m (60,000 ft) would be at slightly higher riskthan jet aircraft which should be fully capable to clear the potentially affected airspace in the event of X-33 failure.

Lockheed Martin would develop a task agreement or some other acceptable formal agreement with the FAA to establish a communication link between the X-33 Operations Control Center on Edwards and the affected Air Route Traffic Control Centers described in the respective Airspace and Air Traffic Sections for the proposed launch, landing, and intervening flight corridors. This communications link would permit real time tracking of flight events and movement of the X-33 and facilitate rapid notification of any NOTAMs that would be required in the event of a flight anomaly. In the event that the AFFTC Range Safety Officer determines that flight termination is necessary, a request for priority airspace would be requested from appropriate Air Route Traffic Control Center(s), and pre-arranged NOTAMs issued by FAA. Requests for emergency/priority airspace range from 2-3 per day to 2-3 per month at the Air Route Traffic Control Centers documented in Appendix D. In the event of an abort, the X-33 would be commanded by the Operations Control Center at Edwards or by the vehicle's own programmed systems to abort and "soft" land (land as intended) at a pre-arranged/approved landing area or control its final flight directly into ground (nose down crash) at a pre-determined area that is safe and unpopulated. All decisions would be made only with approval of the AFFTC Range Safety Officer. Final abort details would be in the Launch and Landing Flight Safety Plans.

Risk assessments of specific to general aviation would also be part of documentation provided to the X-33 Range Safety review meetings, which would include FAA representatives. The risk criteria for non-mission aircraft is 1×10^{-9} (Range Commanders Council 1997A). Due to the low risk numbers for the public, it is expected that X-33 test flights would also meet this criteria. This data would also be used to prepare X-33 Launch and Landing Site Safety Plans to be

approved by the AFFTC Chief of Safety and relevant landing site safety offices. NOTAMs would be used to supply information on vacating the X-33 flight track in the vicinity of potential debris. Three methods of communication between FAA and X-33 flight operations would be used to assist with the potential of a vehicle emergency such as abort with a controlled "soft" landing; abort with a controlled flight resulting in a whole body or nose down crash; and breakup of the vehicle. These communications methods would be: (1) a real time display of the potential debris pattern and impact area for AFFTC Range Safety Officers and FAA representative; (2) an open communications net between AFFTC Chief of Safety or designated representative, Range Safety Officers at the X-33 Operations Control Center, and FAA representatives at Edwards and at the potentially affected Air Route Control Centers would be established prior to launch time and remain open until deem unnecessary by the Range Control Officers; and (3) NOTAMs would be issued wherever potential for the vehicle and/or debris to enter National Air Space occurs.

The length of time for emergency procedures to be initiated depends on whether the FAA chooses to limit or restrict all air traffic within the confines of the entire flight region within airspace under FAA control and length of time for debris to enter an area where air traffic may be affected. With real time data and flight decisions being made available to FAA along with an open net being maintained throughout flight to facilitate rapid communication, X-33 emergency procedures for the protection of general aviation is anticipated to be fully adequate to ensure protection of all aircraft that might be using National Air Space under the flight track of the X-33.

The use of NOTAMs and/or other risk mitigation techniques would be reviewed when final trajectory risk analyses are provided following conclusion of development, fabrication, and systems testing of the X-33. These issues would be discussed at X-33 Flight Working Group meetings in which the FAA participates along with Range Safety Officers from Edwards, Lockheed Martin flight safety experts, and NASA flight and safety representatives. Recommended results would be coordinated with the R-2508 Complex Control Board; landing site safety offices; affected FAA Air Route Traffic Control Centers; regional offices and headquarters officials; and any other appropriate authorities and officials.

Flight tests of the X-33 are not expected to require airspace clearance in FAA Positive Airspace Control for nominal flights except in the vicinity of descent at Silurian Lake, Malmstrom, and Moses Lake as discussed in the respective air traffic sections. Due to substantial efforts required to satisfy the AFFTC Chief of Safety prior to launch and launch and landing site installation safety and command authorities followed by approval by the AFFTC Commander, it is expected that there would be minimal risk to the public.

4.4 Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." This Executive Order is designed to focus the attention of federal agencies on the human health and environmental conditions in minority communities and low-income communities. It requires federal agencies to adopt strategies to address environmental justice concerns within the context of agency operations. In an accompanying Presidential memorandum, the President emphasizes that existing laws, including the National Environmental Policy Act (NEPA), provide opportunities for federal agencies to address environmental hazards in minority communities and low-income communities. In March 1995, NASA released its strategy on environmental justice establishing Agency-wide goals and defining the approaches by which NASA would ensure that disproportionately high and adverse human health or environmental effects on minority communities and low-income communities are identified and addressed (NASA 1995).

4.4.1 Environmental Justice Screening Analysis

4.4.1.1 Screening for Native American Lands

NASA conducted a preliminary screening analysis of each corridor to ensure that the NEPA process was fully utilized to address concerns identified by Indian tribes, enhance protection of tribal environments and resources, and identify Native American lands which may be affected by the proposed action.

4.4.1.2 Corridor Level Screening

Proposed flight corridors were determined based on the Program objectives and strategy drivers detailed in Section 1 of this EIS. Figure 4-52 shows the proposed flight corridors in relation to the counties affected. NASA conducted a screening level analysis to identify potential environmental justice concerns, and determine the existence of low-income and/or minority populations within the proposed alternative flight corridors. Census data characterized the population within each projected flight corridor in terms of minority and economic demographics. Specifically, this EIS examines income and racial characteristics of counties within each proposed flight corridor to determine which areas, if any, could be classified as "low income" or "minority." Low income and minority populations in all areas within the flight corridors were well below the 50 percent composition guideline set by the federal Government. This means that all corridors would be in compliance with the Executive Order (EPA 1996).

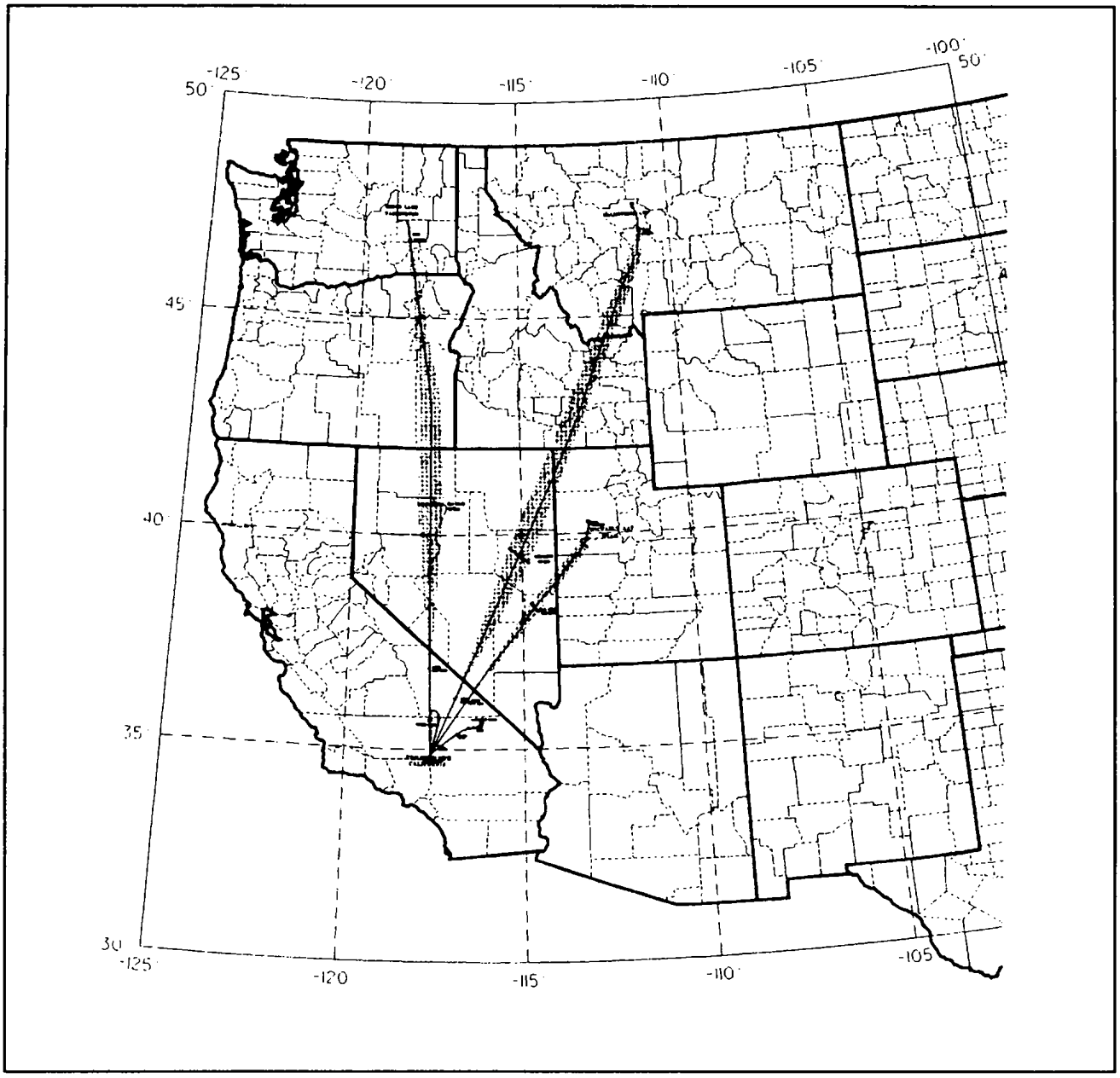


Figure 4-52. Proposed Flight Corridors in Relation to the Counties Affected.

The EPA Office of Environmental Justice issued draft "Guidance for Federal Agencies on Key Terms in Executive Order 12898" on August 8, 1995. It listed two available sources for identifying low-income thresholds: (1) the Department of Health and Human Services' poverty guidelines (for a family of three, $12,590), and (2) the Department of Housing and Urban Development's (HUD) statutory definition of very low income (for a family of four, 50 percent of the area's median family income). These thresholds, along with the HUD low income level (for a family of four, 80 percent of the area's median family income), are used in this EIS. In defining poverty level populations, the 1990 Census statistic "persons below poverty" was used for this EIS.

The White House Office of Environmental Justice defines "minority" as individuals classified by Office of Management and Budget Directive No. 15 as Black/African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other non-white persons. The White House Office indicates that for a population to be classified as minority, the minority composition should either exceed 50 percent or be meaningfully greater than the minority population percentage in the general population or other unit of geographic analysis. Further, the appropriate unit of geographic analysis may be a governing body's jurisdiction, a neighborhood, Census tract or other similar unit (EPA 1996). This EIS uses the Census county as the geographic analytical unit, since racial composition data are readily available from the 1990 Census.

Tables in the following subsections display income and race characteristics for the counties affected by the proposed alternative corridors.

4.4.1.2.1 Edwards to Silurian Lake Corridor

NASA compared characteristics of the counties affected in the proposed flight corridor from Edwards to Silurian Lake, near Baker, California, with characteristics of the state of California, as shown in Table 4-17 below, and determined that no area would be classified as either minority or low income. Average characteristics of the entire flight corridor are also compared to U.S. characteristics for race and income. Although the average minority populations in affected counties of California and the state of California as a whole are higher than the average minority population of the U.S., the numbers are still below what would be classified as a minority area. Impacts of this proposed alternative do not appear to disproportionately affect any income or racial group. The range of impacts as they relate to this proposed flight trajectory are considered in more detail in Section 4.4.2.2.1 below. Based on corridor-level Environmental Justice screening analysis, the proposed corridor would be in compliance with the Executive Order.

Table 4-17. Income and Race Characteristics in the Edwards to Silurian Lake Corridor.

Area Affected	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
	Low Income Threshold[a]	Very Low Income Threshold[a]		
CA Counties				
Kern	40.0%	25.4%	16.4%	37.0%
San Bernardino	40.8%	24.8%	12.3%	39.0%
CA State Average	41.4%	22.9%	12.1%	42.6%
Corridor Average	40.4%	25.1%	14.4%	38.0%
US Average[d]	41.8%	24.3%	12.8%	24.3%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*
[d] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3C, P1, P5, P8, P80, P80A, P117.*

4.4.1.2.2 Edwards to China Lake Naval Air Weapons Station Corridor

NASA compared characteristics of the counties affected in the proposed flight corridor from Edwards to China Lake Naval Air Weapons Station, Ridgecrest, California, with characteristics of the state of California, as shown in Table 4-18 below and determined that no area would be classified as either minority or low income. Also, average characteristics of the entire flight corridor are compared to U.S. characteristics for race and income. Although the average minority population in affected counties of California and of the state of California as a whole are higher than the average minority population of the U.S., the numbers are still below what would be classified as a minority area. Impacts of this proposed alternative do not disproportionately affect any income or racial group. The specific areas of impact for this trajectory are considered in more detail in Section 4.4.2.2.2 below. Based on corridor-level Environmental Justice screening analysis, the proposed corridor would be in compliance with the Executive Order.

Table 4-18. Income and Race Characteristics in the Edwards to China Lake Corridor.

Area Affected	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
	Low Income Threshold[a]	Very Low Income Threshold[a]		
CA Counties				
Kern	40.0%	25.4%	16.4%	37.0%
San Bernardino	40.8%	24.8%	12.3%	39.0%
Inyo	41.8%	25.9%	11.6%	18.8%
CA State Average	41.4%	22.9%	12.1%	42.6%
Corridor Average	40.9%	25.4%	13.4%	31.6%
US Average[d]	41.8%	24.3%	12.8%	24.3%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*
[d] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3C P1, P5, P8, P80, P80A, P117.*

4.4.1.2.3 Edwards to Dugway Proving Ground Corridor

NASA compared income and racial characteristics of the counties affected in the proposed flight corridor from Edwards to Michael Army Airfield on Dugway Proving Ground, Utah, with characteristics of the states involved, as shown in Table 4-19 and determined that no area would be classified as either minority or low income. Average characteristics of the entire corridor are also compared to the U.S. characteristics for race and income, and the proposed corridor does not deviate from the characteristics experienced by the U.S. as a whole. In fact, the percentage of minority population in most of the counties along this corridor is quite a bit lower than the percentage calculated for the U.S., as a whole. Impacts of this proposed corridor do not appear to fall disproportionately on any income or racial group. Specific areas of impact for this trajectory are considered in more detail in Section 4.4.2.2.3. Based on corridor-level Environmental Justice screening analysis, the proposed corridor would be in compliance with the Executive Order.

Table 4-19. Income and Race Characteristics in the Edwards to Dugway Proving Ground Corridor.

Area Affected	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
	Low Income Threshold[a]	Very Low Income Threshold[a]		
CA Counties				
Kern	40.0%	25.4%	16.4%	37.0%
San Bernardino	40.8%	24.8%	12.3%	39.0%
Inyo	41.8%	25.9%	11.6%	18.8%
CA State Average	41.4%	22.9%	12.1%	42.6%
NV Counties				
Nye	42.1%	23.8%	10.4%	12.4%
Lincoln	43.2%	24.3%	13.1%	9.8%
White Pine	39.7%	27.5%	10.0%	13.9%
NV State Average	39.1%	20.5%	10.0%	21.1%
UT Counties				
Millard	43.3%	26.1%	13.8%	4.9%
Juab	40.2%	25.9%	10.4%	2.7%
Tooele	39.7%	22.0%	11.3%	13.9%
UT State Average	41.3%	21.9%	11.1%	8.7%
Corridor Average	41.2%	25.1%	12.1%	17.0%
US Average[d]	41.8%	24.3%	12.8%	24.3%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*
[d] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3C P1, P5, P8, P80, P80A, P117.*

4.4.1.2.4 Edwards to Malmstrom Air Force Base Corridor

NASA compared income and racial characteristics of the counties affected in the proposed flight corridor from Edwards to Malmstrom Air Force Base, Montana, with characteristics of the states involved as shown in Table 4-20 and determined that no area would be classified as either minority or low income. Although average minority populations in affected counties of California where the vehicle takes off are higher than the rest of the counties in this trajectory, the numbers are below what is characteristic of the state of California as a whole. Average characteristics of the entire corridor are also compared to the U.S. characteristics for race and income, and the proposed corridor does not deviate from the characteristics experienced by the U.S. as a whole. In fact, the percentage of minority population along this corridor is quite a bit lower than the percentage calculated for the U.S. as a whole. Impacts of this proposed alternative do not appear to fall disproportionately on any income or racial group. The specific areas of impact for this trajectory are considered in more detail in Section 4.4.2.2.4 below. Based on corridor-level

Environmental Justice screening analysis, the proposed corridor would be in compliance with the Executive Order.

Table 4-20. Income and Race Characteristics in the Edwards to Malmstrom Air Force Base Corridor.

Area Affected	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
	Low Income Threshold[a]	Very Low Income Threshold[a]		
CA Counties				
Kern	40.0%	25.4%	16.4%	37.0%
San Bernardino	40.8%	24.8%	12.3%	39.0%
Inyo	41.8%	25.9%	11.6%	18.8%
CA State Average	41.4%	22.9%	12.1%	42.6%
NV Counties				
Nye	42.1%	23.8%	10.4%	8.3%
White Pine	39.7%	27.5%	10.0 %	8.8%
Elko	39.0%	23.5%	9.2%	13.5%
NV State Average	39.1%	20.5%	10.0%	15.7%
UT Counties				
Box Elder	37.6%	20.9%	7.2%	4.9%
UT State Average	41.3%	21.9%	11.1%	6.1%
ID Counties				
Cassia	41.3%	22.9%	12.3%	10.1%
Blaine	38.0%	17.7%	7.6%	2.4%
Power	40.6%	19.1%	13.1%	13.5%
Bingham	38.0%	21.2%	15.4%	13.8%
Butte	43.2%	30.4%	13.4%	2.3%
Jefferson	38.5%	22.2%	14.2%	5.7%
Clark	38.7%	16.5%	9.3%	10.6%
ID State Average	38.7%	21.8%	13.0%	5.6%
MT Counties				
Beaverhead	42.8%	24.5%	17.7%	1.7%
Madison	39.7%	29.7%	18.1%	0.9%
Gallatin	42.6%	25.5%	16.1%	2.9%
Broadwater	42.6%	19.6%	16.0%	1.4%
Meagher	37.9%	24.6%	19.5%	1.6%
Cascade	41.2%	24.2%	13.3%	7.0%
MT State Average	43.3%	26.5%	15.6%	15.6%
Corridor Average	40.3%	23.5%	13.2%	9.0%
US Average[d]	41.8%	24.3%	12.8%	19.7%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*
[d] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3C P1, P5, P8, P80, P80A, P117.*

4.4.1.2.5 Edwards to Moses Lake Corridor

NASA compared income and racial characteristics of the counties affected in the proposed flight corridor from Edwards to Moses Lake, Washington, with characteristics of the states involved as shown in Table 4-21 and determined that no area would be classified as either minority or low

income. Although average minority populations in affected counties of California where the vehicle takes off and the state of California as a whole are higher than the average minority population of the U.S., the numbers are still below what would be classified as minority. While minority populations in Adams and Franklin Counties in Washington are higher than the average for Washington state or the average for the corridor, these averages are below what is considered a minority population. However an in-depth look at the areas involved in relation to the area of impact is completed below in Section 4.4.2.2.5. Average characteristics of the entire corridor are also compared to the U.S. characteristics for race and income. It does not appear that the proposed corridor deviates from the characteristics experienced by the U.S. as a whole. Impacts of this proposed alternative do not appear to fall disproportionately on any income or racial group. Specific areas of impact for this trajectory are considered in more detail in Section 4.4.2.2.5. Based on corridor-level Environmental Justice screening analysis, the proposed corridor would be in compliance with the Executive Order.

Table 4-21. Income and Race Characteristics in the Edwards to Moses Lake Corridor.

Area Affected	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
	Low Income Threshold[a]	Very Low Income Threshold[a]		
CA Counties				
Kern	40.0%	25.4%	16.4%	30.2%
Inyo	41.8%	25.9%	11.6%	13.3%
CA State Average	41.4%	22.9%	12.1%	30.9%
NV Counties				
Esmeralda	40.6%	28.0%	15.3%	12.9%
Nye	42.1%	23.8%	10.4%	8.3%
Churchill	42.0%	23.8%	10.7%	10.9%
Pershing	39.6%	27.4%	12.9%	13.2%
Humboldt	39.0%	22.7%	10.1%	16.2%
NV State Average	39.1%	20.5%	10.0%	15.7%
OR Counties				
Malheur	43.3%	23.2%	19.0%	18.6%
Baker	39.5%	27.6%	14.3%	1.6%
Union	39.0%	27.9%	15.4%	3.1%
Umatilla	43.2%	25.5%	15.9%	11.0%
OR State Average	41.0%	20.8%	12.1%	7.2%
WA Counties				
Walla Walla	41.8%	24.7%	14.8%	10.5%
Franklin	40.1%	25.4%	22.7%	28.0%
Adams	38.8%	23.9%	17.4%	33.1%
Lincoln	40.6%	25.0%	12.1%	2.2%
Grant	38.2%	19.8%	19.4%	13.8%
WA State Average	39.3%	21.4%	10.6%	11.4%
Corridor Average	40.6%	23.5%	14.9%	14.2%
US Average[d]	41.8%	24.3%	12.8%	19.7%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*
[d] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3C P1, P5, P8, P80, P80A, P117.*

4.4.2 Range of Impacts

4.4.2.1 Air Issues Pertaining to Environmental Justice

Current average operational levels of the X-33 are well within the emission standards set forth in the Clean Air Act. Because air emissions concerning X-33 activities are expected to have minor impacts and are not disproportionately distributed among communities, there are no environmental justice concerns regarding air pollutants for the proposed action or any of the action alternatives.

4.4.2.2 Noise Issues Pertaining to Environmental Justice

Liftoff noise, ascending rocket noise, and noise from sonic booms were evaluated for each proposed flight corridor. Quasi-static noises, such as liftoff noise and ascending rocket noise, were evaluated using two standards. Maximum A-weighted sound levels (dBA) were evaluated to determine human response to the noise produced in areas such as annoyance, hearing protection, and health and safety. Overall unweighted sound levels (dB) were evaluated to determine structural impacts from noise. Guidelines for evaluating impacts of quasi-static noise levels are given in Section 4.1.12.

Liftoff/static test maximum A-weighted and overall sound levels are shown in Section 4.1.12, Figures 4-4 through 4-7. For populated areas outside Edwards boundaries, A-weighted noise level estimates do not exceed 80 dBA. Overall sound pressure estimates do not exceed 110 dB for populated areas outside Edwards boundaries. Liftoff noise produced by X-33 does not exceed any of the federal guideline standards for human response, hearing conservation and health factors where base personnel or private property may be exposed. There are no expected impacts to the general public with regard to liftoff noise.

Maximum A-weighted and overall levels for ascending rocket noise are shown in Section 4.1.12, Figures 4-8 through 4-27. Although footprints of projected noise varied slightly depending on the trajectory, maximum levels were constant, regardless of trajectory. For populated areas outside base boundaries, A-weighted noise level estimates do not exceed 80 dBA. All ascending rocket noises are below federally accepted guidelines, and there are no expected impacts to the general public with regard to ascending rocket noise for proposed flight trajectories.

Overall sound pressure levels for ascending rocket noise during proposed flights do not exceed 100 dB. There are no expected impacts to privately owned structures from ascending rocket noise for this proposed trajectory.

Noise from sonic booms is a very short term, impulsive event. Sonic boom levels are shown for each trajectory in Section 4.1.12, Figures 4-31 through 4-50. Table 4-6 provides possible structural damages versus sonic boom sound pressures.

The subsections below evaluate the sonic boom noise produced along each flight trajectory as it relates to environmental justice issues. Flight trajectories are shown in Figure 1-3. In areas where the sonic boom overpressure levels are 0.14 kPa (3.0 psf) or above, noise is evaluated in relation

to the Census tract affected. The Census tract is used as the geographic analytical unit, since racial composition data are readily available from the 1990 Census. All discussions and analyses are based on nominal flight trajectories. Slight changes in trajectory may alter the locations of the maximum expected noise to areas close to those expected in this analysis.

4.4.2.2.1 Edwards to Silurian Lake Corridor

Sonic boom overpressure contours for the proposed flights from Edwards to Silurian Lake are shown in Section 4.1.12, Figure 4-31. As the vehicle makes its initial pitch after launch, overpressure levels ranging from 0.02 to 0.14 kPa (0.5 to 3.0 psf) are generated in San Bernardino County. Low levels of sound ranging from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are anticipated in northwestern San Bernardino County. Levels ranging from 0.02 to 0.14 kPa (0.5 to 3.0 psf) occur in San Bernardino County, northeast of Edwards, in Census tract 119.

As the vehicle descends to the landing site, sound overpressure levels are expected to range from 0.02 to 0.14 kPa (0.5 to 3.0 psf). Low level overpressures, from 0.02 to 0.05 kPa (0.5 to 1.0 psf), are expected in northern San Bernardino County and southeastern Inyo County. Overpressures from 0.05 to 0.14 kPa (1.0 to 3.0 psf) are primarily anticipated to occur on the Ft. Irwin Military Reservation, extending approximately 32 km (20 mi) to the southeast of base property, within Census tract 103.

Figures 4-53 and 4-54 show the Census tract outline maps for San Bernardino and Kern Counties, California. Income and racial characteristics of the Census tracts affected by sound overpressure levels of 0.14 kPa (3.0 psf) or above were examined and are shown in Table 4-22.

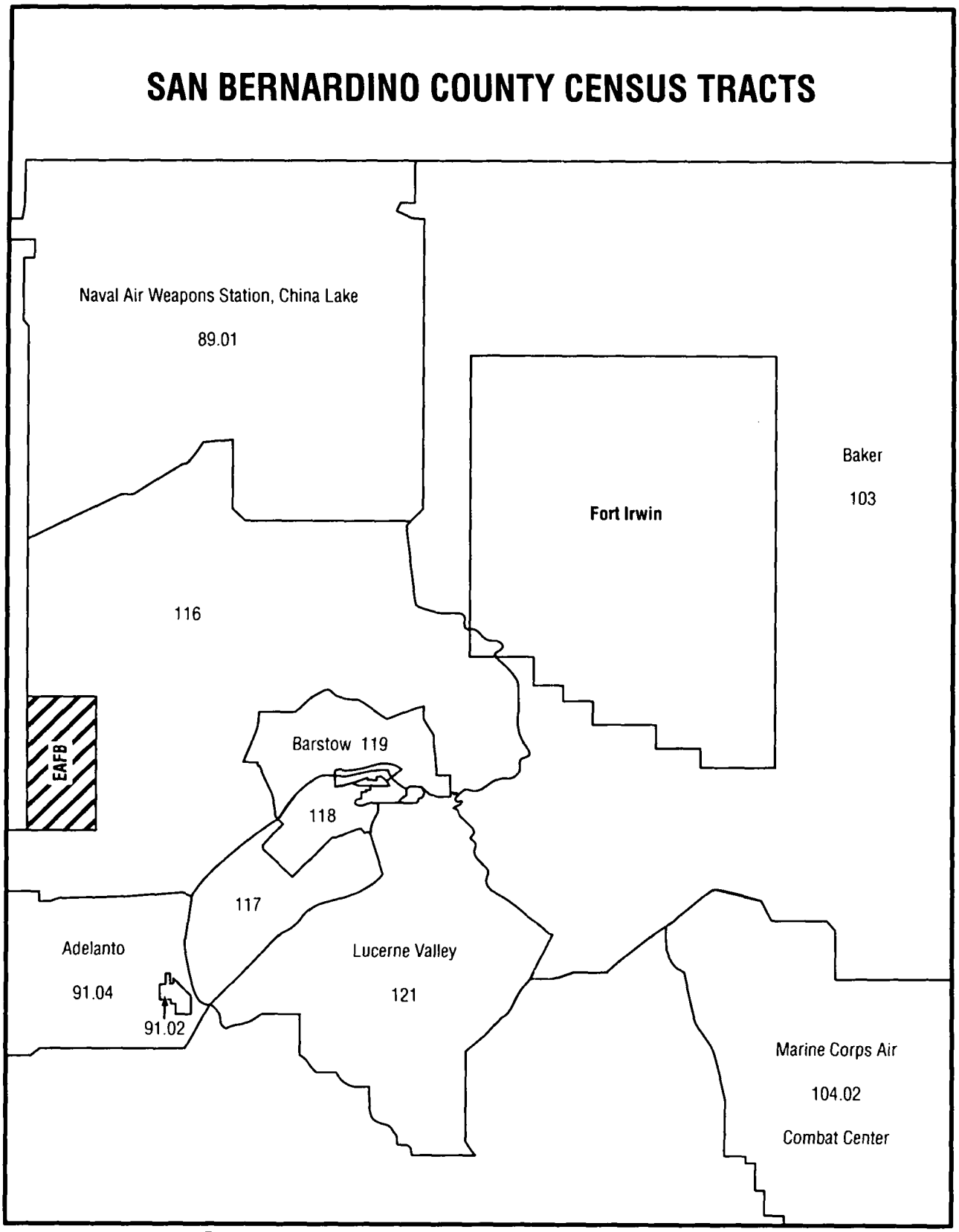


Figure 4-53. San Bernardino County Census Tracts.

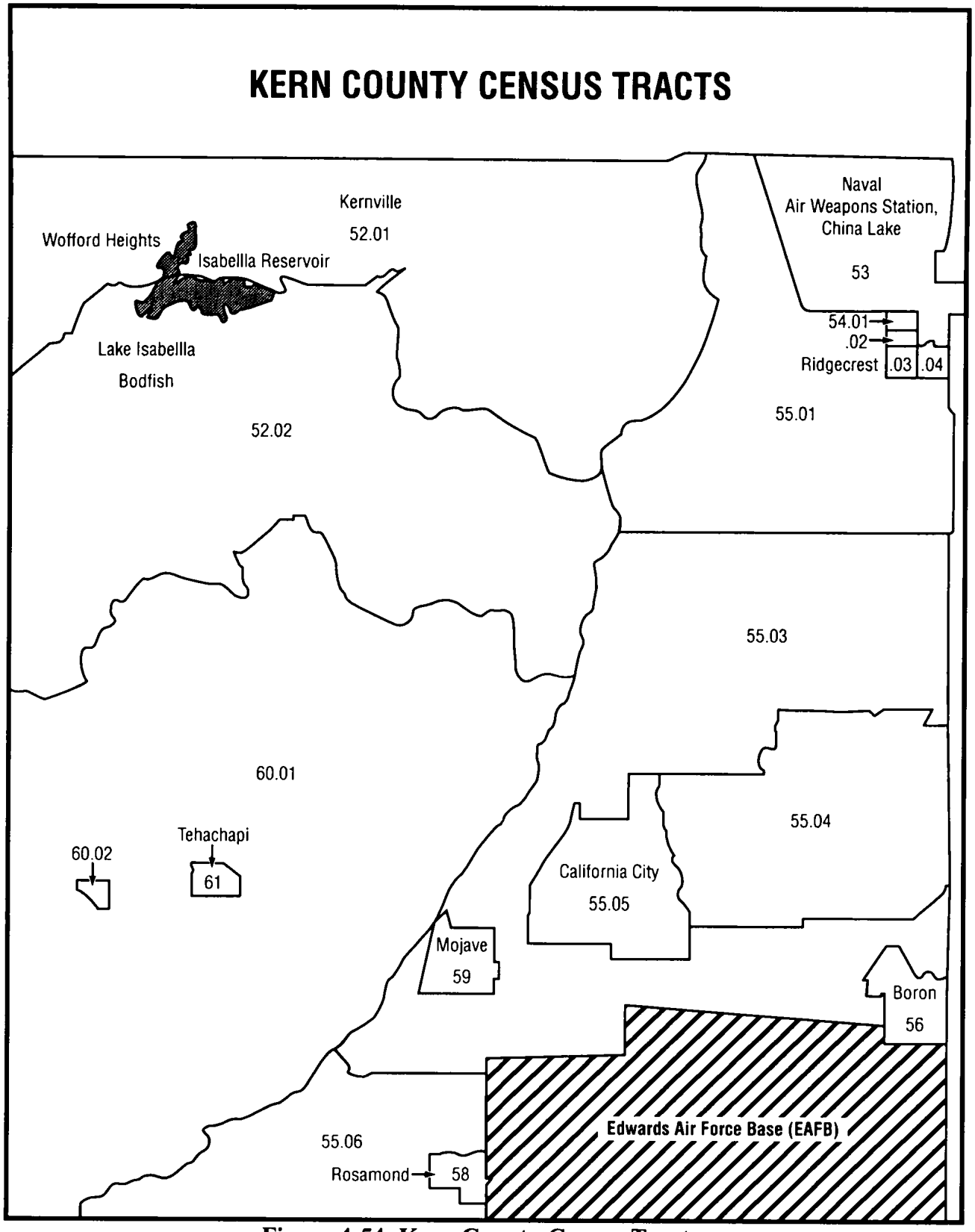


Figure 4-54. Kern County Census Tracts.

Table 4-22. Income and Race Characteristics in the Edwards to Silurian Lake Corridor.

Census Tract Affected	Max Over-pressure level (psf)	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
		Low Income Threshold[a]	Very Low Income Threshold[a]		
County					
San Bernardino					
Census Tract 103	0.5 - 3.0	40.2%	22.9%	8.4%	32.9%
Census Tract 116	0.5 - 3.0	41.3%	26.7%	8.3%	20.0%
County Average		40.8%	24.8%	12.3%	39.0%
CA State Ave.		41.4%	22.9%	12.1%	42.6%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8*

Based on this analysis, the proposed flight from Edwards to Silurian Lake would not produce noise from sonic boom that disproportionately affects low income or minority populations. No Indian lands are affected in this trajectory. In comparing income and racial data for the individual Census tract potentially affected by noise to the county and state averages, it is clear that impacts are not directed towards a minority race or low income population.

4.4.2.2.2 Edwards to China Lake Naval Air Weapons Station Corridor

Sonic boom overpressure contours for the proposed flights from Edwards to China Lake Naval Air Weapons Station are shown in Section 4.1.12, Figure 4-35. As the vehicle makes its initial pitch after takeoff, overpressure levels ranging from 0.02 to 0.14 kPa (0.5 to 3.0 psf) may impact portions of Kern and San Bernardino Counties. Low levels of sound, ranging from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are anticipated in northeastern Kern County and northwestern San Bernardino County. Levels ranging from 0.02 to 0.14 kPa (0.5 to 3.0 psf) occur to the north and east of the California city area, in Kern County, Census tract 55.03, and in San Bernardino County, Census tract 116.

As the vehicle approaches the landing site, sound overpressures may range from 0.02 to 0.50 kPa (0.5 to 10.0 psf). Low level overpressures from 0.02 to 0.05 (0.5 to 1.0 psf) are anticipated to occur in portions of Tulare, Kern, San Bernardino and Inyo Counties. Overpressure levels ranging from 0.02 to 0.24 kPa (0.5 to 5.0 psf) are expected to occur just west of the China Lake military base boundaries within Inyo County Census tract 6. Overpressure levels ranging from 0.02 to 0.50 kPa (0.5 to 10.0 psf) are anticipated on China Lake Naval Air Weapons Station property.

Overpressure levels reaching 0.14 kPa (3.0 psf) or above off military base property are examined in Table 4-23. Maps depicting the Census tracts examined are shown in Figures 4-53 through 4-55.

Table 4-23. Income and Race Characteristics in the Edwards to China Lake Corridor.

Census Tract Affected	Max Over-pressure level (psf)	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
		Low Income Threshold[a]	Very Low Income Threshold[a]		
County					
Kern					
Census tract 55.03	0.5 - 3.0	43.0%	26.3%	13.9%	17.5%
County Average		40.0%	25.4%	16.4%	37.0%
Inyo					
Census Tract 6	0.5 - 5.0	43.9%	21.4%	12.3%	22.9%
San Bernardino					
Census Tract 116	0.5 - 3.0	41.3%	26.7%	8.3%	20.0%
County Average		40.8%	24.8%	12.3%	39.0%
CA State Ave.		41.4%	22.9%	12.1%	42.6%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*

Based on this analysis, the proposed flight from Edwards to China Lake Naval Air Weapons Station would not produce noise from sonic boom that disproportionately affects low income or minority populations. Indian lands are not affected by this trajectory. In comparing income and racial data for the individual Census tracts affected by sonic boom overpressures of 0.14 kPa (3.0 psf) or above to the county and state averages, it is clear that impacts are not directed towards a minority race or low income population. Income thresholds for Kern, Inyo and San Bernardino Counties Census tracts affected are very close to the county and state averages, while the percentage of minority populations are far below county and state averages.

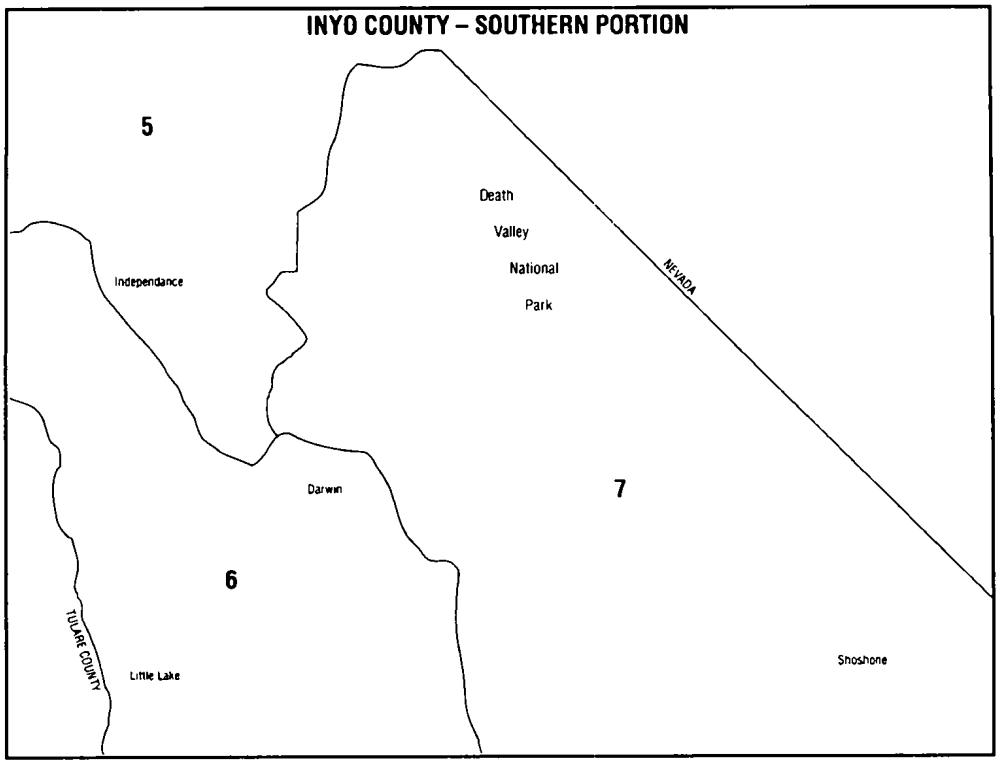


Figure 4-55. Inyo County (Southern Portion) Census Tracts.

4.4.2.2.3 Edwards to Dugway Proving Ground Corridor

Sonic boom overpressure contours for the proposed flight from Edwards to Dugway Proving Ground, Utah, are shown in Section 4.1.12, Figure 4-39. Sound pressure levels generated as the vehicle makes its initial pitch after takeoff range from 0.02 to 0.14 kPa (0.5 to 3.0 psf). Low levels of sound ranging from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are expected in parts of San Bernardino, Kern and Inyo Counties. Maximum overpressure levels of 0.14 kPa (3.0 psf) due to ascent are anticipated in northwestern San Bernardino County, within Census tracts 89.01 and 116. Income and racial characteristics of the Census tracts potentially affected by sound overpressure levels of 0.14 kPa (3.0 psf) were examined and are shown in Table 4-24 below.

Table 4-24. Income and Race Characteristics in the Edwards to Dugway Proving Ground Corridor.

Census Tract Affected	Max Over-pressure level (psf)	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
		Low Income Threshold[a]	Very Low Income Threshold[a]		
County					
San Bernardino					
Tract 89.01	0.5 - 3.0	42.4%	26.0%	14.9%	17.7%
Track 116	0.5 - 3.0	41.3%	26.7%	8.3%	20.0%
County Average		40.8%	24.8%	12.3%	39.0%
CA State Ave.		41.4%	22.9%	12.1%	42.6%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Censu of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*

As the vehicle descends to the landing site, sound overpressure levels may range from 0.02 to 0.14 kPa (0.5 to 3.0 psf). Low sound levels of 0.02 kPa (0.5 psf) are anticipated in Lincoln and White Pine Counties in Nevada, and Millard, Juab and Tooele Counties in Utah. Levels from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are expected in Juab and Tooele Counties. Indian lands affected by low level noise of 0.02 kPa (0.5 psf) include the Skull Valley Indian Reservation, just east of Dugway Proving Ground. All sound overpressures above 0.05 kPa (1.0 psf) are anticipated to occur within the Dugway Proving Ground base property with a maximum of 0.24 kPa (5.0 psf) anticipated in the southwestern side of the base.

Based on this analysis, the proposed flight from Edwards to Dugway Proving Ground would not produce noise from sonic boom that disproportionately affects low income or minority populations. In comparing income and racial data for the individual off base Census tracts affected by noise levels of 0.14 kPa (3.0 psf) to the county and state averages, it is clear that impacts are not directed towards a minority race or low income population.

4.4.2.2.4 Edwards to Malmstrom Air Force Base Corridor

Sonic boom overpressure contours for the proposed flight from Edwards to Malmstrom are shown in Section 4.1.12, Figure 4-43. Sound overpressure levels generated during the vehicle's ascent are expected to range from 0.02 to 0.38 kPa (0.5 to 8.0 psf). Low level sound overpressures are shown to occur in southeastern Tulare County and northeastern Kern County, California. Levels from 0.02 to 0.10 kPa (0.5 to 2.0 psf) are anticipated south of the city of Ridgecrest in Kern County and northwest of Ft. Irwin in San Bernardino County. For the nominal case, analyses show that overpressure levels above 0.10 kPa (2.0 psf) generated during ascent are expected to occur within base property of the Ft. Irwin military reservation.

As the vehicle descends to the landing site, sound overpressure levels may range from 0.02 to 0.07 kPa (0.5 to 1.5 psf). Low sound overpressure levels of 0.02 kPa (0.5 psf) are anticipated in Madison, Gallatin, Park, Jefferson, Lewis and Clark, Cascade, Teton, Chouteau, Judith Basin, and Meagher Counties in Montana. Levels of 0.05 kPa (1.0 psf) are anticipated in Meagher, Judith Basin, Chouteau, and Cascade Counties. Maximum overpressure levels of 0.07 kPa (1.5 psf) are expected in Cascade County southeast of Great Falls, Montana.

Based on this analysis, the proposed flight from Edwards to Malmstrom would not produce noise levels from sonic boom that disproportionately affect low income or minority populations. Indian lands are not affected by noise in this trajectory.

4.4.2.2.5 Edwards to Moses Lake Corridor

Sonic boom overpressure contours for the proposed flight from Edwards to Moses Lake, Washington are shown in Section 4.1.12, Figure 4-47. Sound pressure levels generated as the vehicle makes its initial pitch after takeoff may range from 0.02 to 0.24 kPa (0.5 to 5.0 psf). Maximum overpressures of 0.24 kPa (5.0 psf) anticipated to occur north of California City in Kern County Census tract 55.03 and San Bernardino County Census tract 116. Analyses for these Census tracts are shown in Table 4-25 below. Low levels of sound, ranging from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are expected in other portions of Kern and San Bernardino Counties in California.

Table 4-25. Income and Race Characteristics in the Edwards to Moses Lake Corridor.

Census Tract Affected	Max Over-pressure level (psf)	Percent of Total Households Below		Persons Below Poverty Level[b]	Percent Minority Population[c]
		Low Income Threshold[a]	Very Low Income Threshold[a]		
County					
Kern					
Census Tract 55.03	0.5 - 3.0	43.0%	26.3%	13.9%	17.5%
County Average		40.0%	25.4%	16.4%	37.0%
San Bernardino					
Census Tract 116	0.5 - 3.0	41.3%	26.7%	8.3%	20.0%
County Average		40.8%	24.8%	12.3%	39.0%
CA State Average		41.4%	22.9%	12.1%	42.6%

Sources:
[a] *1990 Census of Population and Housing, Characteristics of Income, Summary Tape File 3A, P5, P80, P80A.*
[b] *1990 Census of Population and Housing, Poverty Status, Summary Tape File 3A, P1, P117.*
[c] *1990 Census of Population and Housing, General Profile Summary, Summary Tape File 3A, P1, P8.*

As the vehicle descends to the landing site, sound overpressure levels may range from 0.02 to 0.07 kPa (0.5 to 1.5 psf). Low sound overpressure levels of 0.02 kPa (0.5 psf) are anticipated in Malheur, Harney, Grant, Baker, Union, Umatilla, and Wallowa Counties in Oregon, and Asotin,

Garfield, Whitman, Lincoln, Grant, Adams, Franklin, and Benton Counties in Washington. Two Indian reservations within the state of Oregon are expected to be affected by low level sound of 0.02 kPa (0.5 psf). They are the Umatilla Indian Reservation in northeastern Oregon and Fort McDermitt Indian Reservation in southeast Oregon. Levels from 0.02 to 0.05 kPa (0.5 to 1.0 psf) are anticipated in Adams, Franklin, and Lincoln Counties in Washington. Maximum overpressure levels of 0.07 kPa (1.5 psf) are expected in Adams County.

Based on this analysis, the proposed flight from Edwards to Moses Lake would not produce noise levels from sonic boom that disproportionately affect low income or minority populations.

4.4.3 Environmental Justice during Scoping and Planning

To ensure that the National Environmental Policy Act process is fully utilized to address concerns identified by all areas of the communities involved in the proposed action and that environmental justice concerns were incorporated into the Environmental Impact Statement development, the following actions were taken during the planning process for scoping:

- Although no minority areas were identified during the initial screening process, two counties in the Moses Lake, Washington, area were recognized as having potential for significant minority populations to be involved in the scoping process. Points-of-contact at Grant County Airport, Mr. David Bailey, and the Grant County Planning Director, Mr. Larry Angell, were contacted and asked to identify any needs during the scoping process, such as the need for:

    - multilingual distribution of the Notice of Intent
    - interpreters during the meeting
    - multilingual fact sheets.

Program personnel were informed that all areas of the Program communicated in English would be adequate.

- During the initial screening process, Native American lands along each potential flight corridor were identified. Areas of significance included those Native American lands in close proximity to the proposed launch and landing sites. Two Native American tribes were identified on the east and west sides of Dugway Proving Ground, Utah. Contact was made with tribal council leadership and an additional meeting was held as discussed in Section 1.5.2. The tribal officials identified no archeological, cultural, or religious sites of concern, but expressed an interest in viewing the test flight of the X-33.

4.5 Global Environment

4.5.1 Troposhere

The major combustion product of X-33 test flights, as well as a possible successor liquid oxygen (LOX)/liquid hydrogen (LH_2) reusable launch vehicle (RLV) system, is water. Although water vapor is a greenhouse gas, it is abundant in the troposphere. Additional amounts of water vapor to the troposphere from either the X-33 or an operational RLV system would be minute. The X-33 or RLV would not contribute any other quantifiable trace greenhouse gas. The X-33 or its potential planned successor would not release any acid in the engine exhaust as compared to some launch vehicles requiring solid rocket motors for boost.Global warming, also known as the "greenhouse effect," is the warming of the Earth's surface and troposphere, as described in Section 3.3.1. The greenhouse effect tends to intensify with an increase in atmospheric carbon dioxide, water vapor and other gases such as nitrous oxide, methane, and chlorofluorcarbons (commonly known by such terms as Freon and CFCs). The approximate maximum amount of water vapor that would be released in the troposphere per flight of the X-33 would be 49,000 l (13,000 gal). This amount of water is approximately equal to 0.4 percent of the water vapor entering the lower atmosphere from one hectare (2.5 ac) surface of water body that has evaporatively lost 1 cm (0.4 in) of water. A planned successor vehicle based on X-33 technology would be approximately 8 times higher per flight. Evaporative loss in tropical and subtropical zones such as along the southern coastal areas of ther United States would be approximately 150 cm (60 in) per year. Therefore, water vapor contribution to the troposphere that would contribute to global warming is extremely minute in comparision to natural sources. Therefore, no individual or cumulative impact to global warming (greenhouse effect) is expected from flights of either the X-33 or a successor RLV based on X-33 technology.

4.5.2 Stratosphere

Jackman, Considine, and Fleming (1995) modeled stratospheric ozone impacts of a theoretical launch vehicle using all LH_2/LOX engines for propulsion and a comparably-sized conventional launch vehicle using a combination of LH_2/LOX engines and solid rocket motors. Eight annual launches each of the theoretical and conventional launch vehicles using the same trajectories and atmospheric conditions were assumed. Stratospheric impacts from chlorine species deposited in the stratosphere from solid rocket motors during ascent contribute substantially more to reductions in ozone than water as a combustion product because chlorine is more catalytically destructive (WMO 1994). Results indicate that a potential successor spaceplane, based on the X-33 design and propulsion technologies, would reduce ozone impacts in the stratosphere by a factor of approximately 1,000. Current launch vehicles using solid rocket motors, however, produce a relatively small reduction in stratospheric ozone. As stated in a report to Congress by the Congressional Research Service, "Although there remain some unknowns about the effects that rockets in general, and solid rockets in particular, have on stratospheric ozone and UV (ultraviolet) exposures, there is little debate that given current launch rates and the current understanding of ozone chemistry, the impact appears to be relatively small" (Moteff, 1991). In the same report, Moteff (1991) notes that even critics of solid rocket motors do not suggest eliminating current launch vehicles, but desire to see cleaner technologies considered on future space launch development programs.

4.6 Minor Test Flight Support Facilities

NASA has committed to locate these stations in areas which would not adversely impact protected species. The small tracking stations would be fully contained, thereby precluding any potential contamination to surrounding water and soil. Energy would be supplied to the tracking stations through small diesel generators that would be properly permitted, if required by local and/or state regulatory authorities. Their use would be limited to system checkout and the short flights of the X-33 on a temporary basis. Minimal to no impact is expected from these stations.

4.7 Cumulative Impacts

The X-33 program plans would require approximately 1 1/2 years to prepare the launch and landing sites for Program activities. Flight tests are expected to be accomplished in a 10 month consecutive time period and then cease. A maximum of 19 ha (47 ac) of desert tortoise critical habitat, consisting of creosote bush scrub and Joshua tree woodland habitats, within Edwards would be disturbed with permanent structures, adding a small increment to the desert habitat changed from its pristine state if the Haystack Butte alternative is selected. The Space Port 2000 alternative would affect approximately one-half of habitat area that Haystack Butte would affect. Long-term impacts would include potential desert tortoise mortalities.

The current owner of Siluran Lake is BLM. However, Ft. Irwin has proposed a significant expansion of its training facilities which would include Silurian Lake (BLM 1996). NASA has met with U.S. Army officials at Ft. Irwin to determine if NASA's proposed use of the lake bed would be feasible should the training center be officially expanded by 1999. The U.S. Army has informally indicated acceptability, and NASA would continue to honor the commitments made in the Final EIS along with any others imposed by the U.S. Army. The nature of proposed U.S. Army activities are extensive and long-term. The temporary use of Silurian Lake would add insignificant contributions to the projected U.S. Army impacts.

Due to the minimal nature and level of expected impacts, the short time frame of the entire project, and commitment to protection of natural resources, short-term cumulative impacts are expected to be minimal, and long-term environmental impacts are expected to be non-existent.

4.8 Relationship Between Short-Term Use of the Human Environment and the Maintenance and Enhancement of Long-Term Productivity

Environmental impacts attributable to the X-33 flight test program are minimal to moderate and not considered cumulative in nature. However, the potential for long-term beneficial impacts on the environment from substantial stratospheric ozone and surface acid deposition reduction impacts with the planned successor spaceplane based on the X-33 design would be major.

4.9 Irreversible and Irretrievable Commitments of Resources

Resources in terms of materials to prepare launch and landing sites and fabricate the vehicle and energy to sustain equipment and power systems are minimal. It is anticipated that a significant

portion of all equipment utilized in project activities would be reutilized on future programs/projects. Excessed metals and materials with sufficient recyclable value will be recycled. Therefore, it is expected that the X-33 Program will have minimal impact from irreversible and irretrievable commitments of resources.

4.10 Unavailable Information

Due to this project being planned as an X-plane project, information through evaluation of similar X-planes, the Space Shuttle, or supersonic aircraft using known data and proven theoretical modeling was available to determine most environmental impacts. In addition, proposed alternatives are well established installations, except Silurian Lake. A formal jurisdictional wetlands determination was not available for Silurian Lake. However, the X-33 Program would assume that it does meet criteria established by the U.S. Army Corps of Engineers and would apply for a Section 404 permit for any disturbance and/or fill of the lake bed.

5.0 MITIGATION, MONITORING, AND PERMITTING

To the extent practicable, the X-33 Program has committed to mitigation measures to prevent or reduce environmental impacts. In order to assure that mitigation measures are effective and in compliance with applicable regulatory requirements, appropriate monitoring would be conducted such as water sampling and analyses, archaeological surveys and avoidance of areas with historical artifacts, and biological species surveys by specialists to monitor health and numbers of animals of concern. Permitting of activities with conditions imposed by regulatory authorities will be accomplished. These measures are summarized below.

5.1 Pollution Prevention

In accordance with Executive Order (EO) 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," federal facilities are required to conduct assessments of their facilities to ensure development of Pollution Prevention Programs that incorporate source reduction into facility waste management and acquisitions. The EO defines pollution prevention as any practice which reduces the amount of a hazardous substance or contaminant entering any waste stream or otherwise released to the environment prior to recycling, treatment, or disposal; and any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

Pollution Prevention Programs typically address the following elements: ozone depleting substances, Environmental Protection Agency (EPA)-17 Industrial Toxins Project chemicals, hazardous waste minimization, municipal solid waste management, affirmative procurement, energy conservation, and toxic chemicals/toxic releases. Elements relevant to the X-33 Program are further addressed below.

Hazardous Waste, Hazardous Chemicals and Spill Prevention

In compliance with the Emergency Planning and Community Right-to-Know Act, each proposed site has submitted an emergency planning notification to respective Local Emergency Planning Committees.

At some landing sites, X-33 activities would include refueling of the 747 carrier vehicle. Each landing site has a Spill Prevention Control and Countermeasure Plan for the handling of petroleum products during aircraft refueling in accordance with Title 40 Code of Federal Regulations Part 112.

The following mitigation for hazardous materials would be implemented:

1. The contractor/proponent shall coordinate all Standard Operating Instruction and other launch site operations and procedures with the Phillips Laboratory Safety and Health staff and the Phillips Laboratory Chief of Safety and Health at (805) 275-5522.

2. The Contractor shall coordinate renovation plans with Environmental Management (AFFTC/EMCC) and the Civil Engineer Group Environmental Coordinator (795

CES/CEZHW) prior to any disturbance to the interior or exterior portions of Buildings 9800 and 9804. Additional asbestos surveys and initial LBP surveys may be required. Submittal of an AF Form 813, *Request for Environmental Impact Analysis*, will be required if any site preparation work, including renovations to either of these buildings needs to occur prior to the completion and acceptance of the EIS. Coordinate with OLAC/SEH and AFFTC/EMXC for submittal of the AF Form 813.

3. No asbestos-containing building material shall be used on Edwards AFB.

4. The Contractor shall submit an Asbestos Abatement and Disposal Plan and a Lead Abatement and Disposal Plan (if sampling reveals the presence of lead-based paint) for coordination with Environmental Management (AFFTC/EMCC), Civil Engineering Group Environmental Coordinator (795 CES/CEZHW), and Bioenvironmental Engineering (95 AMDS/SGPB) prior to abatement activities. Coordination by the contractor is required to insure proper engineering controls are in place for the abatement and disposal. This would include the appropriate testing requirements for waste characterization.

5. Lead-based paint abatement work must be performed by qualified and trained workers as defined in Title 8 CCR Section 1532.1 and Title 29 CFR Part 1926.62. Inaddition, the following shall be adhered to:

Title 8 CCR, Section 3202, *Illness and Injury Prevention Program.*
Title 29 CFR Part 1910.1025, *Federal Occupational and Health Standards, Lead.*
Title 40 CFR, Part 61, Subpart M, *National Emission Standards for Hazardous Air Pollutants.*

6. All buildings scheduled for renovation.demolition shall be checked for PCB contamination before the project begins. Contractors will contact the Civil Engineering Group Environmental Coordinator (795 CES/CEZHW) for information regarding identification and proper means of removal, safe handling, and disposal of PCB-contaminated equipment.

7. Equipment, including pre-1976 fluorescent light ballasts, with PCB greater than 5 ppm must be disposed of as PCB/PCB-contaminated waste in accordance with 40 CFR Parts 261 and 761 and CCR Title 22. The wastes from PCB shall not remain on Edwards AFB longer than 29 days and shall be disposed of at an EPA-approved landfill. The AFFTC/EMCC manager will coordinate the signing of all manifests and manage the certificates of destruction.

The following regulations apply to the above mitigations:

California Code of Regulations (CCR)
- Title 8 CCR Section 1532.1, *Lead.*
- Title 8 CCR, Section 3202, *Illness and Injury Prevention Program.*
- Title 22, CCR, *Hazardous Criteria.*

Code of Federal Regulations (CFR)
- Title 29 CFR, Part 1910.1025, *Federal Occupational and Health Standards, Lead.*
- Title 29 CFR Part 1926.62, regarding Lead-based paint.
- Title 40 CFR 61, Subpart M, *National Emission Standards for Hazardous Air Pollutants.*
- Title 40 CFR, Part 761, *Polychlorinated Biphenyls.*

The following Edwards plans apply to the above mitigations.

OLAC PL Instruction (PLI) 32-4001, *Disaster Preparedness Program.*

OLAC PLI 91-202, 1995, *Laboratory Safety, Health, and Environmental Programs,* March.

Solid Waste Reduction and Recycling

Pursuant to EO 12873, "Federal Acquisition, Recycling, and Waste Prevention," each federal facility is required to follow a waste reduction program and must have goals in place for solid waste reduction and recycling. In addition, each facility is requested to follow a waste reduction program.

Edwards operates its own recycling facilities. Edwards' solid waste reduction goals are detailed in the Edwards Air Force Base Pollution Prevention Plan (EAFB 1996D). Solid waste generated by the X-33 Program would consist of debris and waste generated by Program personnel during operations. The amount of waste generated would be small compared to daily waste produced by normal range operations.

Energy Efficiency

Pursuant to the Energy Policy Act of 1992 (Public Law 102-486), each facility should strive to:

- reduce overall energy use by 30 percent by the year 2005 from their 1985 energy use levels
- increase energy efficiency by 20 percent by the year 2000, using 1990 as the baseline year
- minimize the use of petroleum products
- increase the use of solar and other renewable energy sources.

Since the X-33 would be fully reusable, the X-33 Program would substantially reduce energy demands by not having to refurbish motors, manufactor new tanks, and/or utilize several thousand workers to check out and reassemble the vehicle for each flight. In addition, the possible successor vehicle would also require substantially less energy at support facilities for the same reasons listed for X-33. Therefore, the X-33 Program would comply with the intent of the Energy Policy Act of 1992.

Toxic Chemicals/Toxic Releases

Federal facilities strive to eliminate or reduce production or acquisition of products which contain extremely hazardous substances or toxic chemicals. The Community Right-to-Know Act requires facilities that manufacture more than 11,300 kg (25,000 lb) or otherwise use more than 4,500 kg (10,000 lb) of listed toxic chemicals to publicly report their wastes and releases to EPA's Toxic Release Inventory (TRI). Federal facilities which exceed threshold requirements must develop goals to reduce releases and offsite transfers by 50 percent by the end of 1999. In order to assure that the X-33 Program does not impact Edwards ability to

meet pollution prevention goals, Edwards reported toxic release data was obtained. Since July 1995 federal facilities have been required to submit TRI reports. The 1994 TRI report was submitted by the Air Force to EPA in June 1995. Table 5-1 lists the chemicals that were reported for 1994.

Table 5-1. Chemicals Reported in Edwards 1994 TRI Report.

Chemical	Total Use/Storage lbs (kg)
Chlorinated Fluorocarbon 113	16,989 (7,706)
Chlorine	14,400 (6,532)
Hydrochloric Acid	28,757 (13,044)
Isopropyl Alcohol	53,430 (24,235)
Phosphoric Acid	8,421 (3,820)
Based upon current usage levels, not including X-33 levels.	

There were no chemicals that exceeded the required threshold (7,500 pounds) in 1995; therefore, the TRI report submitted to Air Force Material Command in July 1996 indicated no TRI chemicals to report (EAFB 1996 D). Increased use of toxic chemicals due to the X-33 Program would be minimal. Therefore, NASA does not expect that TRI thresholds would be exceeded if the X-33 Program were to be implemented at Edwards.

In an effort to meet the goals set forth by EO 12856, many organizations have initiated projects affecting both the physical infrastructure and program/project operations on the proposed sites. Incorporating newer, more environmentally friendly processes produce benefits for many elements of the sites involved. Some examples of technology used on the X-33 Program which would benefit pollution prevention efforts include:

- Use of graphite/epoxy composites in the manufacture of structural components to produce a structure which requires less propellant per unit weight to orbit. Composite processing is solvent free and does not require a high degree of corrosion protection; therefore, fewer materials containing volatile organic compounds are used.

- Ceramic matrix composites used to generate a stable thermal protection system do not break apart, decompose, or burn. The product is also reusable.

- Aqueous or terpene material used for surface preparation, verification, and cleaning replace or reduce the use of ozone depleting chemicals.

- Control devices, such as scrubbers or filters, are being added in cleaning practices in addition to switching to less hazardous chemicals.

- Liquid oxygen/liquid hydrogen is a clean-burning propellant, releasing only water vapor into the environment.

NASA sponsors a significant number of research and development (R&D) and materials substitution projects for the mutual benefit of the aerospace industry and the environment (MSFC 1995B).

5.2 Flight Safety

Mitigation of risk and impact from emergency resulting from an X-33 test flight are:

- periodic updates of risk assessments using component and/or systems test data as available
- final approved flight termination system must ensure that flight can and would be effectively terminated in a fail safe manner and would ensure that the vehicle does not present danger to personnel, the public, property or a sensitive facility in the event of an abort
- avoidance of overflight of sensitive facilities such as the weapons storage area on Malmstrom and the chemical/biological warfare laboratories on Dugway
- update of risk assessments flight-to-flight with actual test flight data
- emergency response plans prepared in advance of first flight with input from potentially affected agencies and approved by the AFFTC Chief of Safety and landing site safety offices
- special emergency response precautions, training, and/or equipment included in emergency response plan(s) and provided by Lockheed Martin
- agreement with FAA to be formalized to provide for consultation in safety planning, real time communication with Air Route Traffic Control Centers during flight operations, and issuance of appropriate NOTAMs in the event of an emergency

5.3 Air Quality

The following mitigation measures would be followed at Edwards to minimize potential air quality impacts:

(1) The proposed project will require either Kern County Air Pollution Control District (KCAPCD) or Mojave Desert Air Quality Management District (MDAQMD) air quality permits for stationary internal combustion engines, flare stacks, generators, storage tanks, and the X-33 Advanced Technology Demonstrator Vehicle's equipment static testing activities. The required air permits shall be coordinated with Environmental Management (AFFTC/EM).

(2) The proposed project (where required) shall comply with all Best Available Control Technology specified in KCAPCD Rule 210.1, New and Modified Stationary Source Review.

(3) The project shall comply with all applicable KCAPCD and MDAQMD rules and regulations.

(4) The proposed project will comply with all applicable rules and regulations as identified in AFI 32-7040, Air Quality Compliance (9 May 1994).

(5) All earthwork will be planned and conducted to minimize the duration that soils would be left unprotected. The extent of the area of disturbance necessary to accomplish the project will be minimized.

(6) Ground disturbance activities will be delayed, to the maximum extent practicable, during high wind conditions (in excess of 25 knots (47 km/hr, 29 mi/hr)). Vehicular traffic, grading, and digging should not be permitted in the project area during high wind conditions. Exposed surfaces will be periodically sprayed with water or a soil binder (soil binders must be coordinated with Environmental Management (AFFTC/EM)).

(7) A dust control plan would be developed and approved by AFFTC/EM prior to beginning earth grading activites.

5.4 Cultural Resources

Three site alternatives have potential to affect cultural resources: the two launch site alternatives and the Silurian Lake landing site alternative. These alternatives are the only ones which involve site preparation activities and ground disturbance. Launch site alternatives have been surveyed, and no eligible sites are expected to be affected. Additional pre-site preparation surveys would be performed and should sites be discovered during that time, additional investigations would be conducted, as appropriate, to mitigate effects. Known sites will be flagged for avoidance. If a site is unexpectedly encountered during preparation of the launch site or other X-33 Program areas, ground disturbance would be stopped, the Base Historic Preservation Officer called, who in turn would call the State Historic Preservation Officer. Determination of future actions at the site and resolution of the "find" would be made before resuming work on the area. At Silurian Lake, it is highly unlikely that any sites would be affected. However, mitigation similar to that for Edwards would be performed in the event a site(s) was identified. In addition, a supplemented site-specific survey and analysis could be required by BLM before issuance of a right-of-way reservation.

Should modifications to or renovation of Buildings 9800 and/or 9804 on Edwards at the Haystack Battle site be necessary, the Base Historic Preservation Officer would be contacted in the planning stage in order to implement cultural resource protection measures.

5.5 Transportation

The only site alternative expected to produce impacts to ground transportation corridors is the Silurian Lake landing site. During operations, it is expected that a 40 km (25 mi) segment of California State Highway 127 would be closed for up to 4 consecutive hours just prior to launch through landing. A smaller section of the road (approx. 1.6 km (1 mi)) in the vicinity of the lake bed would be cleared of traffic for 15 to 30 minutes for landing and takeoff of the Boeing 747. Road closure is to ensure safety of the public and vehicles and protection of the fragile desert environment. There would be a maximum of three landing events over a 3-month period.

Mitigation for these impacts would involve early notification of travelers, both public and commercial, through coordination with appropriate state transportation departments, local area Chambers of Commerce, and direct public notifications via newspapers and other media. Notifications would include information on flight schedules, closure duration, and routing alternatives. Escorts for critical needs such as medical emergencies and perishable commodity deliveries will be available at both the north and south road blocks.

5.6 Threatened and Endangered Species

The only potential adverse impacts expected from the X-33 project to federally listed species or critical habitat are for desert tortoises at the Haystack Butte launch site and Silurian Lake alternatives. Desert tortoise mortalities may result from a test failure, vehicular traffic, grading activities, and release of deluge water. Harassment of desert tortoises may result from relocation of tortoises prior to construction activities and displacement due to increased human activity in the area. A maximum area of approximately 19 ha (43 ac) of desert tortoise critical habitat and 9.3 ha (23ac) of desert tortoise habitat would be disturbed by preparation of the launch site at Haystack Butte and Space Port 2000, respectively. A maximum disturbance of critical habitat may also be impacted by a test failure resulting in fire, dispersion of fragments, release of deluge water, and emergency response and clean up operations. In a worst case scenario, the amount of disturbance would be unknown. However, such impacts are anticipated to be within the explosive safety perimeter that would surround the site. Additionally, because desert tortoises are not sedentary, it is likely that over the course of the X-33 project, several tortoises from the general area would be encountered. Based on the estimated tortoisedensities, between 15 and 20 tortoises may be affected in the Haystack Butte vicinity and approximately half the number at the Space Port 2000 site. These impacts would be minimized by the construction of the fence surrounding the launch site. The proposed use of Silurian Lake would disturb approximately 0.1 ha (0.3 ac of creosote bush habitat over an area approximately 27 ha (68 ac). In conclusion, initiation of Section 7 consultation with the USFWS and the proposed minimization measures listed in the Biological Assessment (provided in Appendix E) for desert tortoise protection in conjuction with the USFWS Terms and Conditions of the Biological Opinion which will be forthcoming for this project would minimize any potential adverse impacts to desert tortoise and its habitat. This assessment includes potential impacts to protected listed species at all alternative sites.

The following steps would be taken to minimize effects of habitat loss:

(1) All project personnel working on site shall attend the desert tortoise education program prior to working on the site. Short term visitors to the site being escorted by tortoise trained individuals would be allowed by procedures established by EAFB Environmental Management Conservation Branch..

(2) An Edwards biologist would designate a biological monitor and would determine which site preparation and placement of equipment activities must be monitored Any interaction between workers and tortoises, including mortalities, would be reported to the biological monitor.

(3) No more than 48 hours prior to groundbreaking in any new area (i.e., launch facilities, access road, utilities lines, towway), a biological monitor would survey the area for burrows. Any active or inactive burrows would be excavated by the biological monitor using hand tools. Tortoises removed from the burrows would be placed in the closest suitable habitat that would not be disturbed. An artificial burrow would be provided for any relocated tortoises. This protocol would also be followed if tortoises are found in site preparation areas outside of their burrows.

(4) Preparation sites would be clearly delineated and activities would remain within designated areas, including vehicle and equipment parking and staging areas. Site preparation areas could be delineated with chain-link fencing, including tortoise exclusionary fencing, thereby reducing the need for biological monitoring.

(5) Vehicles would travel only on established roads whenever possible. If off-road travel is necessary, vehicle operators would be alert for desert tortoises and other wildlife, and vehicle speeds would not exceed 24 km/hr (15 mi/hr).

(6) Habitat loss and disturbance would be minimized. Previously disturbed or denuded areas would be used for development wherever feasible. To promote revegetation and soil stabilization in disturbed areas, the Edwards' Revegetation Plan would be implemented upon project completion (Mitchell et al. 1994). The least destructive equipment available would be used to accomplish tasks (e.g., ATV's to install fencing, cable plow to install fiberoptic cable). On-site contractors would be required to follow good environmental practices, such as minimizing water use and waste, containing trash in predator-proof receptacles, and minimizing dust.

(7) Aboveground pipes and lines would be placed at least 50 cm (20 in) above the surface to allow passage underneath by tortoises.

(8) Excavations would be dug with a 3:1 slope at either end. Open excavations would be inspected for trapped wildlife daily and prior to filling. Any wildlife found would be reported to the biological monitor who would be in charge of removal. Any open pipe or conduit would be capped or stored in such a way as to discourage use by wildlife.

(9) In the event of a test failure, a desert tortoise and critical habitat damage assessment would be performed and documented by an Edwards biologist.

(10) At the end of the X-33 project, any direct and indirect impacts to desert tortoises would be determined by an Edwards biologist and documented in a report to the U.S. Fish and Wildlife Service for NASA. This determination would be based on records of mortalities and relocations compiled by the biological monitor during the project and the final amount of critical habitat disturbed and/or destroyed.

(11) An authorized biologist would survey the route to be travelled when the need to drive off established routes is necessary. Workers and site visitors would inspect for sheltering tortoises under all vehicles prior to operating them.

(12) Sensitive plant species (such as desert cymoterus) should be avoided by delineating population boundaries.

(13) Electrical poles without cross arms and/or bird roosting deterrents would be installed.

(14) Excavations would be secured (covered over) to deter desert tortoise entry when left unattended. Fencing, plywood, or other suitable materials and/or methods would be used to secure excavations.

(15) Additional mitigation measures may be added as a result of the U.S. Fish and Wildlife Service Section 7 consultation.

5.7 Snow Avalanche

There is a theoretical possibility that the sonic booms produced during descent of the X-33 could trigger a snow avalanche at the Spout Springs ski area (for the Moses Lake landing site alternative) or at the Showdown ski area in Neihart, Montana (for the Malmstrom landing site alternative). Operations at the Spout Springs ski area typically begin in mid-November and last until early April. Spout Springs has no record of historical avalanche activity. Snow conditions are surveyed regularly by ski patrol members and no action has been required to stabilize the main ski slope (Spout Springs 1997). At the Showdown ski area, operations typically begin in late November and last until mid-April. Showdown employs snow-cutting as the primary method of artificial release. Periods of high avalanche danger typically occur during the first 10 to 15 days of operations. After the initial settling period, Showdown's three main snow slopes remain stable for the duration of the season (Showdown 1997).

To reduce the risk of injury or structural damage resulting from snow avalanche, X-33 flights to Moses Lake or Malmstrom would be coordinated with Spout Springs and Showdown, respectively. These ski facilities would be provided with the schedule for the X-33 flights indicating the time of day that the overflights would occur, thus allowing them to complete avalanche survey and control operations prior to anticipated X-33 overflights. X-33 launch would not occur until conclusion of control operations was verified. Criteria for snow avalanche is discussed in Section 3.2.4.17.

5.8 Regulatory Permits and Agreements

In order for the X-33 Program to go forward and implement the Proposed Action, a number of permits and agreements must be applied for and negotiated with regulatory authorities and facility owners, respectively. Permits and agreements are summarized in Table 5-2.

Table 5-2. Permit or Agreement Requirements Launch and Landing Sites.

Alternative	Equipment or Operation Covered	Regulatory or Authorizing Agency	Requirement
Launch Site:			
Either Haystack Butte *or* Space Port 2000	1. LOX Flare Stack 2. Diesel Generator at the Launch Pad 3. Diesel Generator at the ODC 4. Bldg. Drive System IC Engine 5. Propane Burner for N_2 Vaporizer 6. 2300 Gal Diesel Tank at Pad 7. 350 Gal Diesel Tank at OCC	MDAQMD	1. Air permits to construct/ operate must be obtained from the MDAQMD. It would include the source listed. 2. MDAQMD 3. Permit application would be submitted by Edwards' Environmental Management.
	Concrete Batch Plant	MDAQMD	If required. Notes above are applicable to this source.
	Flight operations and Launch	U.S. Air Force	1. Memorandum of Agreement/Task Agreement granting use of specific sites, buildings, access, etc. 2. Lockheed Martin would be required to obtain.
Landing Sites:			
Silurian Lake	Landing	BLM	1. Right of Way Reservation (Section 507 of Federal Land Policy and Land Management Act) to be relinquished at the conclusion of the test. 2. Lockheed Martin would prepare and submit through NASA
	Landing	U.S. Army Corps of Engineers	1. Section 404 Clean Water Act permit required for activities on lake bed if grading or other modifications are required. 2. Lockheed Martin would develop, and NASA would submit following authorization by BLM for NASA to submit permit.
	Flight Test	FAA	1. Sterile airspace, void of aircraft, required to temporarily restrict all aircraft from airspace in vicinity of landing when X-33 descends under 18,300m (60,000ft). 2. Lockheed Martin would submit.
	Traffic Control (Tourists)	CDOT	1. California Department of Transportation would require an Encroachment permit to restrict traffic on SH 127. 2. Lockheed Martin would prepare and submit through NASA

Table 5-2. (Continued) Permit or Agreement Requirements Launch and Landing Sites.

Alternative	Equipment or Operation Covered	Regulatory or Authorizing Agency	Requirement
China Lake	Landing	U.S. Navy	1.Memorandum of Agreement/Task Agreement granting landing privileges and specifying conditions. 2. Lockheed Martin would be required to obtain.
Michael Army Airfield	Landing	U.S. Army/US Air Force	1. Memorandum of Agreement/Task Agreement granting landing privileges and specifying conditions. 2. Lockheed Martin would be required to obtain.
Malmstom Air Force Base	Landing	U.S. Air Force and/or Congress	1. Memorandum of Agreement/Task Agreement granting landing privileges and specifying conditions and financial outlays. 2. Lockheed Martin through NASA would be required to provide information to initiate Congressional action if required.
	Flight Test	FAA	1. Sterile airspace, void of aircraft,. required to temporarily restrict all aircraft from airspace in vicinity of landing when X-33 descends under 18,300m (60,000 ft). 2. Lockheed Martin would submit.
Moses Lake	Landing	Port of Moses Lake	Lockheed Martin would be required to obtain a Landing Agreement.
	Flight Test	FAA	1. Sterile airspace, void of aircraft required to temporarily restrict all aircraft from airspace in vicinity of landing when X-33 descends under 18,300m (60,000 ft). 2. Lockheed Martin would submit.

6.0 REFERENCES

AFFTC 1994	Air Force Flight Test Center, Edwards Air Force Base, *Operations—Utah Test and Training Range*, AFFTC Regulation 55-18, March 1, 1994.
Air Products and Chemicals, Inc. (1990A)	Air Products and Chemicals, Inc., Industrial Gas Division, Allentown, PA. Hydrogen Material Safety Data Sheet, March 1990/
Air Products and Chemicals, Inc. (1990B)	Air Products and Chemicals, Inc., Industrial Gas Division, Allentown, PA. Nitrogen Material Safety Data Sheet, 1990.
Air Products and Chemicals, Inc. (1990C)	Air Products and Chemicals, Inc., Industrial Gas Division, Allentown, PA. Helium Material Safety Data Sheet, 1990.
ANSI 1980	American National Standards Institute, *Sound Level Descriptors for Determination of Compatible Land Use,* (Standard ANSI S3.23-1980), 1980.
Army Research Laboratory 1993	U.S. Army Materiel Command, *Final Environmental Impact Statement for the Relocation of the Woodbridge Research Facility Electromagnetic Pulse Simulators,* 1993.
ASA 1988	American National Standards, *Quantities and Procedures for Description and Measurement of Environmental Sound, Part I*, (Standard ASA S12.9-1988), 1988.
ASM Affiliates, Inc. 1997	*Preliminary Draft, Exploiting the Desert Oases: Archaeological and Paleoenvironmental Investigations in the Silurian Valley and Adjacent Areas of Southeastern California*, (Contract No. DAC09-94-0-0019), prepared for U.S. Army Corps of Engineers, Los Angeles District, prepared by ASM Affiliates, Inc., edited by Brian F. Byrd, March 1997.
Berry 1997	Personal Communication between K. Berry, J.S. Geological Survey, Biological Resources Division, Desert Tortoise Research Project, Riverside, California, and R. B. Smith, Dynamac, Kennedy Space Center, subject: noise effects on desert tortoises, March 1997.
BioSystems 1994	BioSystems Analysis, Inc., *Life on the Edge, A Guide to California's Endangered Natural Resources: Wildlife,* Santa Cruz, California, 1994.

Black & Veatch 1993	Port of Moses Lake, *Grant County Airport Master Plan*, Black & Veatch, 1993.
BLM 1996	United States Department of the Interior, Bureau of Land Management, California Desert District, *Draft Environmental Impact Statement for the Army's Land Acquisition Project for the National Training Center, Fort Irwin, California, and Proposed Amendment to the California Desert Conservation Area Plan,* U.S. Army Corp of Engineers, Los Angeles District, with Chambers Group, Inc., and Michael Brandman Associates, Inc., December 1996.
Bowles 1997	Abstract from paper presented to the 22nd Annual Meeting and Symposium of the Desert Tortoise Council, *"Effects of Recreational Noise on Wildlife: An Update,"* by A. E. Bowles, Las Vegas, Nevada, April 1997.
Bowles/Eckert/Starke 1997	Abstract from paper presented to the 22nd Annual Meeting and Symposium of the Desert Tortoise Council, *"Effects of Simulated Sonic Booms and Low-Altitude Aircraft Noise on the Behavior and Heart Rate of the Desert Tortoise (Gopherus agassizii),"* by A. E. Bowles, S. A. Eckert, and L. Starke, Las Vegas, Nevada, April 1997.
Bowles/Francine/Matesic/ Stinson 1997	Abstract from paper presented to the 22nd Annual Meeting and Symposium of the Desert Tortoise Council, *"Effects of Simulated Sonic Booms and Low-Altitude Aircraft Noise on the Hearing of the Desert Tortoise (Gopherus agassizii),"* by A. E. Bowles, J. K. Francine, J. Matesic, Jr., and H. Stinson, in Las Vegas, Nevada, April 1997.
Burrell 1997	Personal Communication between Jeff Goodson, CSC, and Sam Burrell, Chief, Health and Safety, Phillips Laboratory, subject: treatment of deluge water following use of rocket engine/motor testing at the Phillips Laboratory on Edwards Air Force Base, March 11, 1997.
Busacca 1997A	Personal Communication between Mike DeKeyerl, BLM/Barstow, CA, and Mario Busacca, NASA/Kennedy Space Center, FL, subject: regarding traffic counts on State Highway 127 near Silurian Lake, 1997.
Busacca 1997B	Personal Communication between Ted Austin, Dugway Proving Ground, Utah, and Mario Busacca, NASA/Kennedy Space Center, subject: wastewater on Dugway, 1997.

CHABA 1981	*Assessment of Community Noise Response to High-Energy Impulsive Sounds*, Report of Working Group 84, Committee on Hearing, Bioacoustics, and Biomechanics, Assembly of Behavioral and Social Sciences, National Research Council, National Academy of Science, Washington, DC, 1981.
Chien/Soroka 1980	*"A Note on the Calculation of Sound Propagation Along an Impedance Surface,"* Journal of Sound and Vibration, 69:340-343, 1980.
COE 1994	U.S. Army Corps of Engineers, *Identification and Classification of "Waters of the United States" on one Playa at the U.S. Army Dugway Proving Ground,* Dugway, Utah, by Robert Lichvar, Steven Sprecher, and James Wakeley, 1994.
CPIA 1971	Chemical Propulsion Information Agency, *"Chemical Rocket/Propellant Hazards, "* (Publication 194, Volume I), 1971.
DFRC/EAFB 1994-A	National Aeronautics and Space Administration Facts, *The Research Airplane Program,* Dryden Flight Research Center, Edwards Air Force Base, California, February 2, 1994.
DFRC/EAFB 1994-B	National Aeronautics and Space Administration Facts, *X-31 Enhanced Fighter Maneuverability Demonstrator,* Dryden Flight Research Center, Edwards Air Force Base, California, February 2, 1994.
DFRC/EAFB 1995	National Aeronautics and Space Administration Facts, *X-31 Research Aircraft Accident,* Dryden Flight Research Center, Edwards Air Force Base, California, January 19, 1995.
DPG Home Page 1996	Dugway Proving Ground (DPG), Internet Address: http://www.ATC.Army.mil/~Dugway/fact1.html, January 8, 1996.
DPG Census Data 1990	U.S. Census Data, Database C90STF3A, Internet address: http://venus.census.gov/cdrom/lookup/861211473, 1990.
DPG/Tooele County Census Data 1996	U.S. Bureau of the Census, U.S.A. Counties, Internet address: http://www.census.gov/statab/USA96/49/045.txt, 1996.

DPG 1996A	Personal Communications with Robert Johnson from the Environmental Programs, Natural Resources Staff, at Dugway Proving Ground, and R.B. Smith, Dynamac, Kennedy Space Center, subject: General Ecology, December 1996.
DPG 1996B	Reptile Amphibian List from Dugway Proving Ground, October 1996.
DPG 1996C	Bird List from Dugway Proving Ground, December 31, 1996.
DPG 1996D	Mammal List from Dugway Proving Ground, October 1996.
EAFB 1991	Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Historic Resources Overview and Management Plan,* by Richard L. Wessel, Ralph A. Anton, Virginia M. Howard, and Teri Caruso Wessel, 1991.
EAFB 1993	Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Biological Resources Environmental Planning Technical Report, prepared in support of the Programmatic Environmental Assessment for Basewide Implementation of the Installation Restoration Program (IRP) at Edwards Air Force Base, California*, December 1993.
EAFB 1994A	Air Force Flight Test Center, Edwards Air Force Base, *Comprehensive Plan*, June 1994.
EAFB 1994B	U.S. Army Corps of Engineers, Sacramento District, and the Air Force Flight Test Center, Environmental Management Office, *Programmatic Environmental Assessment for Basewide Implementation of the Installation Restoration Program at Edwards Air Force Base, California,* prepared by GRW Engineers, Lexington, Kentucky, and Tetra Tech, Inc., San Bernardino, California, February 1994.
EAFB 1994C	Personal Communication between Southern California Association of Governments, San Bernardino County Planning Department, and Kern County Planning Department subject: population of ROI and communities surrounding Edwards Air Force Base, California, July-August 1994.

EAFB 1995A — Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Mohave Ground Squirrel Studies at Edwards Air Force Base, California,* by K. Buescher, D. R. Mitchell, B. M. Ellis, J. S. Sawasaki, D. M. Laabs, and M. L. Allaback, July, 1995.

EAFB 1995B — Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Historical Overview of the Rocket Laboratory, Edwards Air Force Base, California,* by Dena S. Komporlides, Christopher Hurst, Susan L. Bupp, Linda Auten, and Carry Cotterman, July 1995.

EAFB 1995C — Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Cultural Resources Literature Search for the Proposed Continuation of Precision Impact Range Area (PIRA) Operations, Edwards AFB, Kern, Los Angeles, and San Bernardino Counties, California,* by Margaret Ronning, July 1995.

EAFB 1995D — Air Force Flight Test Center, FMC, Edwards Air Force Base, California, *Air Force Flight Test Center Summary, Cost and Business Strategies Division, Edwards Air Force Base, California*, March 31, 1995.

EAFB 1996A — Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Relative Density Estimates of Desert Tortoise on Edwards Air Force Base, California,* by D. M. Laabs, M. L. Allaback, B. M. Ellis, D. R. Mitchell, J. S. Sawasaki, and E. LaRue, Jr. (p. 24), 1996.

EAFB 1996B — Air Force Flight Test Center, Environmental Management Office, Edwards Air Force Base, California, *Final Environmental Assessment for the Continued Use of the Precision Impact Range Area (PIRA), Edwards Air Force Base, California*, February 1996.

EAFB 1996C — United States Air Force Flight Test Center, Environmental Management Office, by The Earth Technology Corporation, *Installation Restoration Program, Remedial Investigation/Feasibility Study, Operable Unit 4, Final Field Sampling Plan,* Volume 1, May 1996.

EAFB 1996D — Air Force Flight Test Center, Environmental Management Office, California, *Edwards Air Force Base Pollution Prevention Plan,* December 1997.

EAFB 1997 — Computer Sciences Corporation, Edwards Air Force Base, California, subject: *X-33 Inputs for EIS*, March 10, 1997.

(Ecology USA 1997)

Egan 1997 — Personal Communication between T. Egan, Bureau of Land Management, and R. B. Smith, Dynamac, Kennedy Space Center, subject: desert tortoises at Silurian Lake, California, March 1997.

Ellis/Mindell 1991 — Environmental Pollution 74:53-83, *Raptor Responses to Low-Level Jet Aircraft and Sonic Booms*, by D. H. Ellis and C. H. Ellis, and D. P. Mindell, 1991.

EPA 1974 — Environmental Protection Agency, *Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety,* (U.S. Environmental Protection Agency Report 550/9-74-004), 1974.

EPA 1987 — Environmental Protection Agency, *Ultraviolet Radiation and Melanoma,* Washington, DC, 1987.

EPA 1996 — U.S. Environmental Protection Agency, Office of Federal Activites, *Review Draft, Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analysis*,, July 12, 1996.

FAA 1997 — Draft Environmental Impact Statement for The Southwest Regional Spaceport, Federal Aviation Administration, Associate Administrator for Commercial Space Transportation

FEMA (1989) — Federal Emergency Management Agency, U.S. Dept. of Transportation, and U.S. Dept. of Energy, Handbook of Chemical Hazard Analysis Procedures, Washington, D.C., 1989.

FIC 1980 — Federal Interagency Committee on Urban Noise, *Guidelines for Considering Noise in Land-Use Planning and Control*, Washington, DC, 1980.

FIC 1992 — Federal Interagency Committee on Noise, *Federal Agency Review of Selected Airport Noise Analyses Issues,* Washington, DC, 1992.

Finegold et al. 1994	"Noise Control Engineering Journal ", Volume 42, no. 1, pp. 25-30, Finegold, L.S., Harris, C.S., and Von Gierke, H. E., *Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People,* by L.S. Finegold, C.S. Harris, and H.E. Von Gierke, January-February 1994.
FWS 1994	United States Department of the Interior, Fish and Wildlife Service, Ecological Services, Ventura Field Office, California, *Biological Opinion for the Precision Impact Range Area, Edwards Air Force Base, California (1-8-94-F-6),* March 10, 1994.
Gomez 1997	Comments received from China Lake Naval Air Weapons Station, R. Gomez, March 22, 1997.
Grant County 1995	Grant County, Washington, *Draft Grant County Comprehensive Plan,* by Grant County Planning Department, May 1995.
Grant County 1996	*Moses Lake Sugar Beet Processing Plant Draft Environmental Impact Statement,* issued by Grant County and Washington State Department of Ecology and prepared by Pacific Northwest Sugar Company, May 1996.
GSFC/WFF 1994	Goddard Space Flight Center, *Draft Supplement Impact Statement for Sounding Rocket Program,* Wallops Island, Virginia, 1994.
Gubler 1992	Swiss Federal Institute of Snow and Avalanche Research, *"Artificial Release of Avalanches ",* by H. Gubler, 1992.
Haber/Nakaki 1989	BBN Systems and Technologies, *"Sonic Boom Damage to Conventional Structures,"* (Report No. 67829), by J. M. Haber and D. Nakaki, Canoga Park, California, 1989.
Hagan 1997	Personal Communication between Mark Hagan, Base Wildlife Biologist, AFFTC/EMXC and Tom Mull, CSC, subject: estimated tortoise densities, May 5, 1997.
Hallion 1984	National Aeronautics and Space Administration, article, *"On the Frontier, Flight Research at Dryden, 1946-1981,"* by Richard P. Hallion, Scientific and Technical Information Branch, Washington, DC, 1984.

Jackman/Considine/Fleming 1995	Article: *"Simulations of the Effects of the Space Shuttle Launch Vehicle on the Stratosphere Using a Two-Dimensional Model,"* by C. H. Jackman, E. B. Considine, and E. L. Fleming, 1995.
Jarvinen/Hill 1970	*"Universal Model for Underexpanded Rocket Plumes in Hypersonic Flow,"* Proceedings of the 12th JANNAF Liquid Meeting, by Jarvinen, P. O. and Hill, J. A. F., 1970.
Johnson 1993	Marshall Space Flight Center, *"Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development"*, NASA/MSFC Technical Memorandum No. 4511, by D.L. Johnson, August, 1993.
Kiva 1991	Kiva Biological Consulting, *Estimated Distribution and Density of the Desert Tortoise at China Lake, Naval Weapons Center,* Inyokern, California, 1991.
LaBerteaux 1994	Naval Air Weapons Station, China Lake, *A Proposed Managment Plan for the Inyo California Towhee (Pipilo crissalis eremophilus) on Naval Air Weapons Station, China Lake, California*, Contract Number N60530-90-D-0071(0018), pp. 77, 1994.
LaBerteaux 1997	Personal Communication between D. LaBerteaux, EremiCo, and R. B. Smith, Dynamac, Kennedy Space Center, subject: Inyo, California towhees, March 1997.
Laye 1997	Personal Communication between D. Laye, U.S. Fish and Wildlife Service, Barstow, California, and R. B. Smith, Dynamac, Kennedy Space Center, Florida, subject: protected species at China Lake Naval Air Station and Silurian Lake, March 1997.
Letchworth 1997	Personal Communication and Fax between Gary Letchworth, Lockheed, Titusville, and Dave Barker, NASA/Kennedy Space Center, subject: X-33 Program Flight Safety, May 9, 1997.
MAFB 1991	Science Applications International Corporation, *Installation and Restoration Program, Stage 2, Remedial Investigation/Feasibility Study for Malmstrom Air Force Base, Montana*, July 1991.

MAFB 1994	Air Mobility Command, *Abbreviated Environmental Assessment Force Structure Changes,* Malmstrom Air Force Base, Montana, March 1994.
MAFB 1996A	Air Force Space Command and 341st Missile Wing, *Integrated Natural Resources Management Plan for Malmstrom Air Force Base,* prepared for 341 CES/CEV Malmstrom Air Force Base, Montana, prepared by EA Engineering, Science, and Technology, Lincoln, Nebraska, March 1996.
MAFB 1996B	*Malmstrom Air Force Base, Montana, Comprehensive Plan/General Plan,* Malmstrom Air Force Base, January 1996.
Maglieri/Plotkin 1991	NASA Reference Publication 1258, *"Sonic Boom,"* Chapter 10, *Aeroacoustics of Flight Vehicles: Theory and Practice,* by D.J. Maglieri and K.J. Plotkin, Hubbard, H. H. (Ed.), August 1991.
Martin 1997	Personal Communication between S. Martin, U.S. Fish and Wildlife Service, Benton Lake National Wildlife Refuge, Montana, and R. B. Smith, Dynamac, Kennedy Space Center, subject: wildlife species of concern at Benton Lake National Wildlife, March 1997.
McCaleb 1996	Personal Communications on Silurian Lake Bed between Antol Szijj, U.S. Army Corps of Engineer, Los Angeles District, and Dr. Rebecca McCaleb, NASA/MSFC, subject: Silurian Lake Bed, 1996.
McGetrick (1997)	McGetrick, Lawrence, (Archeologist, Computer Sciences Corporation), Phase I Cultural Resources Inventory and Phase II Cultural Resources Evaluation for the Proposed X-33 Launch Pad at Haystack Butte, Edwards AFB, Kern, Los Angeles and San Bernardino Counties, CA. Document is on file at Environmental Management at Edwards AFB, CA., 1997
McLaughlin 1997	Personal Communication between Computer Science Corporation, and Frank McLaughlin subject: survey information on asbestos, lead-based paint and polychlorinated biphenyls in Bldg. 9800 and 9804,.

Meade 1997	Personal Communication between Carl Meade, Lockheed Martin Skunk Works, Palmdale, California, and Rebecca McCaleb, NASA/MSFC, subject: debris fall rates, June, 1997.
Miller 1988	Orion Books, article: *"The X Planes, Aerofax, Inc,"* by Jay Miller, Arlington, Texas, 1988.
Mitchell et al. 1994	"*Edwards Air Force Base Revegetation Plan,*" by D.R. Mitchell, J.S. Sawaski, B.M. Ellis, and S. White, 1994.
Molina/Rowland 1974	*"Stratospheric Sink for Chloroflurometh anes: Chlorine Atom Catalyzed Destruction of Ozone,"* (Nature 249:810-814), by M.J. Molina and F.S. Rowland, 1974.
Monastersky 1990	Science News, article: *"UV Damages Base of Antarctic Food Web," (p. 87),* by R. Monastersky, August 1990.
Montana 1997	Personal Communication between Montana Department of Transportation representative and Andy Linehan, CH2M Hill, subject: Montana Department of Transportation, 1997.
Moteff 1991	Congressional Research Service, *"Rockets and Ozone: Should Alternative Technologies be Developed?"* by John D. Moteff, November 22, 1991.
MSFC 1963	National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Alabama, *A Technique for Predicting Far-Field Acoustics Environments Due to Moving Rocket Sound Source,* (Technical Note TN-D-1832), by S.A. Wilhold, S.H. Guest, and J.H. Jones, 1963.
MSFC 1995A	National Aeronautics and Space Administration, Marshall Space Flight Center, *A Cooperatice Agreement Notice, Reusable Launch Vehicle (RLV) Advanced Technology Demonstrator, X-33,* (CAN 8-1), George C. Marshall Space Flight Center, Alabama, February 24, 1995.
MSFC 1995B	National Aeronautics and Space Administration, Marshall Space Flight Center, *Proceedings of the NASA Environmental Technology Conference*, (NASA Conference Publication 3298), George C. Marshall Space Flight Center, Alabama, 1995.

MSFC 1996A	National Aeronautics and Space Administration, George C. Marshall Space Flight Center, *Final X-33 Programmatic Environmental Assessment: Vehicle and Technology Demonstration Concepts*, George C. Marshall Space Flight Center, Alabama, June 1996.
MSFC 1996B	National Aeronautics and Space Administration, Marshall Space Flight Center, *A Cooperative Agreement Notice, X-33 Phase II: Design and Demonstration,* (CAN 8-3), George C. Marshall Space Flight Center, Alabama, April 1, 1996.
MSFC 1996C	National Aeronautics and Space Administration, Marshall Space Flight Center, *Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program,* George C. Marshall Space Flight Center, Alabama, November 1996.
NAS 1991	National Academy of Science, *Policy Implementations on Greenhouse Warming,* National Academy Press, Washington, DC, 1991.
NAS/NRC 1984	National Academy of Science, and National Research Council, *Causes and Effects of Changes in Stratospheric Ozone: Update 1983,* National Academy Press, Washington, DC, 1994.
NASA 1978	National Aeronautics and Space Administration, NASA Headquarters, *Environmental Impact Statement Space Shuttle Program Final Statement,* Washington, DC, 1978.
NASA 1993	National Aeronautics and Space Administration, NASA Headquarters, *Access to Space Transportation Technology Team Final Report,* Washington DC, 1993.
NASA 1995	National Aeronautics and Space Administration, NASA Headquarters, *Environmental Justice Strategy,*Washington,DC, 1995.
National Goegraphic Society 1996	National Geographic Society, *Federal Lands in the Fifty States,* October 1996.
NASA 1996	National Aeronautics and Space Administration, NASA Headquarters, Final Tier 2 Environmental Impact Statement for International Space Station, Washinton, D.C., 1996.

NOAA 1997A	National Oceanics and Atmospheric Administation, *IFR Environment High Altitude-U.8 May, H-4 Southeast/H-2 Southwest*, Effective March 27, 1997.
NOAA 1997B	National Oceanics and Atmospheric Administation, *IFR Environment High Altitude-U.8 May, H-3 Northeast/H-1 Northwest*, Effective March 27, 1997.
PDR 1996	Lockheed-Martin Skunk Works, Operations Preliminary Design Review, Palmdale, California, December 10-12, 1996.
Pittman 1996	CSC, Technical Data Exchange, ENGT-703/09-03 *"Proposed X-33 Launch Pad at Space Port 2000,"* by Matthew Pittman, Archeaologist, September 3, 1996.
Plotkin 1989	American Institute of Aeronautics and Astronautics (AIAA), *"Review of Sonic Boom Theory,"* (AIAA-89-1105), by K. J. Plotkin, Washington, DC, 1989.
Plotkin 1993	Journal of Aircraft, Volume 30, No. 1, *"Sonic Boom Focal Zones from Tactical Aircraft Maneuvers,"* , by K.J. Plotkin, January-February 1993.
Plotkin 1996	Data Report provided under NASA/MSFC NAS8-40082 CH120, by K>J> Plotkin, March 1996.
Range Commanders Council 1997A	Range Commanders Council, "Common Risk Criteria for National Test Ranges," Standard 321–97, Published by Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1997.
Range Commanders Council 1997B	Range Commanders Council, "Common Risk Criteria for National Test Ranges, Subtitle: Inert Debris," Supplement to Standard 321-77, Published by Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1997.
Schott 1997	Personal Communication between Jerry Schott, Director of Public, Safety, Port of Moses Lake, and Dave Barker, Safety, Kennedy Space Center, subject: security at Moses Lake, April 10, 1997.

Schultz 1978	J. Acoust. Soc. Am 64:377-405, *"Synthesis of Social Surveys on Noise Annoyance,"* by T. J. Schultz, 1978.
SCS 1988	USDA, SCS, Interim Report, *Soil Survey of EAFB*, CA,1988.
SCS 1996	USDA, SCS, *Preliminary Draft Soil Survey, Edwards Air Force Base, CA, Part of Kern, Los Angeles, and San Bernardino Counties*, December 1996.
Showdown 1997	Personal Communications between Showdown Ski area representative and Andy Linehan, CH2M-Hill, subject: Showdown Ski area, March 1997.
Spout Springs 1997	Personal Communication between Spout Springs area representative and Andy Linehan/CH2M-Hill, subject: Spout Spings Ski area, 1997.
Stahlecker/Alldredge 1976	Wilson Bulletin 88:151-154, *"The Impact of an Underground Nuclear Fracturing Experiment on Cliff-Nesting Raptors,"* by D. W. Stahlecker and A. W. Alldredge, 1976.
Sutherland 1968	Wyle Laboratories Research Staff, WR 68-2, prepared for MSFC under NASA Contract NAS8-11217, by Louis C. Sutherland, et al., March 1968.
Sutherland 1993	American Institute of Aeronautics and Astronautics, *"Progress and Problems in Rocket Noise Prediction for Ground Facilities,"* (AIAA 93-4383), by Louis C. Sutherland, Washington, DC, October 1993.
Sverdrup 1997	Sverdrup Corporation ,*X-33 Single Stage to Orbit (SSTO), X-33 Explosive Siting Information*, prepared for Lockheed-Martin Skunk Works, Palmdale, California, April 11, 1997.
Tiegerman 1975	*"Sonic Booms of Drag-Dominated Hypersonic Vehicles, "* Doctoral Thesis, Cornell University, by T. Tiegerman, August 1975.
USAF 1990	UTTR Flight Test Center, *Environmental Assessment of 6545th Test Group (AFSC, Hill AFB, Utah) Routine Operations and Facilities on Dugway Army Proving Grounds,* prepared by Computer Sciences Corporation, February 1990.

USAF 1992A — U.S. Air Force, *Preliminary Draft Environmental Impact Statement, Administrative Attachments, National Aero-Space Plane Flight Test Program,* November 1992.

USAF 1992B — U.S. Air Force, Hill Air Force Base, Utah, *Sonic Boom/Animal Disturbance Studies on Pronhorn Antelope, Rocky Mountain Elk, and Bighorn Sheep,* Contract No. F42650-87-C-0349, February 1992.

USAF 1992C — U.S. Air Force, Preliminary Draft Environmental Impact Statement, National Aero-Space Plane Flight Test Program, November 1992.

USAF 1995A — 6510 TESTTW/DOTF, Edwards Air Force Base, *R-2508 Complex User's Handbook,* 1995.

USAF 1995B — U.S. Air Force, *Range User Handbook, EWR 127-1*, May 31, 1995.

U.S. Army 1982 — *Installation Environmental Assessment, U.S. Army Dugway Proving Ground,* Prepared by Carlos, F.A. Pinkham, Ph.D., L. Dale King, D.A. Gauthier, G.T. Crane, H.E. Stark, Ph.D., A.P. Adams, Ph.D., Paul E. Carlson, and G.L. Choules, Ph.D., January 1982.

USDA 1995 — USDA Forest Service, *Description of the Ecoregions of the United States,* (2nd edition revised and expanded, Misc. Publication No. 1391), by R. G. Bailey, 1995.

USN 1989 — Department of the Navy, Western Division, Naval Facilities Engineering Command, *Naval Weapons Center China Lake Master Plan, Volume I: Center-wide Analysis* and *Volume 2: Planning Areas Analysis,* June 1989.

USN 1994 — Department of Defense, Aircraft Department, Naval Air Warfare Center, Weapons Division, China Lake, California, and Kern County Air Pollution Control District, Lahonton Regional Water Quality Control Board, Kern County Environmental Health Department, *Environmental Assessment Proposal by the Aircraft Department toCconstruct andOoperate a New Aircraft Ready Fuel Storage Facility, at the Naval Air Weapons Station, China Lake, California,* (823E00D/940023), October 8, 1994.

USN 1997	United States Naval Academy, *"Introduction to Naval Weapons Engineering,"* Internet address: http://web/wse.nadn.navy.mil/wse/academic/courses/es310/Lectures/Warheads.htm.
Vest 1962	*"The Plant Communities and Associated Fauna of Dugway Valley in Western Utah,* Doctoral Thesis," by E. Dean Vest, to the Department of Botany, University of Utah, August 1962.
Whaley 1997	Personal Communication between K. Whaley, U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge, Florida, and R. B. Smith, Dynamac, Kennedy Space Center, Florida, subject: bald eagle nesting on Kennedy Space Center, March 1997.
White 1972	*Effects of Repetitive Sonic Booms on Glass Breakage*, FAA Report FAA-RD-72-3, by R. White, April 1972.
Williams 1997	Personal Communication between S. Williams, U.S. Navy Biologist, China Lake Naval Air Station, and R. B. Smith, Dynamac, Kennedy Space Center, subject: federally listed species at China Lake Naval Air Station, March 1997.
WMO 1985	World Meteorological Organization, *Atmospheric Ozone,* Geneva, Switzerland, 1985.
WMO 1989	World Meteorological Organization, *Scientific Assessment of Stratospheric Ozone,* Geneva, Switzerland, 1989.
WMO 1991	World Meteorological Organization, *Scientific Assessment of Ozone Depletion,* Geneva, Switzerland, 1991.
WMO 1994	World Meteorological Organization, *Scientific Assessment of Ozone Depletion,* Geneva, Switzerland, 1994.
Woodman/Kohfield/Bagley	*Plant and Wildlife Species of Special Management Concern on the Naval Air Weapons Center China Lake, California,* (p. 11), by P. Woodman, B. Kohfield, and M. Bagley, 1996.
Wyle 1996	Wyle Laboratories, Inc. *PC Boom 3 Sonic Prediction Model-Version 1.0*, Wyle Research Report WR 95-22C, by Kenneth J. Plotkin, Arlington, Virginia, 1996..
Wyle 1997	Wyle Laboratories, Inc. Sonic Boom Contours, Wyle, 1997.

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Betty Lehrman
Harvey Lowthian
Brooks Madison
Ron Miller
M. Miller
The Mills's
Fred Naeher
Robert Nebel
Shawn Nelson
Allan Nickolson
Randy Peck
Michael Rieley
Tim Ryan
Gary Scott
Clayton Sheets, L.P.A.
Dr. Bob Sletten
James Taflan
Edward R. Teddy, Jr.
Chris Thennis
Mary Thornton
Shane Tracy
Joe Tropila
Thomas Ware
Larry Westfall
John Wilson

Nevada

Businesses and Organizations
Elko Daily Free Press
Ely Daily Times
The Humboldt Sun
Las Vegas Review Journal

Las Vegas Sun
Nevada Appeal
Reno Gazette-Journal

Oregon

Businesses and Organizations
Daily Argus Observer
Kathleen Kirkpatrick Nash, Ecosynergy, LLC
Portland Oregonian
Statesman Journal

Utah

Elected Officials
Honorable Eli H. Anderson, Utah State Representative
Honorable Wilford R. Black, Utah State Senator
Honorable Afton B. Bradshaw, Utah State Representative
Honorable Mary Carlson, Utah State Representative
Honorable DeeDee Corradini, Utah State Representative
Honorable Gene Davis, Utah State Representative
Honorable James R. Gowans, Utah State Representative
Honorable R. J. Greensides, Utah State Representative
Honorable David M. Jones, Utah State Representative
Honorable George Mantes, Utah State Senator
Honorable Ronald J. Ockey, Utah State Senator
Honorable Frank Pignanelli, Utah State Representative
Honorable Robert C. Stiner, Utah State Senator
Honorable Pete Suazo, Utah State Representative
Honorable Blaze Wharton, Utah State Senator

Federal Agencies
Fish Springs National Wildlife Refuge, Jay Banta

State and Local Agencies and Officials
Bureau of Microbiology, Dr. Susan Mottice
Division of Comprehensive Emergency Management, Lorayne Frank
Division of Comprehensive Emergency Management, Corinne Kenney
Salt Lake County Fish and Game
Tooele County Attorney, Douglas Ahlstrom
Tooele County Engineer, Raymond Johnson
Toole County Sheriffs Office, Sheriff Frank Scharmann
Tooele County Wildlife, Gene Ekenstam
Tooele Fire Department, James Jensen
Tooele Police Department, Chief Jess Peterson
Utah County Emergency Management, Lt. Richard Casto
Utah Highway Patrol, Captain Ray McKaye

Military
Systems Manger, Tooele Operations, Tooele Army Depot, South Area

Businesses and Organizations
AAUW, Betsy Bedrero
Air Chem Lab, Craig Rhodes
American Legion, Pete Warburton
American Lung Association of Utah
APTUS, Sharla J. Barber
APTUS Western Environmental Services, Jim Manning
Basin Land and Livestock
Beta Sigma Prec. Alpha, Elaine Wassom
Chevron USA, Inc., L. R. Shanks
Civic League, Ludean Long
Council of the Arts, Dorothy Leonelli
The Daily Herald
DDOU-WA, Del Fredde
Deseret News, Brend Israelsen
Desert Star
Eagles Lodge
Eckoff Watson & Preator, James Olsen
Ecova Corporation, Lee Snowhite
EG&G Defense Materials, Inc.
Elks, Bill Buckingham
Elks Auxiliary, Vikki Griffith
Envirocare of Utah, Jay Vance
Ernie Owens Battelle, Dr. David Clark
Flying J., Inc., Jeff Utley
Four H Club, Halcyon Robins
Gem and Mineral Club, Maurine Coffman
Grantsville Elementary School, Cheryl Dearing
Grantsville Lions, Bradford T. Walters
Great SL Audubon, Douglas Stark
The Herald Journal
Holmes Roberts & Owen, Mary E. Floyd
Illinois Power Company, Thomas V. Clevenger
ISRI, Clare Hessler
Job Service, Ed Bryans
KALL AM, KLCY FM
KBYU-TV, Channel 11
KCPX AM, KCPX FM
KDYL AM, KSFI FM
Kennecott Utah Copper, Drew Hunter
Kiwanis Club, Dave Isolampo
KJZZ, Channel 14
KOOG-TV, Channel 30
KPCW FM
KRSP AM, KRSP FM

KSL AM 1160
KSL-TV, Channel 5
KSOP AM, KSOP FM
KSTU, Channel 13
KTKK AM
KTLE FM
KTVX, Channel 4
KUED TV, Channel 7
KUER FM, University of Utah
KULC, Channel 9
KUSU FM News, Utah State University, Kerry Bringhurst
KUTR AM, KLTO FM
KUTV, Channel 2
LDS Relief Society, Ned and Mary Herron
Lions Club, Gordon Woods
Magna Times
McFarland and Hullinger
Meridian Oil, Inc.
Millard County Concerned Citizens, Thomas Chandler, DMD
Radian Corporation, Paul Bitter
Republican Ladies, Amalia Ayala
Republican Party, Max Durrant
Salt Lake Tribune, Jim Woolf
Senior Citizens, Anne Winneggee
Sons of Utah Pioneers, Don Hosenburg
Stoel Rives Boley, Jones & Grey, James A. Holtkamp
Tooele BPW President, Cheryl Barrus
Tooele County Corporation, Kari Sagers
Tooele County Development Corporation, Scott Muir
Toole County Senior Citizens
Tooele Methodist Church
Tooele Transcript Bulletin
Travelers Aid Society, Karen Denton
TU Council, Bill Partner
Union Pacific Railroad Co., Steven A Goodsell
University of Utah, Community Relations, John Dwan
USPCI, Charlie Roberts
USPCI CIF, David M. Sewell
USPCI GM, Robert M. Apple
Utah Cattlemens Association
Utah Federation BPW, Barbara L. Despain
Utah Nature Society
Utah Manufacturers Association, Larry D. Bunkall
Watch Front Regional Council, Barry V. Banks

Individuals
Duane Allen
Bradley Angel
Dave and Roni Barton

William T. Barton
David Bickmore
Lim Bradley
Glen E. Brown
Melvin R. Brown
Grace Bukowski
Arnold Christensen
Bruce Clegg
John Cluff
Lavell and Kathy Cummings
Ellen Eckels
David Faddis
Fred W. Finlinson
Kelly H. Gubler
Thomas Hardy
Byron L. Harward
Celestia Himstreet
John P. Holmgren
Jerry Hurst
John Craig Joosten
Becky Kennedy
R. B. Land
Donald R. LeBaron
Daniel Linares
Ruth Lundgren
Donald Mackey
Joe Melling
Joseph K. Miner
Barbara A. Moore
Richard Muir
Alarik Myrin
Karen Oldroyd
David S. Ostler
Brad Parson
Gary Payne
Cary G. Peterson
Craig A. Peterson
Don Peterson
Ronald G. Peterson
M. John Pilny
Randy Poulsen
Lorin Powell
Bob Pruitt
Don Rogers
Ray S. Schmutz
Gayle Stevenson
Karl G. Swan
Linn Taylor
Mary Thornton
Joseph L. Trujillo

Gary Walvaine
Thomas Ware
Paul Wayman
Jim Wheeler
Beverly J. White
June Wickham
Ferris Williams
Jeril B. Wilson
Brian Yanagitani
Henry Yeates, M.D.

Washington

Federal Agencies
U.S. Army Corps of Engineers
U.S. Department of Agriculture, Soil Conservation Service

State and Local Agencies and Officials
Central Washington Railroad
Department of Transportation
East Columbia Basin Irrigation District, Richard Erickson
Farm Bureau, John Bates
Grant County Airport, Leon M. Bodie
Grant County Airport, Delone D. Krueger
Grant County Airport, Larry Peterson
Grant County Fire District No. 5
Grant County Fire Marshall
Grant County Health District
Grant County Housing Authority, Kenneth Palek
Grant County Planning Department
Grant County Public Works Director
Grant County Weed Board
Interagency Committee for Outdoor Recreation
Moses Lake Irrigation and Rehabilitation District
Moses Lake School District
Mosquito Control District
Public Hospital District No. 1
Washington Sate Department of Ecology
Washington State Department of Ecology, Vickie Baxter

Businesses and Organizations
Big Bend EDC
Board of Realtors, Cris Blessing
Columbia Basin Herald, A. Caputo
EBSN Radio
Grant County Journal

KWIQ Radio
Superintendent of Public Instruction, Carter Bragg
Tri City Herald
Walla Walla Union Bulletin
Wenatchee Daily World

Individuals
Denny Eckelberger
Cindy Felis
Peter Havens
Wally Hendrickson
Roland O. Jones
John Kamerrer

Other

Jim Denier, Denver, CO
John Geddie, Albuquerque, NM
David H. Vomacka, Ph.D., Dayton, OH

10.0 GLOSSARY

100 Year Flood. Flood having a one percent chance of being equalled or exceeded in magnitude in any given year.

100 Year Floodplain. Land adjoining a river, stream, or watercourse that will be covered by water in the event of a 100-year flood.

A-Weighted Sound Level (dBA). A number representing the sound level which is frequency weighted according to a prescribed frequency response established by the American National Standards Institute (ANSI S1.4-1971) and accounts for the response of the human ear.

Acoustic Focusing. The effect relating to the refraction or "reflection" of acoustic energy as it moves through the atmosphere, occurring when meteorological conditions of temperature and winds are such that the speed of sound increases with increasing altitude thereby resulting in higher levels of sound at a given point than that which would be expected otherwise.

Acoustics. The science of sound which includes the generation, transmission, and effects of sound waves, both audible and inaudible.

Ad Hoc. A meeting or committee serving a specific purpose but with general application.

Aeolian. Referring to or of the wind.

Aerodynamics. The branch of aeromechanics that deals with the forces exerted by air or other gases in motion.

Aero-lift. The "lift" provided to an airplane due to its wings or other structural features.

Aeroshell. Outer shell of an aircraft.

Aerospike Engine. A rocket engine requiring no bell nozzle. The hot gases (products of combustion) are ejected from the engine in a manner which influences their forming an "aerospike" in the atmosphere and changing with the changing atmosphere as the rocket ascends.

Aft. The rear of an aircraft.

Aileron. A pilot or mechanically controlled airfoil attached to, in, or near the trailing edge of an aircraft wing, for controlling the rolling movements of the aircraft.

Airspace. The space lying above a nation and coming under its jurisdiction.

Air Traffic Control Assigned Airspace. Airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activities being conducted within the assigned airspace and other instrument flight rules air traffic.

Alkaline Soils. Soils containing an alkali, any soluble substance, as mineral salt or mixture of salts, that can neutralize acids and has a pH greater than 7.0. Strong alkalis are caustic.

Alluvial Fan. A gradually sloping mass of alluvium that widens out like a fan from the place where a stream slows down little by little as it enters a plain.

Alluvium. Soils such as sand, clays, silts, and loams gradually deposited by moving water, as along a river bed or shore of a lake.

Ambient Air Quality Standards. Standards established on a state or federal level that define the limits for airborne concentrations of designated "criteria" pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, total suspended particulate, ozone and lead), to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards).

Ambient/Air Concentration. Concentration in the atmosphere.

Ambient Noise Environment. Noise level measured under normal, everyday conditions.

Ambient/Air Pressure. Atmospheric force measured under normal, everyday conditions.

Amplitude. The extreme range of a fluctuating quantity, as an alternating current or swing of a pendulum, and generally measured from the average or mean to the extreme.

Anomalies. Departures from the regular arrangement, general rule, or usual method.

Apogee. The highest or farthest point.

Aqueduct. A large pipe, conduit, or canal made for bringing water from a distant source.

Aqueous. A water-based substance.

Aquifer. An underground layer of porous rock or sand containing water, into which wells can be sunk.

Archaeology. A scientific approach to the study of human ecology, cultural history, and cultural process.

Attainment Areas. A region that meets the National Ambient Air Quality Standards for a criteria pollutant under the Clean Air Act.

Autonomously Controlled Spaceplane. Controlled by a combination of onboard guidance, navigation and control equipment and flight managers from the launch control center.

Auxiliary Power Unit. Power units aboard an autonomously controlled spaceplane which generate power for the electromechanical actuators which move the flight control surfaces as directed by onboard computers or commanded from the ground control center.

Avionics. The branch of electronics dealing with the development and use of electronic equipment in aviation and astronautics.

Bell Nozzle. Nozzle in the shape of a bell such as the nozzles on the end of the Space Shuttle's Main Engines that control the configuration and angle of release of the hot gases of combustion.

Biome. Any of several major life zones of interrelated plants and animals determined by the climate, as deciduous forest or desert.

Biphenyl (diphenyl). Combining form containing two phenyl (the basis of aromatic compounds) groups in each molecule.

C-Weighted Sound Exposure Level (CSEL). The C-weighted sound level integrated over the entire duration of the event and referenced to a duration of one second.

C-Weighted Day-Night Average Sound Level (L_{Cdn}). Similar to L_{dn} , but uses C-weighted sound level rather than A-weighted, allowing low-frequency dominated noise emissions to be evaluated.

Caldera. A broad, crater-like basin of a volcano, formed by an explosion or by collapse of the cone.

Carbon Epoxy Panels. Panels made up of synthetic organic carbon epoxy material.

Carbon Monoxide (CO). A colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion. One of the six pollutants for which there is a national ambient standard. See Criteria Pollutants.

Carpet Boom. Shock waves produced by an aircraft traveling at supersonic speeds that cover the ground in a parabolic shape, resulting in a sound resembling a short, impulsive noise, similar to a double gunshot.

Caustics. Corrosive substances which can burn, eat away, or destroy tissue by chemical action.

Chemical Surety Materials. Chemical warfare agents.

Chinooks. The warm, dry wind blowing intermittently down the east side of the Rockies during the winter and early spring, which causes the rapid thawing of snow.

Chlorides. Compounds in which chlorine is combined with any of certain other elements or with a radical.

Chloroform ($CHCl_3$). A toxic, cancer producing, colorless, volatile liquid with a sweet taste, used as a solvent.

Clean Air Act. Federal law setting basic criteria, requirements, and regulatory authority for managing air quality.

Coalesce. To unite or merge into a single body, group, or mass.

Community Right-to-Know Act. Federal law requiring all companies using or storing threshold quantities of toxic chemicals to provide an annual inventory to the public.

Composite Materials. High strength, light weight engineering materials consisting of various combinations of alloys, plastics, and ceramics.

Composite Structure. The primary aircraft structure composed of composite materials and providing support for the vehicle, internal tanks, flight control surfaces, and thermal protection system.

Controlled Airspace. Airspace designated as a control zone, airport radar service area, terminal control area, transition area, control area, continental control area, or positive control area wherein some or all aircraft may be subject to air traffic control.

Correlation Coefficient. Statistics. Any of several measures of accompanying variations of two or more variables.

Criteria Pollutants. The Clean Air Act required the Environmental Protection Agency to set air quality standards for common and widespread pollutants after preparing "criteria documents" summarizing scientific knowledge on their health effects. Current standards in effect for six "criteria pollutants" are: sulfur oxide (SO_2), carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb).

Cryogenic. A gas in a liquid state, having very low temperature; any material having very low temperature.

Cultural Resources. Prehistoric and historic districts, sites, buildings, objects, or any other physical evidence of human activity considered important to a culture, subculture, or a community for scientific, traditional, religious, or any other reason; for purposes of environmental analysis includes paleontological remains.

Cumulative Impacts. The combined impacts resulting from all activities occurring concurrently at a given location.

Cyanide. A substance composed of a radical group in combination with some element or radical. The resultant compounds are extremely poisonous and often used for extracting gold from low-grade ores, electroplating, casehardening of steel, and as a fluxing material.

Decibel (dB). A unit of measurement on a logarithmic scale which describes the magnitude of a particular quantity of sound pressure or power with respect to a standard reference value.

Deleterious. Harmful to health or well-being.

Deluge. A great flood or heavy rainfall.

Demate. Remove X-33 from its piggy-back mountings on the Shuttle Carrier Aircraft.

Demilitarization. The process of freeing from organized military control; as related to ordnance, render harmless.

DeMinimus. Threshold quantities above which further detailed air quality analyses are required to demonstrate conformity with Clean Air Act standards.

Demonstrator Vehicle. Vehicle designed with the sole purpose to demonstrate state-of-the-art materials and processes.

Double Redundancy. Having two of the same equipment to increase reliability.

Drag. A resisting force exerted on an aircraft parallel to its airstream and opposite in direction to its motion.

Ecotone. A transitional zone between two adjacent communities, containing species characteristic of both as well as other species occurring only within the zone.

Effluent. The outflow of a sewer, septic tank, or treatment plant.

Emergent Wetland. Wetland plants growing below and above the surface of the water.

Endangered Species. A plant or animal that is in danger of extinction throughout all or a significant portion of its range.

Endemic. Native to a particular country, nation, or region: said of plants, animals, and sometimes customs.

Envelope. An established level of performance.

Environmental Protection Agency (EPA). The independent federal agency, established in 1970, that regulates environmental matters and oversees the implementation of environmental laws.

Ephemeral. Short-lived.

Ephemeral Streams. Transitory streams of short duration, often lasting only one day.

Epizoological Studies. Study of epidemic animal diseases.

Erosion. Wearing away of soil and rock by weathering and the action of streams, wind, and underground water.

Ethnographic. Referring to the branch of anthropology that deals descriptively with specific cultures, especially those of nonliterate peoples or groups.

Ethylene Glycol. A colorless, viscous liquid used as an antifreeze, solvent, in resins.

Expendable. Designated supplies or equipment expected to be used up or destroyed in service.

Explosive Safety Quantity-Distance (ES/QD). The quantity of explosive material and distance separation relationships which provide defined types of protection. These relationships are based on the level of risk considered acceptable for each stipulated exposure and are tabulated in the Q-D tables. Separation distances are not absolute safe distances but are relative protective or safe distances.

Faults. Fracture in earth's crust accompanied by a displacement of one side of the fracture with respect to the other and in direction parallel to the fracture.

Federal Register. Daily federal publication containing federal laws, actions, executive orders, regulations, etc., in draft or final form.

Ferrous Metals. Metals containing iron.

Fiberoptics. The transparent fibers used in the transmission of light and images.

Flight Corridor. Flightline or trajectory of vehicle with expanded width based on maximum potential deviation.

Flight Envelope Expansion. Flight test plan of meeting objectives through a systematic increase in speed, altitude, and distance.

Flight Readiness Firing. Static test of fully assembled vehicle accomplished by firing the engines for a short period of time (approximately 20 seconds) with vehicle secured to the launch pad.

Flight Trajectory. The curved flight path of an aircraft from the time it is launched until the point it touches the ground.

Focal Zone. Concentrated regions where sonic booms generated at different times can converge simultaneously due to vehicle maneuvers such as during acceleration from subsonic to supersonic speeds, in the region where the boom first reaches the ground or when a supersonic vehicle turns sharply enough that the boom toward the inside of the turn will coalesce into a focal zone.

Focusing. See Acoustic Focusing.

Frequency. The time rate (number of times per second) that the wave of sound repeats itself, or that a vibrating object repeats itself; now expressed in Hertz (Hz), formerly in cycles per second.

Fugitive Dust. Dust from a non-point source such as a car on an unpaved road.

Geomorphic. Pertaining to the shape of the earth or its topography.

Glaciolacustrine Materials. Materials of glacial lake formation.

Ground Acceleration. Force from an earthquake causing movement of bedrock. Measured in fraction of the acceleration of gravity.

Groundwater. Water within the earth that supplies wells and springs.

Habituate. To become accustomed to frequent repetition or prolonged exposure.

Halogenate. To introduce a nonmetallic chemical element (halogen) such as chlorine or bromine into a compound.

Halophytic. Describing a plant that can grow in salty or alkaline soil.

Hard Surface Runway. Paved or conditioned to achieve equivalent hardness.

Hazardous Air Pollutants. Air pollutants as defined by the Clean Air Act.

Hazardous Material. Generally, a substance or mixture of substance that has the capability of either causing or significantly contributing to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or posing a substantial present or potential risk to human health or the environment. Use of these materials is regulated by Department of Transportation, Occupational Safety and Health Administration, and Superfund Amendment Reauthorization Act.

Hazardous Materials Pharmacy. A facility or system that stores, distributes, or otherwise controls chemicals and substances determined to be hazardous to human health or to the environment.

Hazardous Waste. A waste, or combination of wastes, which, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may either cause, or significantly contribute to, an increase in mortality or in serious irreversible or incapacitating reversible illness; or posing a substantial present or potential risk to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Regulated under the Resource Conservation and Recovery Act (RCRA).

Helium. A colorless, odorless chemical element, one of the noble gases, having the lowest boiling and melting points. Used here in safing functions to purge the vehicle tanks of hydrogen.

Herbarium. A building containing a collection of dried plants classified, mounted, and used for botanical study.

Herbivores. Plant eating animals.

Herpetofauna. Reptiles and amphibians of a specific region or time.

Hertz. The international unit of frequency, equal to one cycle per second.

Hummocks. Tracts of fertile, heavily vegetated land, higher than a surrounding area.

Hybridization. The production of hybrids; crossbreeding.

Hydrant System. The system for drawing water from a water main.

Hydric Soils. Soils containing hydrogen.

Hydrogen Sulfide (H_2S). A flammable, poisonous gas with the characteristic odor of rotten eggs, widely used as a reagent in analytical chemistry.

Hypersonic. Flight at speeds above approximately Mach 5.

Impacts. An assessment of the meaning of changes in all attributes being studied for a given resource; an aggregation of all the adverse effects, usually measured using a qualitative and nominally subjective technique. In this Environmental Impact Statement, the work impact is used synonymously with the work effect.

Incendiary. Causing or designed to cause fires.

Inconel. An alloy of iron, nickel and cobalt.

Inert. Without power to move, act, or resist and having few or no active properties.

Infrastructure. The basic installations and facilities on which the continuance and growth of a community, state, etc., depend, e.g., roads, power plants, transportation, communication systems, etc.

Installation Restoration Program. One of a series of programs to clean up hazardous waste disposal and spill sites nationwide, established by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 and the Superfund Amendment and Reauthorization Act of 1986 (SARA). The Defense Environmental Restoration Program, which became law as SARA Section 211 and was codified at Title 10 USC Section 2701 et seq., governs the Installation Restoration.

Intercontinental Ballistic Missile. Missile capable of traveling long distances between continents.

Interstate. The designated National System of Interstate and Defense Highways located in both rural and urban areas; they connect the East and West coasts and extend from points on the Canadian border to various points on the Mexican border.

Ionosphere. The part of the atmosphere above 80 km (50 mi).

Jet Routes. Airways which extend from 18,000 to 45,000 feet, and designate frequently used routings.

Jurisdictional Wetlands. Wetlands formerly designated as meeting wetlands criteria established by the U.S. Army Corps of Engineers.

Lacustrine. Found or formed in lakes.

Lifting Body. An aircraft that obtains lift from the airfoil shape of the fuselage.

Liquid Hydrogen. A colorless and odorless fluid with a boiling point of -423.0°F, used as a cryogenic propellant.

Lithic Scatters. An archaeological site consisting of dispersed stone artifacts and fragments.

Loam, Loamy. Rich, permeable soil composed of a mixture of clay, silt, sand, and organic matter.

Loudness. The qualitative judgment of intensity of a sound by a human being.

Lower Atmosphere. The portion of the gaseous layer surrounding the Earth's surface that is affected by ground based activities and low-level flight; the troposphere.

Mach Number. The ratio of the speed of an object to the speed of sound in the surrounding medium.

Magnitude. Richter scale logarithmic measurement of the energy released by an earthquake.

Manganese (Mn). A grayish-white, metallic chemical element, usually hard and brittle, which rusts like iron but is not magnetic: it is used in the manufacture of alloys of iron, aluminum, and copper.

Mate. To secure together.

Maximum Sound Level. The highest sound level recorded during an event without regard for duration.

Mesosphere. The part of the atmosphere from approximately 50 to 80 km (30 to 50 mi) above the earth.

Military Operations Area. Airspace areas of defined vertical and lateral limits established for the purpose of separating certain training activities, such as air combat maneuvers, air intercepts, and acrobatics, from other air traffic operating under instrument flight rules.

Mineral. Naturally occurring, homogenous, inorganic substance with a specific chemical composition and characteristic crystalline structure, color, and hardness.

Mineral Resources. Mineral deposits that may eventually become available - known deposits not recoverable at present or yet undiscovered.

Mitigation. A method or action to reduce or eliminate program impacts.

Monoculture. The raising of only one crop or product without using the land for other purposes.

Mustelid. Fur-bearing carnivores, including the weasel, marten, polecat, and mink.

National Air Space. Airspace above the United States controlled and managed by the Department of Transportation/Federal Aviation Authority.

National Ambient Air Quality Standards (NAAQS). Section 109 of the Clean Air Act requires the Envrionmental Protection Agency to set nationwide standards, the National Ambient Air Quality Standards, for widespread air pollutants. Currently, six pollutants are regulated by primary and secondary NAAQS carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM_{10}), and sulfur dioxide. See Criteria Pollutants.

National Priority List. A list of sites (federal and state) that contain hazardous materials that may cause an unreasonable risk to the health and safety of individuals, property, or the environment.

National Register of Historic Places. A register of districts, sites, buildings, structures, and objects important in American history, architecture, archaeology, and culture, maintained by the Secretary of the Interior under authority of Section 2(b) of the Historic Sites Act of 1935 and Section 101(a)(1) of the National Historic Preservation Act of 1966, as amended.

Native Americans. Used in a collective sense to refer to individuals, bands, or tribes who trace their ancestry to indigenous populations of North America prior to Euro-American contact.

Native Vegetation. Plant life that occurs naturally in an area without agricultural or cultivation efforts. It does not include species that have been introduced from other geographical areas and become naturalized.

Nautical Mile. A unit of distance used for air navigation based on the length of a geographical minute of arc. It is equal to 6076.115 feet.

Nitrogen Dioxide (NO_2). Gas formed primarily from atmospheric nitrogen and oxygen when combustion takes place at high temperature. NO_2 emissions contribute to acid deposition and formation of atmospheric ozone. One of the six pollutants for which there is a national ambient standard. See Criteria Pollutants.

Noise. Any sound that is undesirable because it interferes with speech and hearing, or is intense enough to damage hearing, or is otherwise annoying (unwanted sound).

Noise Attenuation. The reduction of a noise level from a source by such means as distance, ground effects or shielding.

Noise Contour. A curve connecting points of equal noise exposure on a map. Noise exposure is often expressed using the average day-night sound level, L_{dn}.

Nominal. Planned.

Non-attainment Areas. An area that has been designated by the Environmental Protection Agency or the appropriate state air quality agency, as exceeding one or more national or state Ambient Air Quality Standards.

Non-ferrous Metals. Metals not containing iron.

Nonhalogenated. Containing no halogens such as chlorine or fluorine.

Overpressure. The pressure, exceeding ambient pressure defined in pounds per square foot (psf), manifested in the shock wave of an explosion or sonic boom.

Ozone (stratosphere). Oxygen between 10 and 20 miles in altitude absorbs solar ultraviolet radiation in a wavelength range not screened by other atmospheric components.

Ozone (ground level). A major ingredient of smog. Ozone is produced from reactions of hydrocarbons and nitrogen oxides in the presence of sunlight and heat.

Paleontological. Prehistoric.

Payload. A load that consists of anything carried by an aircraft that is not essential to its flight operations, including warheads, satellites, spacecraft, or passengers.

Percolation. Diffusion of water through soil, penetration.

Permeability. The capacity of a porous rock or sediment to transmit a fluid.

Perturbation. Something that causes a disturbance.

Petroleum Hydrocarbons. Petroleum constituents made up of only carbon and hydrogen.

Phase. The fractional part of a cycle through which an oscillation, as of light or sound waves, has advanced, measured from an arbitrary starting point.

Photochemical Formation. Something formed by chemical action by the effect of light or other radiant energy.

Physiography. A description of the features and phenomena of nature.

Playa. The level area at the bottom of a dry lake bed formed of hard clay and sometimes temporarily covered with water.

Plume. An elongated mass of contaminated fluid moving with the flow of the fluid.

Polyethelene (C_2H_4). A thermoplastic resin made by the polymerization of ethylene: used in making translucent, lightweight and tough plastics, films, containers, insulation, etc.

Positive Controlled Airspace (PCA). Airspace designated in Federal Air Regulations, Part 71 within which there is positive control of aircraft. Flight in PCA is normally conducted under instrument flight rules. PCA is designated throughout most of the conterminous United States and its vertical extent is from 5,500 m (18,000 ft) mean sea level to and including 18,300 m (60,000 ft).

Potable Water. Suitable for drinking.

Prevailing Winds, Prevalent Winds. The most frequent or common wind direction for any given location.

Propagate. To cause to reproduce; to spread.

Proprietary. Held under patent, trademark, or copyright by a private person or company.

Propulsion System. System that propels a vehicle forward.

Prototype. The first thing of its kind; something that serves as a model for one of a later period.

Purge. To empty or drain a fuel tank using pressurized inert gas.

Purveyor. Someone that furnishes or supplies.

Quantity Distance. The adequate safety zone between storage and other infrastructure which is a function of the amount of explosive potential based on the maximum quantity of fuel or oxidizer in storage, storage conditions, and mixing potential will fuels or oxidizers necessary to support combustion.

Quasi-static. Seemingly static (forces at rest).

R-2508 Complex. Tri-service complex of restricted airspaces in the upper Mojave Desert which includes: (1) all the land and airspace managed by Edwards Air Force Base, Ft. Irwin National

Training Center, and China Lake Naval Air Warfare Center; and (2) MOAs and Air Traffic Control Assigned Airspace Areas.

Reaction Control System. Small jet system to assist in trajectory corrections.

Record of Decision. Document issued after release of Final Environmental Impact Statement recording the program's decision.

Refraction. The bending of a ray or wave of light, heat, or sound, as it passes obliquely from one medium to another of different density, in which its speed is different, or through layers of different density in the same medium.

Remediation. The long-term, permanent cleanup of CERCLA sites.

Restricted Area. Airspace above a surface area of published dimensions within which flight of aircraft is subject to restrictions caused by "unusual and often invisible hazards" published in FAR 73. Area where restrictions are in force to minimize interference between friendly forces.

Reusable Launch Vehicle. Launch vehicle which does not jettison components anywhere from launch to landing.

Riparian. Of , adjacent to, or living on the bank of a river or lake.

Saline Soils. Soils containing common salt, or sodium chloride.

Sediment. Material deposited by wind or water.

Sensitive Habitat. An area inhabited by rare, threatened or endangered species, an ecosystem supporting a wide variety of plants, birds and wildlife.

Skink. Any of a family of widely distributed lizards having an elongated, shiny body, smooth scales and short legs.

Sonic Boom. Sound resembling an explosion produced when shock waves form at the nose of an aircraft traveling at supersonic speed reaches the ground.

Sound. The auditory sensation evoked by the compression and rarefaction of the air or other transmitting medium.

Spaceplane Shock Signature. Frequency and characteristics of the shock wave produced by a vehicle traveling at a velocity greater than the speed of sound. The shock signature is essential data needed to project sonic boom impacts.

Stage. One of two or more successive propulsion units of a rocket vehicle that fires after the preceding unit has been jettisoned.

Stratosphere. The portion of the atmosphere above the troposphere and below the mesosphere from approximately 10 to 50 km (6 to 30 mi).

Strongback. Brace for preventing vehicle distortion when changing its position from horizontal to vertical and vice versa.

Suborbital. Not leaving Earth's atmosphere and not achieving orbit.

Subsonic. Speeds less than the speed of sound.

Substrate. A substance acted upon, as by an enzyme; the medium.

Sulfur Dioxide (SO_2). A toxic gas that is produced when fossil fuels, such as coal and oil, are burned. SO_2 is the main pollutant involved in the formation of acid rain. SO_2 also can irritate the upper respiratory tract and cause lung damage. During 1980, some 27 million tons of sulfur dioxide were emitted in the U.S., according to the Office of Technology Assessment. The major source of SO_2 in the U.S. is coal-burning electric utilities.

Sulfur Oxides (SO). Any of a group of organic compounds containing the group or the divalent radical SO.

Supersonic. Traveling at a speed greater than the speed of sound.

Supersonic Corridor. Designated airspace used for aircraft flight test and training activities at speeds greater than the speed of sound.

Swale. A hollow depression or low area of land.

Tannin. Any of a group of naturally occurring phenolic compounds that precipitate proteins, alkaloids, and glucosides form solution, and convert hide into leather.

Tectonic. Designating of, or pertaining to changes in the structure of the Earth's crust, the forces responsible for such deformation, or the external forms produced.

Telemetry. Automatic data measurement and transmission from remote sources, such as space vehicles, to a receiving station for recording and analysis.

Terminal Area Energy Maneuver. Maneuvers performed by the vehicle to reduce energy, i.e., slow down the vehicle on its approach to landing.

Terminal Control Area. Controlled airspace extending from the surface of the primary airport it surrounds, to specified altitudes within which all aircraft are subject to operating rules and pilot and equipment requirements.

Terpene. Any of a series of isomeric, unsaturated hydrocarbons of the general formula $C_{10}H_{16}$ found in resins, oils, and solvents.

Tetrachloroethene. Common halogenated solvent. Also referred to as perchloroethylene and PCA.

Thermal Protection System. Material on the outerskin of the vehicle to prevent overheating upon ascent and descent through the atmosphere.

Thermosphere. Part of the Earth's atmosphere that begins at the mesosphere and extends to outer space, and is characterized by steadily increasing temperature with height.

Threatened Species. Plant and wildlife species likely to become endangered in the foreseeable future.

Thrust. The forward force produced in reaction to the gases escaping rearward from a jet or rocket engine.

Titanium. A silvery or dark-gray, lustrous, metallic chemical element found in rutile and other minerals and used as a cleaning and deoxidizing agent in molten steel, and in the manufacture of aircraft and satellites.

Translating Shelter. Shelter designed to protect the vehicle from adverse weather conditions at the launch site.

Trichloroethylene (TCE). An organic solvent used in dry cleaning and removal of grease from metal.

Triple Redundancy. Three of the same equipment, system, etc., to increase reliability.

Troposphere. Portion of the atmosphere which is below the stratosphere from approximately 0 to 10 km (0 to 6 mi) from the earth's surface, and in which generally temperature decreases rapidly with altitude, clouds form, and convection is active.

Vascular Plant. A plant having specialized tissues that conduct water and synthesized foods, an any fern, gymnosperm, or angiosperm.

Volatile Organic Compounds. Organic compounds that easily volatilize and can break down through photodestructive mechanisms. Examples: trichloroethylene (TCE) and isopropyl alcohol (IPA).

Volatilize. Cause to pass off as vapor; to become volatile.

Wapiti. A large, North American deer with widely branching antlers and a short tail.

Wetlands. Areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil. This classification includes swamps, marshes, bogs, and similar areas.

Wind Rose. A diagram that shows for a particular place the frequency and intensity of wind from different directions.

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