NATIONAL TRANSONIC FACILITY

FINAL

AMENDMENT 1

TO

ENVIRONMENTAL IMPACT STATEMENT

August 1971

for

Langley Research Center

Hampton, Virginia

NASA

National Aeronautics and Space Administration

January 1977

NATIONAL TRANSONIC FACILITY

FINAL

AMENDMENT 1

TO

ENVIRONMENTAL IMPACT STATEMENT

August 1971

for

Langley Research Center

Hampton, Virginia

January 1977

Table of Contents

	Page
LIST OF TABLES	iv
LIST OF FIGURES	v
SUMMARY	vi
I. BACKGROUND, DESCRIPTION OF PROPOSED ACTION, AND DESCRIPTION OF THE AFFECTED ENVIRONMENT	1
A. BACKGROUND	1
B. DESCRIPTION OF THE PROPOSED ACTION	2
1. General Description	2
2. Construction Activities	3
3. Operation Activities	5
C. DETAILED DESCRIPTION OF FACILITY	8
1. Introduction	8
2. Tunnel	8
3. Fan Drive System	15
4. Tunnel Cooling and Pressurization System	17
5. Air Supply and Vacuum Systems	20
6. Controls and Instrumentation	20
7. Buildings and Associated Structures	22
D. DESCRIPTION OF THE AFFECTED ENVIRONMENT	25
1. General Description of the Site	25
2. Natural Systems	26
3. Community/Infrastructure Systems	50
II. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE POLICIES, PLANS, AND CONTROLS	67
A. LANGLEY RESEARCH CENTER	67
B. REGIONAL LAND USE AND PLANS	67

		Page
III.	PROBABLE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION	76
	A. DIRECT ENVIRONMENTAL EFFECTS	76
	1. Of Construction of the Proposed Plant	76
	2. Of Operation of the Proposed Plant	81
	B. INDIRECT ENVIRONMENTAL EFFECTS	103
IV.	ALTERNATIVES TO THE PROPOSED ACTION	104
	A. ALTERNATIVE METHODS OF ACHIEVING HIGH REYNOLDS NUMBERS	104
	1. Increased Scale of Test Model	104
	2. Increased Density of Test Gas	105
	3. Decreased Viscosity of Test Gas	105
	B. ALTERNATIVE LOCATIONS FOR THE NATIONAL TRANSONIC FACILITY	105
	1. Capital Costs	106
	2. Operating Costs	106
	3. Operation and Performance Advantages	106
	4. Environmental Factors	107
	5. Staff and Programs	107
	C. ALTERNATIVE GN_2 RELEASE	107
	1. Jet Engine-Induced GN_2 Stack Draft	107
	2. Alternative Stack Design	107
	3. Storage and Energy Recovery	108
	D. NO ACTION	108
V.	ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED	109
VI.	SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY	110
VII.	IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED	111
VIII.	RESPONSES TO COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT	
	LITERATURE CITED	
	APPENDICES:	
	A: CLIMATOLOGICAL DATA	A-1

		Page
B:	WILDLIFE OF THE LOWER VIRGINIA PENINSULA AND LANGLEY RESEARCH CENTER AND AIR BASE	B-1
C:	NOISE ANALYSIS METHODOLOGY	C-1
D:	AIR QUALITY ANALYSIS METHODOLOGY	D-1
E:	COMMENTS RECEIVED ON DRAFT ENVIRONMENTAL IMPACT STATEMENT	E-1

List of Tables

Table Number		Page Number
1	Probable NTF Annual Operation Requirement, in Hours of Fan Operation	7
2	General Groundwater Chemical Characteristics	29
3	Water Quality Standards	33
4	Water Quality Data for Back River and Brick Kiln Creek for 1975	35
5	Selected Shellfish Taken in VIMS Study of the Lower York River, Virginia, 1972	39
6	Marshes of the Northwest Branch of Back River	40
7	Representative Noise Levels	42
8	Air Quality Standards	49
9	Selected Indicators of Government Economic Activity, Virginia Peninsula, Fiscal Year 1972	56
10	Selected Socio-Economic Characteristics, Newport News-Hampton SMSA	58
11	Land Use in Hampton, 1970	71
12	Nitrogen Discharge Rates from the Vent Stack and Liquid Nitrogen Storage Tank of the National Transonic Facility	87
13	Results of Turbulent Jet Model under Calm Wind Conditions and with Several Ambient Air Temperatures and Relative Humidities	89
14	Results of PTDIS Modeling, Enthalpy Balance, and Opacity Modeling with Wind Velocity = 0.5 m/sec and Stability Class = 1 (Very Unstable), and with Several Ambient Air Temperatures and Relative Humidities	92
15	Results of Application of Meroney Wind Tunnel Equations to NTF Gaseous Nitrogen Discharge	93
16	Present and Planned Electric Power Consumption of Four LaRC Wind Tunnels	101
17	Projected Future LaRC Electrical Energy Consumption	101
18	Net Energy Consumption of the National Transonic Facility	102

List of Figures

Figure Number		On or Following Page
1	Site Plan for the National Transonic Facility	4
2	Perspective View of the National Transonic Facility	9
3	Diagram of the National Transonic Facility	10
4	Diagram of the Gaseous Nitrogen Vent Stack System	19
5	The Chesapeake Bay Region	26
6	The Hampton-Newport News Area	27
7	Proposed Site of the National Transonic Facility	28
8	Geologic Map of the Lower Peninsula	31
9	Stratigraphic Section of the Lower Peninsula	32
10	Water Quality Sampling Stations	36
11	Distribution of Plant Communities at LaRC/LAFB	41
12	Noise Levels from Exsiting 16-ft Wind Tunnel	45
13	Existing Traffic Noise Levels	47
14	Location of Landfill Sites	54
15	Location of Major Employers	57
16	Historical and Archaeological Features of LaRC/LAFB	63
17	Present Land Use at LaRC West Area	68
18	Proposed Land Use for LaRC West Area	69
19	Zoning in the Vicinity of LaRC	72
20	Existing Land Use in the Vicinity of LaRC	74
21	Noise Profile of the National Transonic Facility	84
22	Gaseous Nitrogen Discharge: Profile 1	90
23	Gaseous Nitrogen Discharge: Profile 2	91
24	The National Transonic Facility in its Setting	100
25	Cold Nitrogen Venting from 30 cm Test Stack	114

SUMMARY

NATIONAL TRANSONIC FACILITY

NASA LANGLEY RESEARCH CENTER

HAMPTON, VIRGINIA

( ) DRAFT (X) FINAL

ENVIRONMENTAL IMPACT STATEMENT

Responsible Federal Agency: National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

Official Contact: Robert A. Bruce
Environmental Energy and Conservation Office
Mail Stop 436
Langley Research Center
Hampton, Virginia 23665
PH. (804) 827-4631

1. Name of Action: (X) Administrative
( ) Legislative

2. Brief Description of Action:

The proposed action is the construction and operation at the NASA Langley Research Center of the National Transonic Facility (NTF), a wind tunnel which will provide a much needed capability to test a broad spectrum of commercial and military aircraft, and space vehicles up to full-scale Reynolds numbers. The facility will incorporate a cryogenic approach to achieve high Reynolds numbers by using the evaporation of liquid nitrogen to obtain a low temperature test medium. The facility will be a fan-driven closed-circuit wind tunnel having an operating pressure range from slightly above 1 atm to about 9 atm and a testing temperature range from 79°C to -184°C (175°F to -300°F). The NTF will be constructed on the site of the existing 4 X 4 foot Supersonic Pressure Tunnel. The construction period is expected to be four years. The actual tunnel operating time is expected to be between 150 and 600 hours per year, with less than 20 hours per year at maximum power conditions. The

majority of runs are expected to occur during daytime hours, but runs will be made at night, particularly those where significant dollar savings can be realized in power usage.

3. Summary of Environmental Effects:

Construction of the NTF will cause temporary minor increases in noise and air-borne pollutants during portions of the construction phase. There are two areas of environmental concern associated with the operation of the NTF. The first results from discharge of large quantities of cold gaseous nitrogen into the atmosphere and the second is noise arising from the nitrogen vent system and from the tunnel drive fan. The design of the nitrogen vent system will ensure that the nitrogen will be mixed with sufficient air before being vented into the atmosphere that the mixture will support life. Analyses and tests show that the vented gas mixture will be further warmed by mixing with the atmosphere that there will not be a low temperature safety hazard at any point where the plume may reach ground level. Depending on local weather conditions, however, temperature could be low enough to produce fog or, conceivably, snow. The noise generated by the gas flowing through the vent control valve and by the tunnel drive fan could produce significant increases in noise level at a nearby state highway and trailer court.

4. Summary of Major Alternatives:

Alternatives considered include: No action; alternative methods of achieving high Reynolds numbers; alternative locations; and alternative methods of gaseous nitrogen release.

5. Comments on the Draft Environmental Impact Statement were requested from:

Federal Agencies

Regional Administrator III
US Environmental Protection Agency

Office of Federal Activities
US Environmental Protection Agency

Langley Air Force Base

Department of Defense

Advisory Council on Historic Preservation

Office of Environmental Quality
Department of Housing and Urban Development

Office of Environmental Affairs
Department of Health, Education and Welfare

Environmental Project Review
Department of the Interior

Office of Environmental Quality
Department of Transportation

State of Virginia

State Water Control Board

State Department of Health

State Air Pollution Control Board

State Soil and Water Conservation Commission

State Corporation Commission
Public Utility Division

State Department of Highways and Transportation

Virginia Energy Office

Division of Industrial Development

State Council on the Environment

Department of Intergovernmental Affairs

Local Area

Peninsula Planning District Commission

City of Hampton

City of Poquoson

County of York
York County Courthouse

Council for Environmental Quality, Inc.

Chesapeake Bay Foundation

6. Submittal Date:

Final Statement submitted to CEQ and made available to the public on FEB 14 197

I. BACKGROUND, DESCRIPTION OF PROPOSED ACTION, AND DESCRIPTION OF THE AFFECTED ENVIRONMENT

A. BACKGROUND

Experimental data obtained in existing low Reynolds number transonic tunnels often lead to erroneous conclusions with regard to flight vehicle performance predictions, particularly for conditions when local velocities over the vehicle surface exceed the speed of sound and where shock-boundary layer interaction effects are important. This transonic flight environment is common to a broad spectrum of flight vehicles, including civilian, commercial, military, and space, and it produces Reynolds number-sensitive problems that are generally not amenable to analytical study, and thus for solution require accurate experimental data at or near flight Reynolds numbers.

This need has been corroborated by the NASA/DOD Aeronautics and Astronautics Coordination Board and has been recommended as an essential element of the U.S. large aeronautical facilities plan (AACB, 1975). The need has also been verified and supported by the U.S. Department of Defense, the U.S. aerospace community (Heppe et al., 1968), and by the European nations of NATO (AGARD, 1972). The establishment of this need has stemmed from the recognition that a wind tunnel that will permit accurate experimental measurements at transonic speeds and at Reynolds numbers in the range of flight values is, therefore, necessary to the continuing development of high-speed aircraft technology. This is the base for national leadership in efficient, energy-conservative aircraft design, and for the superiority of U.S. military flight vehicles. Thus, the urgency for the new testing capability stems from national leadership and security needs, which require this capability at the earliest possible time.

An assessment of the full-scale Reynolds numbers of typical current and future flight vehicles indicates that a maximum Reynolds number of about 120 million is required to assure the absence of Reynolds number effects (AACB, 1975). Hence the desired tunnel should be capable of testing at this maximum Reynolds number (based on the wing mean chord length) at Mach number of 1.0 with the lowest possible aerodynamic loads on the model. The tunnel should be sized to have a workable test section and provide a testing interval sufficiently long to permit accurate data measurement for the complete spectrum of aerodynamic research. The quality of the test flow should be of the highest practical level.

There is no wind tunnel in existence that will satisfy the above requirements.

B. DESCRIPTION OF THE PROPOSED ACTION

1. General Description

The proposed action is the construction and operation at the NASA Langley Research Center of the National Transonic Facility, a unique wind tunnel which will satisfy NASA, DOD, and industrial research and development needs. The facility will provide a much needed capability to test a broad spectrum of commercial and military aircraft as well as space vehicles up to full-scale Reynolds numbers. The facility will incorporate a newly developed cryogenic approach to achieving high Reynolds numbers with reduced model loads and will use the evaporation of liquid nitrogen to obtain a low temperature test medium in an otherwise conventional fan-driven wind tunnel circuit. With temperature as a test variable, the facility will permit clear separation of aeroelastic, Mach number, and Reynolds number effects on the aerodynamic performance of test configurations.

The proposed facility will be a fan-driven closed-circuit wind tunnel having an operating pressure range from slightly above 1 atm to about 9 atm and a testing temperature range from 79°C to -184°C (175°F to -300°F). It will be insulated on the inside to minimize the energy consumed in initial cool-down and in maintaining temperature. When operating at cryogenic temperatures, cooling will be provided by direct spray and evaporation of liquid nitrogen into the tunnel gas stream. This facility will be capable of testing models over a Mach number range of 0.2 to 1.2, and Reynolds numbers up to a maximum of 120 million.

The tunnel will be constructed on the site of the existing 4 by 4 ft Supersonic Pressure Tunnel and will use its two existing electric motors for drive power. These motors are capable of 52,199 kW (70,000 hp) for 10 minutes. A new inline 44,742 kW (60,000 hp) synchronous motor will be added to provide a maximum shaft power of 96,940 kW (130,000 hp) for 10 minutes.

In addition to the existing drive motors, the project will utilize the existing cooling towers, pumps, and auxiliary equipment and buildings. The existing building will be modified to accept the larger transonic test section and will be enlarged to provide space for a control and data acquisition room and for an improved model preparation area.

A liquid nitrogen storage and supply system will be provided on the site to allow nitrogen flows to the tunnel at rates up to about 544 kg (1200 lb) per second. This flow is required to remove the heat generated by the fan during constant cryogenic temperature operation. Additionally, a vent and pressure control will be installed to maintain constant pressure during data gathering. The vent will be acoustically treated and fitted with an exhaust stack to meet environmental control standards.

I. BACKGROUND, DESCRIPTION OF PROPOSED ACTION, AND DESCRIPTION OF THE AFFECTED ENVIRONMENT

A. BACKGROUND

Experimental data obtained in existing low Reynolds number transonic tunnels often lead to erroneous conclusions with regard to flight vehicle performance predictions, particularly for conditions when local velocities over the vehicle surface exceed the speed of sound and where shock-boundary layer interaction effects are important. This transonic flight environment is common to a broad spectrum of flight vehicles, including civilian, commercial, military, and space, and it produces Reynolds number-sensitive problems that are generally not amenable to analytical study, and thus for solution require accurate experimental data at or near flight Reynolds numbers.

This need has been corroborated by the NASA/DOD Aeronautics and Astronautics Coordination Board and has been recommended as an essential element of the U.S. large aeronautical facilities plan (AACB, 1975). The need has also been verified and supported by the U.S. Department of Defense, the U.S. aerospace community (Heppe et al., 1968), and by the European nations of NATO (AGARD, 1972). The establishment of this need has stemmed from the recognition that a wind tunnel that will permit accurate experimental measurements at transonic speeds and at Reynolds numbers in the range of flight values is, therefore, necessary to the continuing development of high-speed aircraft technology. This is the base for national leadership in efficient, energy-conservative aircraft design, and for the superiority of U.S. military flight vehicles. Thus, the urgency for the new testing capability stems from national leadership and security needs, which require this capability at the earliest possible time.

An assessment of the full-scale Reynolds numbers of typical current and future flight vehicles indicates that a maximum Reynolds number of about 120 million is required to assure the absence of Reynolds number effects (AACB, 1975). Hence the desired tunnel should be capable of testing at this maximum Reynolds number (based on the wing mean chord length) at Mach number of 1.0 with the lowest possible aerodynamic loads on the model. The tunnel should be sized to have a workable test section and provide a testing interval sufficiently long to permit accurate data measurement for the complete spectrum of aerodynamic research. The quality of the test flow should be of the highest practical level.

There is no wind tunnel in existence that will satisfy the above requirements.

B. DESCRIPTION OF THE PROPOSED ACTION

1. General Description

The proposed action is the construction and operation at the NASA Langley Research Center of the National Transonic Facility, a unique wind tunnel which will satisfy NASA, DOD, and industrial research and development needs. The facility will provide a much needed capability to test a broad spectrum of commercial and military aircraft as well as space vehicles up to full-scale Reynolds numbers. The facility will incorporate a newly developed cryogenic approach to achieving high Reynolds numbers with reduced model loads and will use the evaporation of liquid nitrogen to obtain a low temperature test medium in an otherwise conventional fan-driven wind tunnel circuit. With temperature as a test variable, the facility will permit clear separation of aeroelastic, Mach number, and Reynolds number effects on the aerodynamic performance of test configurations.

The proposed facility will be a fan-driven closed-circuit wind tunnel having an operating pressure range from slightly above 1 atm to about 9 atm and a testing temperature range from 79°C to -184°C (175°F to -300°F). It will be insulated on the inside to minimize the energy consumed in initial cool-down and in maintaining temperature. When operating at cryogenic temperatures, cooling will be provided by direct spray and evaporation of liquid nitrogen into the tunnel gas stream. This facility will be capable of testing models over a Mach number range of 0.2 to 1.2, and Reynolds numbers up to a maximum of 120 million.

The tunnel will be constructed on the site of the existing 4 by 4 ft Supersonic Pressure Tunnel and will use its two existing electric motors for drive power. These motors are capable of 52,199 kW (70,000 hp) for 10 minutes. A new inline 44,742 kW (60,000 hp) synchronous motor will be added to provide a maximum shaft power of 96,940 kW (130,000 hp) for 10 minutes.

In addition to the existing drive motors, the project will utilize the existing cooling towers, pumps, and auxiliary equipment and buildings. The existing building will be modified to accept the larger transonic test section and will be enlarged to provide space for a control and data acquisition room and for an improved model preparation area.

A liquid nitrogen storage and supply system will be provided on the site to allow nitrogen flows to the tunnel at rates up to about 544 kg (1200 lb) per second. This flow is required to remove the heat generated by the fan during constant cryogenic temperature operation. Additionally, a vent and pressure control will be installed to maintain constant pressure during data gathering. The vent will be acoustically treated and fitted with an exhaust stack to meet environmental control standards.

2. Construction Activities

The National Transonic Facility will be constructed on the site of the existing 4 x 4 foot Supersonic Pressure Tunnel (SPT). The location of existing and proposed buildings and other structures associated with the site are shown in Figure 1. The existing structures on the site will remain unchanged with the following exceptions. The 4 x 4 foot SPT will be removed and its associated building will be modified to accomodate the proposed tunnel. The abandoned Propeller Static Test Stand Enclosure will be removed. The new structures on the site will be the NTF tunnel and addition to Building 1236, the liquid nitrogen (LN_2) storage tank, and the gaseous nitrogen (GN_2) vent building. New pavement will be placed for additional parking areas next to the vent building. The area around the removed Propeller Test Stand will also be paved to provide an access for the LN_2 tank trucks to four unloading stations near the LN_2 Storage Tank. Some of the major areas of construction activity are discussed in the following paragraphs.

a. Demolition and Removal.

The existing steel 4 x 4 foot tunnel will be removed, together with its foundation down to pile caps or piles as appropriate.

Portions of the existing tunnel building, a two story steel framed brick structure, will be removed down to first floor level.

The old Propeller Test Stand Enclosure, a concrete walled, unroofed structure, will be removed.

b. Excavation.

The only significant excavation (other than that required for pile caps and footings and trenching for pipes and electrical conduit) will be for a large shallow pit approximately 30 x 24 x 1.2 meters (100 x 80 x 4 feet) to provide clearance below the large diameter portions of the tunnel.

c. Pile Driving.

Piles will be required for support of the tunnel, the LN_2 storage tank, the addition to the tunnel building, and the GN_2 vent building and stack.

d. Construction.

The tunnel and the LN_2 storage tank will be erected by welding together preformed sections. The assembled tunnel pressure shell will be inspected and pressure tested before the enclosing building addition will be built. The construction of the tunnel building addition and the GN_2 vent structure will use customary building techniques.

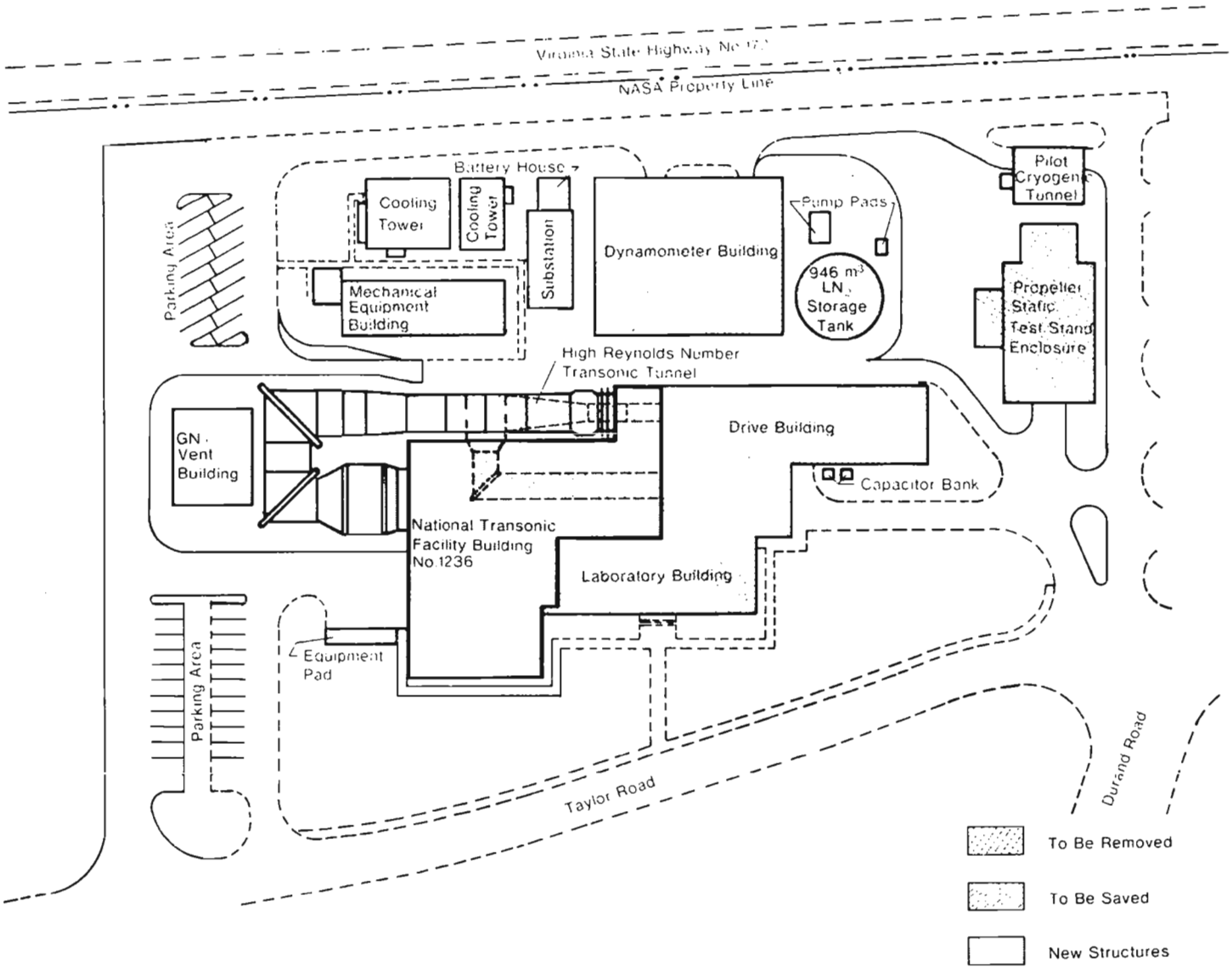


Figure 1
Site Plan for the National Transonic Facility

3. Operation Activities.

a. Typical Operations. There are two distinctly different modes of operation of the NTF, depending on whether the tunnel is operated at cryogenic temperatures using nitrogen as the test medium, or at temperatures essentially at and above ambient using air as the test medium.

(i) Cryogenic Mode:

(a) Pre-test Activities: Before beginning a cryogenic test series, the liquid nitrogen storage tank will be filled. The liquid nitrogen will be trucked to the NTF in tank trucks of approximately 5500 gallons capacity. There will be four unloading stations to which the tankers will be connected and their contents pumped into the 250,000 gallon liquid nitrogen storage tank.

The model to be tested will be mounted in the tunnel test section and checked out. The tunnel access will then be closed, and the tunnel readied for operation.

(b) Tunnel Cool-down and Pressurization: The tunnel fan will be run at a low power level and liquid nitrogen from the storage tank will be pumped into the tunnel through an array of spray nozzles. The resulting liquid nitrogen droplets will vaporize as they mix with the gas flow within the tunnel to make a cold gas, and this cold gas in turn, will cool the interior of the tunnel. Nitrogen gas will be vented from the tunnel at approximately the same mass flow rate as the incoming liquid nitrogen to maintain tunnel pressure. The flow rate of liquid nitrogen will vary during the cool-down and pressurization phase with a maximum of 454 kg/s (1000 lb/s), and the total period of time will be between 30 and 45 minutes. The vented cold nitrogen gas will be mixed with 454 kg/s (1000 lb/s) of air and discharged from the top of a 24.4 m (80 ft) stack with an upward velocity of approximately 30 m/s (100 ft/s) to provide mixing of the vented gas mixture with ambient air.

(c) Tunnel Run: With the tunnel now at the desired temperature and pressure, the fan is run at the speed required for the desired Mach number and a series of data points are taken as the attitude of the model is varied. The flow of liquid nitrogen, and therefore the vent rate of cold nitrogen gas, is proportional to the amount of energy being put into the tunnel by the drive fan which must be removed by the vaporization of the liquid nitrogen. The maximum flow rate is 454 kg/s (1000 lb/s) corresponding to the maximum 96,900 kw (130,000 hp) input power to the tunnel fan. This maximum rate cannot be sustained for more than 10 minutes due to motor rating limitations.

The pressure and temperature may be adjusted to new values and another set of data points taken. The flow of liquid nitrogen may be approximately 20% higher than the amount required by the fan input power for several seconds while pressure and/or temperature are being changed.

On completion of the tunnel run, the tunnel fan is shut down and the flow of liquid nitrogen to the tunnel is stopped. The venting of cold nitrogen gas is then determined by the rate at which heat leaks into the tunnel from the ambient. Under these conditions the vent rate will be approximately 2.7 kg/s (6 lb/s).

(d) Model Changes: After completion of a series of data runs on a given model configuration, it will be necessary to gain access to the test section to alter or replace the model being tested. This can be accomplished without changing the temperature and pressure in most of the tunnel loop by means of two large gates which are used to isolate the test section from the remainder of the tunnel. After the test section is sealed off, it is depressurized to atmospheric pressure. The doors on the sides of the test section are then opened and two insulated access housings, which meet to surround the model, are inserted from the two sides of the tunnel. The nitrogen is flushed from these housings with dry air and the housings are then opened to permit personnel access to the model.

After the required model charges have been made, the access housings will be withdrawn, the tunnel access doors closed, and the test section equalized in pressure with remainder of the tunnel. The gates are then opened and the tunnel is ready for a new run series.

(e) Tunnel Shutdown: After completion of the final run of a cryogenic test series, the tunnel fan will be shutdown and the liquid nitrogen flow stopped. The tunnel will then be depressurized to atmospheric pressure by venting its content of gaseous nitrogen through the vent stacks at a rate of 454 kg/s (1000 lb/s) or less, and the residual nitrogen will be replaced with dry air so that the tunnel can be entered safely for inspection and other activities. Until the next test series, the tunnel will be maintained filled with the dry air at, or slightly above, ambient pressure to avoid any in-leakage of moist air from the surroundings.

(ii) Air Mode: The operations of the NTF in this mode are similar in many respects to those in the cryogenic mode, and the following discussion will primarily emphasize the difference between the two modes.

(a) Pretest Activities: Before beginning an air test series the water-cooled heat exchanger in the tunnel loop is connected and filled with water. During cryogenic runs this heat exchanger must be trained to avoid freezing problems, and short lengths of water piping within the tunnel must be removed to avoid excessive heat leakage.

The model is installed and the tunnel access is closed as for a cryogenic run.

(b) Tunnel Pressurization: The tunnel is pressurized to the desired level with dry compressed air. No cool-down period or tunnel fan operation during pressurization is required as was the case for the cryogenic mode.

(c) Tunnel Run: With the tunnel at the desired pressure, the flow of cooling water through the tunnel water-cooled heat exchanger is turned on, the tunnel fan is brought to the desired speed and a series of data points are taken. Tunnel pressure is maintained or set to new values by venting through the vent stack or admitting additional dry compressed air as needed. After the required data has been collected the tunnel fan and the flow of cooling water are stopped. Since the tunnel will now be cooling from its operating temperature, no venting will be required in contrast to the cryogenic mode.

(d) Model Changes: Access to the model may be made in the same manner as described for the cryogenic mode.

(e) Tunnel Shutdown: After completion of the desired series of tunnel runs, the tunnel fan and cooling water flow will be stopped and the tunnel depressurized to atmospheric pressure. Since the tunnel content is air, no flushing is needed before it is available for manned access.

b. Probable Operating Schedule. As described above, a test series will include a number of tunnel runs interspersed with periods of time for model changes. A typical test series may last for 48 to 72 hours with tunnel run times in the order of 10 minutes and one to several hours between runs.

The annual operational profile planned for the NTF shows the following weekly breakdown.

Cryogenic testing	26
Noncryogenic testing	11
Repair	4
Maintenance	3
Annual maintenance	4
Inspection	4
TOTAL	52

Table 1 indicates the range of hours of NTF fan operation per year. The remaining time is that required for test preparation, maintenance, repair, etc.

Table 1. Probable NTF Annual Operation Requirement, In Hours of Fan Operation.

	Cryogenic Mode	Non-Cryogenic Mode	Total
Maximum	400	200	600
Minimum	100	50	150

Operation of the NTF at full or high fan power levels will occur at night; however, more than half the operating hours are expected to be in the daytime. Full fan power cryogenic testing, and therefore maximum rate of GN_2 venting, are expected only about five percent of the time, or 5 to 20 hours per year.

C. DETAILED DESCRIPTION OF THE PROPOSED FACILITY

1. Introduction.

The following description focuses on those features of the proposed National Transonic Facility which have direct environmental impact implications. Features related to in-plant safety receive less detailed consideration, while design details related to achieving the desired research conditions are discussed only as they relate to environmental impacts. Readers interested in the latter should consult the Preliminary Engineering Report: National Transonic Facility (1975), which is the main reference for the following description.

The National Transonic Facility consists of six major systems:

- Tunnel
- Fan Drive System
- Tunnel Cooling and Pressurization Systems
- Air Supply and Vacuum Systems
- Controls and Instrumentation
- Support Buildings.

The overall configuration of the NTF is shown in Figures 2 and 3.

2. Tunnel.

The tunnel, as shown in Figure 3, is a rectangular circuit approximately 68 m (222 ft) long and 24 m (79.4 ft) deep at the widest points. In cross section, the tunnel is generally circular, with a maximum diameter of 11.2 m (35.65 ft) and a minimum of 4.06 m (13.32 ft). In the test section, the tunnel is square in cross section, 2.5 m x 2.5 m (8.2 ft x 8.2 ft). Major components of the tunnel are discussed below.

a. Pressure Shell. The pressure shell of the tunnel will be designed to withstand a pressure range from 9.08 atm absolute (133.5 psia) to full vacuum, although the range of actual pressures to which it will be exposed will be 8.85 atm (130 psia) to 0.2 atm (3 psia). The design temperature range for the shell will be -195.7°C (-320°F) to 65.6°C (150°F). However, pressure shell temperatures will normally be near ambient even during cryogenic operation because the shell will be insulated from direct contact with flowing gas within the tunnel. The wide temperature tolerance of the shell, which will be achieved by using 9 percent nickel steel, is to provide a margin of safety to insure integrity of the vessel under the most critical possible conditions, that is, the failure of the insulation to isolate the wall from the test stream.

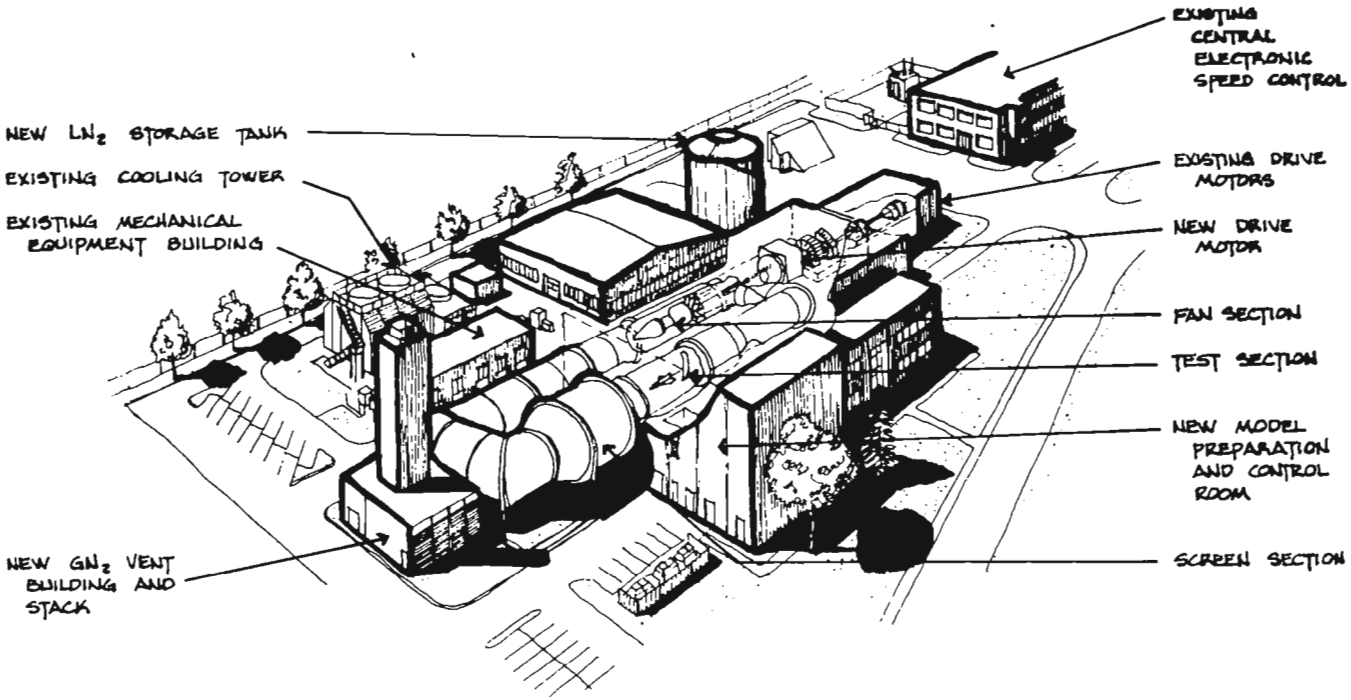


Figure 2
Perspective View of the National Transonic Facility

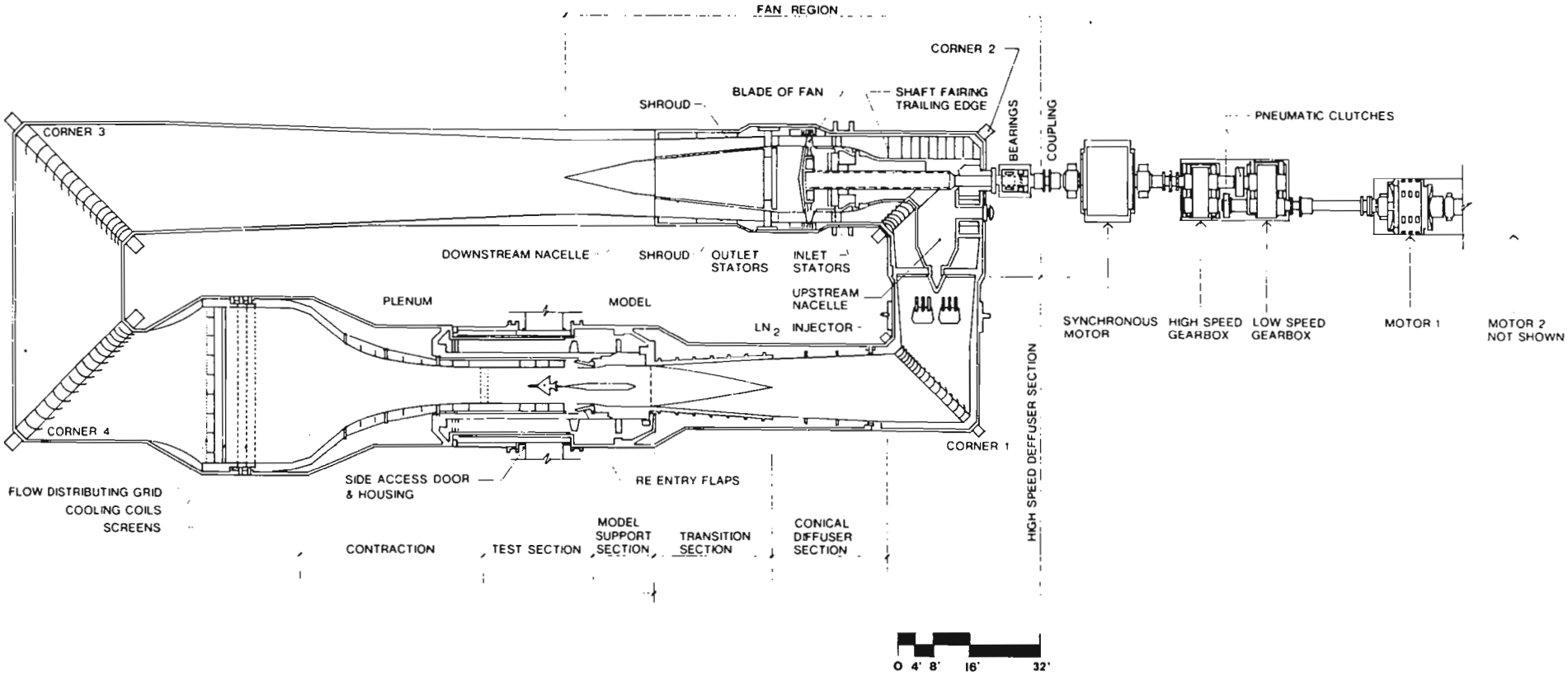


Figure 3
Diagram of the National Transonic Facility

The portion of the tunnel extending outside the building will be equipped with a sunshade. The sunshade will be utilized to minimize effects of solar heating and thus reduce thermal gradients in the pressure shell. The sunshade is envisioned to be made of relatively light-weight sheet metal structure and supported with stand-offs attached to the tunnel shell.

The tunnel pressure shell will be designed in accordance with the ASME Pressure Vessel Code. In addition, a fatigue analysis will be made to predict the cyclic life of the unit. Fabrication will be in accordance with ASME requirements plus any additional requirements developed by the fatigue analysis. All pressure vessel welds will be fully inspected, and the unit will be proof pressure-tested before being placed in service.

The pressure shell will be built of rolled and welded plate using mitered corners and conical reducers where needed. These joints will be suitably reinforced in accordance with ASTM Code requirements. The primary shell material will conform to ASTM Specifications. This material finds wide use in cryogenic applications and is sufficiently tough in welded structures for use at temperatures below -184°C (-300°F). A variety of welding techniques are available, some of which permit allowable stresses equal to those of unwelded plate (Ref. ASME Code Case 1499). However, these result in reduced toughness, so that the reduced allowable stress and higher-toughness weld procedures will be used. The actual procedures will vary with the type of joint to provide the most economical construction and will be qualified in accordance with ASME Boiler and Pressure Vessel Code.

The tunnel circuit shell will contain penetrations for many purposes such as access manways and hatches, piping penetrations for liquid and gaseous flows, future bleed ports, instrumentation ports, etc. In general, these penetrations will have internal reinforcing to comply with ASME Code and will, where practical, be installed so that welds are readily radiographable.

The pressure vessel containing the aerodynamic configuration will weigh about 1691 mtons (1862 tons) and will have a volume of approximately 8,400 m^3 (11,000 yd^3).

Several types of external stiffenings will be required for the pressure shell. First is the reinforcement for the mitered corners. The second type consists of the main supporting frames at various stations around the circuit in the axisymmetric regions. These frames and the corner reinforcing rings transmit the tunnel dead weight and aerodynamic loads to ground through a system of hinged legs and anchors. The legs will permit dimensional changes caused by changes in thermal conditions and, at the same time, restrain the structure from moving due to internal and external loads. The primary anchor point will be at the fan station. The third type of stiffening will be required between some of the main frames to protect the shell from collapse due to external pressure. The corner stiffeners and the main axisymmetric support frames will be built-up sections and the vacuum stiffeners will be principally vertical bar sections welded to the pressure

shell.

Provisions will be incorporated to resist external wind loads. Links will be provided which, in conjunction with the main anchor, are capable of transmitting wind loads of 171 kg/m^2 (35 lb/ft^2) to ground.

b. Fan Region. The fan region will occupy portions of the tunnel in and near corner 2, as shown in Figure 3. An aerodynamic nacelle will be provided that will protect the fan drive shaft and bearings from the cryogenic environment and efficiently diffuse the flow from the fan. The fan will have fixed blades and variable inlet stator vanes to permit regulation of the fan compression ratio. The fan will be equipped with a shroud that will protect the pressure shell should one or more fan blades become detached during operation. The fan will be designed so that the blades can operate at cryogenic temperatures while the shaft and bearings are maintained at ambient temperature.

c. High Speed Region. The high speed region will occupy most of the tunnel between corners 4 and 1 (Figure 3). The principal elements of the high speed region are the following:

- contraction
- plenum
- test section
- model access system
- flow reentry section
- model support section
- high speed diffuser section.

(i) Contraction: The contraction is the aerodynamic flow conditioning element which will produce a uniform acceleration of the test stream before entering the test section. The contraction will have an aerodynamic contraction ratio of approximately 15 to 1. The upstream end of the contraction will be circular in cross section for a length of 4.1 m (9 ft). A 2.4 m (8 ft) long circular-to-square transition will then follow. Finally, the remaining 9.5 m (31 ft) of contraction will be square in cross section.

Just upstream of the contraction there will be several screens (initially three, with space allowed for two more). These screens will serve to reduce turbulence generated elsewhere in the circuit and will also improve the velocity distribution of the flow entering the contraction. The screens will be designed as spherical membranes with a bulge of approximately 0.7 m (2 ft) at center, and will be supported around the circumference by clamp rings, which in turn will be supported from the pressure shell through insulated attachments. A manway on each side of the screens will provide access for inspection.

The water cooling coil will be located upstream of the screens. Its purpose is to extract the heat of compression of the fan when the tunnel is being operated with air in the circuit. The cooling coil will be drained prior to operations at cryogenic temperatures.

(ii) Plenum: The plenum will actually be a continuation of the basic tunnel pressure shell, extending from the contraction to the high speed diffuser section, downstream of the model support system. The internally insulated plenum will contain the test section and model support system, and provide structural support for these elements, as well as any additional internally-mounted systems, such as optical systems for flow visualization.

The plenum shell will contain two main access doors. The access doors will have a clear opening approximately 4 m high by 5.4 m wide (9 x 12 ft), as required for personnel and equipment access to service or change test models and support stings, and for future change of circuit internals.

(iii) Test Section: The test section walls will form a square cross section having a side dimension of about 2.5 m (8.2 ft) and a length of 7.6 m (25 ft). The top and bottom walls will be slotted and will be so designed that the angle they form with the tunnel centerline can be adjusted over the range of 0.5^{o} convergence to 1^{o} divergence. It will be possible to make this adjustment when the tunnel is running, and it will permit correction of flow for varying boundary layer growth with changes in tunnel operating conditions.

The sidewalls of the test section will have two slots in each side and will have a large "door" and three 61 x 76 cm (24 x 30 in) viewing windows in each wall. The doors will form a part of the model access scheme and match the opening in the plenum shell. The doors will move vertically downward to open and will be designed to assure that no aerodynamic interference is produced at the match line and other joints. The windows will provide for visual access to the model and permit use of optical measuring schemes such as schlieren equipment and remote viewing systems.

(iv) Model Access System: The model access system will be designed to permit personnel access to the test model at ambient pressure and temperature without blowing down the rest of the tunnel volume. To depressurize the test section, upstream and downstream isolation valves would be moved into position to isolate the test section from the rest of the tunnel. This operation requires disconnecting the contracting cone (upstream) from the fixed pressure bulkhead and the high speed diffuser (downstream) and moving them away from the test section a distance sufficient to allow the large valves to be remotely moved into place, seated, and dogged against the bulkheads. The test section and plenum volume would be vented through the vent stack to the atmosphere once the valves are in place. Two portable access chambers or tunnels would then be inserted into the test section through the plenum and test section wall openings from opposite sides. These chambers will meet and seal in the center of the test section, surround the model, and provide a continuous passageway for personnel which is thermally and barometrically isolated from the tunnel proper.

After work on the model has been completed, the access tunnels will be withdrawn and the test section pressurized with cold nitrogen to a

pressure equal to that in the remainder of the circuit. At this pressure there is no load on the valves, and they can be unlocked and moved to their stored position. The contraction cone and diffuser section will be moved back to their running position and dogged in place. The tunnel would then be ready to resume testing.

(v) Flow Reentry Section: The flow reentry section, where deflected flaps will be used to control the flow through the test section wall slots, will be located just downstream of the test section. The flaps will lie behind the test section walls, and it will be possible to adjust them on all four sides to vary the amount of flow that is aerodynamically pumped from the plenum back into the main flow at the diffuser entrance. Each flap will be composed of a series of finger-like plates positioned in a plane between the wall support structure beneath each slot. The flap plane deflection can be changed during a run. The flaps will have removable leading edges such that the flap geometry and length can be readily modified at a later date.

(vi) Model Support Section: The model support section will be located just downstream of the slotted test section reentry flaps. This section will provide an aerodynamic and structural housing for the model support. It will also provide structural support for the reentry flaps, and act as a mixing region for the flow pumped from the plenum.

The model support section will be mounted and fixed axially relative to the pressure shell at the downstream bulkhead. Expansion and contraction of the test section and model support section due to temperature changes will be accommodated at the joint between the two sections.

The model support section sidewalls will be locally configured to compensate for aerodynamic interference produced by the model support. The top and bottom walls will be movable and will pivot about a flexure joint at the downstream end. They will be remotely actuated so that the angle of inclination of the top and bottom walls can be set independently to compensate for unsymmetrical flow into the diffuser, such as will be caused by lifting models.

(vii) High Speed Diffuser Section: The high speed diffuser section elements will form the aerodynamic flow channel extending from the downstream end of the model support section, through Corners 1 and 2, to the fan section inlet. These elements will be designed to produce a gradual deceleration of the test stream from the test section region, to minimize the energy losses.

The first element in the diffuser will be a transition section from rectangular to round. The transition will be contoured to provide an area distribution approximating that of a conical diffuser and, in addition, will be designed with no forward facing surfaces in the corners, thereby eliminating the possibility of adverse pressure gradients which could produce separation in the diffuser.

The remainder of the diffuser will be axisymmetric with an expansion half-angle of approximately 2^{o}-35'. The diffuser angle has been selected

to minimize the sum of the diffusion losses and Corner 1 turning losses and is sufficiently small to minimize the risk of separation in the diffuser.

d. Model Support System. The wind tunnel will be equipped with a sector-type model support system, which will be located in the model support section. The sector will be capable of pitching a model over a total range of 24 degrees at a maximum rate of 4 degrees per second and will be equipped with a roll mechanism that can roll the model ±180 degrees at a maximum angular speed of 10 degrees per second.

In most cases, the models will be mounted on stings, and instrumentation will be checked out before being taken into the tunnel. To facilitate handling of these assemblies, as well as the basic models themselves, special power-driven dollies will be provided. The dollies will be designed to accommodate loads of 1816 kg (4,000 lb), and will provide for positioning the assemblies in space, as well as transportation. Preliminary study has indicated that equipment designed for handling external aircraft stores can be readily adapted to this purpose.

3. Fan Drive System.

a. Motors. The basic element of the fan drive system will be the two existing wound rotor motors having a maximum power capability of 52,200 kW (70,000 hp) for 10 minutes at 840 rpm. The existing Kraemer speed control system will be modified by addition of water-cooled liquid rheostats to permit delivery of full-load torque down to 560 rpm motor speed. Regulated speed at reduced torque will be provided down to 100 rpm. An existing single-speed gearbox will be removed from the system.

The existing motor drive system will be augmented by the addition of a new 20 pole synchronous motor operating at 360 rpm. The motor will have a 10 minute rating of 44,740 kW (60,000 hp), thereby providing a total installed power of 96,940 kW (130,000 hp) for the same rating period. Continuous duty rating of the new motor will be about 31,320 kW (42,000 hp).

The new motor will be located in-line with the fan shaft, between the tunnel shell and the gearboxes, and on the output shaft centerline of the gearboxes.

The new motor will furnish power at the synchronous speed only and will be brought up to this speed by the existing motor set. At speeds above and below 360 rpm, the synchronous motor will merely rotate to transmit drive power from the existing motors to the fan. The new motor must therefore be designed to rotate safely at speeds up to about 600 rpm, and its shaft must transmit a total of up to 96,941 kW (130,000 hp). These exceptional operating features can be provided by motor manufacturers; however, the motor design must include oversize bearings and shafting, and the rotor and windings must be designed for the overspeed condition.

b. Gearboxes. The two new gearboxes will change the maximum motor speed of 840 rpm to fan speeds of 600 rpm or 360 rpm, for nominal speed ratios of 1.4:1 and 2.33:1, respectively. Each gearbox will also provide a horizontal shaft displacement of 168 cm (66 in) and a vertical displacement of about 91.4 cm (36 in). While the exact offset dimensions will be determined by good gear design, the above are expected to be near optimum and match the alignment of the existing motor shaft with the desired alignment of the tunnel fan shaft.

It is anticipated that a single-reduction arrangement without idlers will be used for both of the two speed ratios. Two drive pinions on the axis of the existing motor shaft will drive two output gears on the axis of the new motor and fan shaft. Two pneumatically operated clutches will engage one or the other drive pinion according to the speed ratio desired. Speed ratio change is possible at low speed and at reduced power for clutch engagement. There will be savings in operating time and liquid nitrogen consumption with immediate speed changes.

c. Shafts, Couplings, and Bearings. Shafts will transmit power over distances dictated by the relative locations of the new and existing drive motors, the gearboxes, and the fan. The fan shaft will drive, support, and locate the fan, and transmit to bearings and supports all forces produced by fan thrust, weight, and unbalance. Some portions of the shafting will be segmented to simplify assembly and disassembly.

Shafts will be hollow to provide high bending and torsional stiffness at minimum weight. Diaphragm-type flexible couplings will be used to allow for possible angular and parallel misalignment between drive system components and to preclude axial loading due to expansion and contraction of adjacent shaft sections.

The radial bearing supporting the fan will normally carry light loads consisting of the weights of fan and shaft but may be required to carry very heavy loads resulting from maximum fan unbalance. To avoid stability problems at light load, this bearing will be a close restraint type such as a multilobe journal, a fluid pivoted or mechanical tilting-pad type. The fan thrust bearing will be mounted outside the tunnel, and will be a combined radial and thrust bearing of the tilting-pad type. All bearings will be self-aligning and configured for ease of maintenance of shaft and bearings. All other lengths of shafting can be carried by bearings on the motors and gearboxes.

d. Structural Support for the Fan Drive System. The bearing supporting the fan shaft within the tunnel will be mounted in a structural transfer shell within the forward nacelle. The installation will be designed to provide a favorable environment for an oil-lubricated bearing and to contain and prevent oil contamination in the tunnel circuit. Radial loads will be carried by struts from the transfer shell to external foundations. The struts will be integrated with two upstream stator vanes.

The gearboxes and new motor will mount on concrete foundations designed for dead-weight loads plus moments from all operational conditions and events such as sudden speed or loads changes. The existing drive motors will remain on their existing foundations, which are adequate for the new service.

4. Tunnel Cooling and Pressurization Systems.

The tunnel will be designed to accommodate two systems for the removal of the heat of compression from the fan drive and for controlling the temperature of the test gas. In one of these systems, liquid nitrogen (LN_2) will be sprayed directly into the tunnel circuit, and the heat removal will be principally accomplished through the evaporation of the LN_2, the amount absorbed by raising the temperature of the gaseous nitrogen being dependent upon the particular operating temperature.

The other cooling system, which will be used only when the test gas is air, involves a water-cooled heat exchanger in the tunnel coupled with the existing cooling tower facility.

The nitrogen system will also be used to pressurize the tunnel in the cryogenic conditions and for serving other dry-gas requirements in the facility.

a. Nitrogen Systems.

(i) Nitrogen Spray System: The nitrogen spray system is mechanically and aerodynamically simple. LN_2 under pressure will be delivered to four spray bars in a quadrant arrangement located just downstream of the high speed Corner 1 in the circuit. The detailed design will be based on the experience developed in the Langley Research Center pilot tunnel studies. Spray nozzles will be designed to be replaceable, although it is not expected that this will be necessary. Test data indicate that the LN_2 will be fully vaporized before it reaches the fan section, and any maldistribution in temperature that may occur will be removed by the mixing process associated with flow through the fan.

(ii) Liquid Nitrogen Bulk Storage: The LN_2 will be stored in a new vertical, cylindrical, flat-bottom storage vessel of 946.35 m^3 (250,000 gal) capacity. This is somewhat less than a week's supply of nitrogen under projected average operating conditions. The vessel will have an inner and outer tank, separated by insulation. The inner tank will be approximately 9.8 m (32 ft) in diameter and 12.5 m (41 ft) high. The outer tank will be approximately 14.6 m (48 ft) in diameter and 17.7 m (58 ft) high. The space between sides and top of the tanks will contain perlite insulation and between the bottoms will contain Foamglas insulation. The insulation space will be purged, filled with gaseous nitrogen, and maintained at a controlled positive pressure of several centimeters of water.

(iii) Liquid Nitrogen Supply System: The LN_2 will flow from the storage tank into two suction-pot type cryogenic pumps having a capacity

of 18.9 m^3/min (5,000 gpm) each and will be pumped to the tunnel at a pressure of 12.2 atm (180 psia). The LN_2 service lines will include the main line to the tunnel, a coolant loop for the electric motor drives and a controlled bypass from the discharge side of the pumps back to the storage tank. This bypass will allow a wide variation of flow rate to the tunnel from 84.9 m^3/s (10,000 gpm) down to 1.5 m^3/s (400 gpm). The LN_2 boiloff from the tank will increase nominally during periods of pumpback. Valves at the LN_2 spray injection station at the tunnel will be controlled by signals from temperature and pressure sensors within the tunnel and will modulate to control tunnel temperatures to within 1.1°C (2°F) and pressure to within 0.5 percent of total pressure.

The LN_2 systems will include all necessary safety and operational valves, controls, and appurtenances for filling the storage tank from tanker trucks, refilling tanker trucks from the storage tank, for venting the transfer line at startup, and for supplying the tunnel during the cryogenic mode of operation.

(iv) Gaseous Nitrogen Vent System: The venting of the tunnel to atmosphere will be accomplished by control valves in a vent line connected to the shell between Corners 3 and 4, at a large end of the tunnel circuit, as shown in Figure 4. The operating envelope will require an oversized valve to achieve effective control when operating at near-ambient conditions. Depressurization of the tunnel from 8.9 atm (130 psia) to ambient pressure will also be possible in about 8 minutes.

The vent system pressure-reducing control valves, safety relief valves, and piping and controls will be located in a sound-treated building with vent stack terminating 24.4 m (80 ft) above grade. Four axial type fans will draw atmospheric air into the vent building and force the air up the stack. The fans will have a total power rating of 596.6 kW (800 hp). Gaseous nitrogen will be discharged downstream of the fans and up the stack at all times. The fans will be operated continuously during cryogenic operation to guarantee adequate dilution and discharge well above ground. The air flow capacity of the dilution fans has been selected to insure a breathable composition of gas at the stack discharge for the maximum nitrogen release rate from the tunnel. The stack discharge velocity is selected at 305 m/s (100 ft/s) minimum to provide for sufficient vertical ejection of the cold gas to prevent excessive nitrogen concentration and fogging at ground level when GN_2 is released. The vent building and stack will be constructed of insulated metal panels on a structural framework. The internal panels of the vent building and stack will be a perforated acoustical lining. Aluminum is proposed for the stack lining due to exposure to cryogenic temperatures. The air intake for the vent building will be away from the public highway and will have sound traps to reduce the fan and nitrogen discharge noise to a satisfactory level.

b. Cooling Water System. The water cooling coil (heat exchanger) will be a standard finned tube array and will make use of an existing cooling tower and pumping system in its operation. It is designed to allow the tunnel to be operated with air at drive levels up to about 2721 kW (40,000 hp). With air in the circuit, the stagnation temperature will range as high as 79.5°C (175°F), depending upon the pressure and Mach number. Prior to putting nitrogen in the circuit, the cooling coil will be drained and dried.

The existing cooling water system serving the present Supersonic Pressure Tunnel consists of a mechanical induced-draft cooling tower, two cooling water pumps having a total capacity of some 26.5 m^3/min (7,000 gpm), and a supply and return piping system running in the utility tunnel between the mechanical equipment building and the cooling coil of the existing tunnel.

The existing distribution system will be modified to provide two parallel supply and return circuits: (1) a complete new circuit to the liquid rheostat coolers, lube and hydraulic oil coolers, and air coolers for

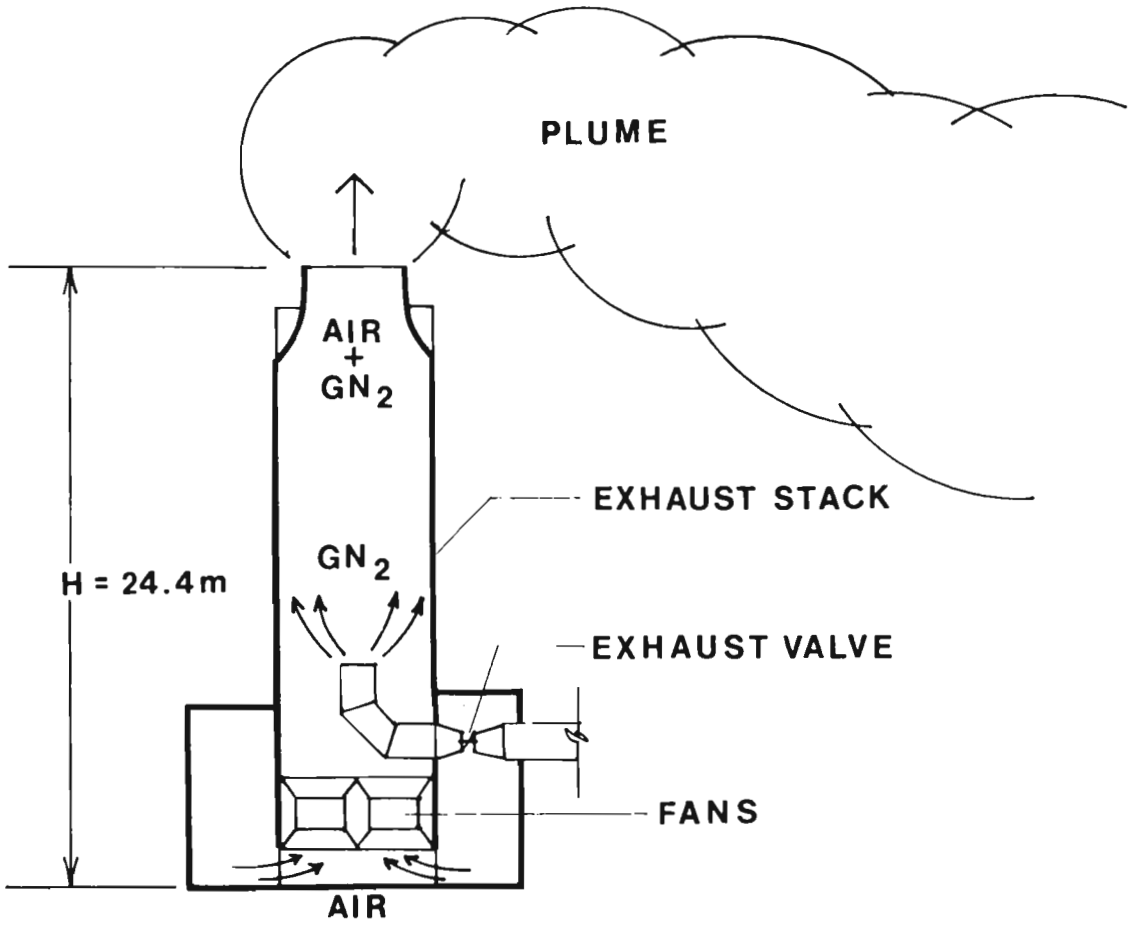


Figure 4
Diagram of the Gaseous Nitrogen Vent Stack System

the new motor in Building 1236; and (2) flanged tees in the supply and return mains to permit circuit to the future tunnel cooling coil. The active circuit will have all necessary isolation and flow control valves, drains, and vents.

5. Air Supply and Vacuum Systems.

The existing high-pressure air supply system consists of offsite storage vessels and a 10 cm (4 in) underground supply line at 122.5 atm (1,800 psig). This system presently serves the 4 ft by 4 ft Supersonic Pressure Tunnel. The new system will consist of a connection to this line and provision of a new pressure regulator station, piping, and a control-isolation valve at the tunnel. This system is adequate to pressurize the tunnel within 40 minutes. An existing Joule-Thompson heater in the basement of Building 1236 will be used to eliminate temperature drop due to expansion of the gas.

An existing vacuum pumping system in the local mechanical equipment building has the capacity to evacuate the tunnel to about 0.2 atm (3 psia). This system consists of three vacuum pumps, piping, and valving. The piping connection to the existing tunnel will be removed and a new connection provided from the existing 40.6 cm (16 in) vacuum main to the NTF pressure shell. The new system will include a cryogenic isolation valve at the tunnel. It is not intended that the vacuum system be operated during tunnel operation, but it will be used primarily for evacuation of moist air from the tunnel circuit and for removing nitrogen from the tunnel before manned access.

6. Controls and Instrumentation.

The controls and instrumentation for the facility are made up of two basic systems:

- the wind tunnel process and operating controls, including the auxiliary system controls;
- the data acquisition system and wind tunnel research instrumentation.

The terminal equipment associated with the above systems will be located in the facility control room.

a. Process and Operating Controls.

(i) Process Controls: The process control system will regulate and sequence all primary tunnel processes by generating command signals for the primary control elements (pressure, temperature, fan speed, inlet guide vanes, test section walls, reentry flaps, model attitude, etc.) from the information it collects from the preset research operating commands, the process variables, and the interlocks and safety system. The system will interface with all the tunnel processes and the research instrumentation systems, assuring the most efficient and least-risk mode of operation.

(ii) Operating Controls: The preset inputs to the system to establish the desired operating conditions will be adjusted or manipulated from the control panel located in the facility control room. The inputs and their time sequence will be established at any of the following levels of automation as selected from the control panel:

- control of Mach number, Reynolds number, dynamic loading and model attitudes as a function of time;
- control of the primary tunnel processes as a function of time;
- control of the process control elements position and subsystem process variables (vent valve position, air supply valve position, liquid nitrogen flow, etc.) as a function of time.

The design will provide, for all three levels of automation, the hardware that is integrated to allow progressive start-up at lower levels of automation, thereby generating data to confirm the software for the next higher level of operation.

(iii) Auxiliary Controls: The auxiliary system controls will monitor and control those systems necessary to supply and maintain the basic wind tunnel in a predetermined operating condition but not directly involved in the establishment of actual test conditions. These include:

- the nitrogen supply system
- the air supply system
- the vacuum system
- the cooling water system
- hydraulic supply systems
- the tunnel drive system
- the electrical supply system.

All of these systems will be capable of being monitored from the facility control room. In addition, control functions critical to the safe and efficient operation of the facility will be carried out from that point. The auxiliary system monitoring panel will be located in the same console as the wind tunnel operating controls, but in a clearly identified and separate section. In addition, all of the auxiliary systems will be provided with local control and monitoring panels. These will permit operation of the subsystems independently for checkout and maintenance.

b. Data Acquisition System and Instrumentation.

(i) Data Acquisition System: A new data acquisition system will be procured and installed which will accept up to 300 low-level analog channels at an overall sampling rate of 50,000 measurements per second. The system will employ computer-controlled sampling sequence and rates as specified by the system operator. It will further control automatic calibration of all analog channels on each gain range and

monitor critical parameters for the safety of personnel and equipment. The computer will supply partially corrected data for on-site quick-look display of selected test parameters to aid in effective test direction. The system will also provide capability for more detailed post-test computation for analysis and a tie to the central computer complex. An FM tape system with play-back and data management under computer control will be provided to record up to 12 channels of high-frequency analog information.

(ii) Research Instrumentation:

(a) Pressure Instrumentation: Instrumentation will be provided for the detailed pressure and temperature measurements in the calibration and initial survey of the tunnel circuit. Pressure instrumentation will include probes, rakes, and wall orifices for detailed measurement of pressures, with the bulk of them being in the test section. For reasons of economy, the number of transducers used will be reduced by employing sampling valves, each with temperature control. The pressure measurement system will include provisions for measuring at approximately 400 locations. Additionally, specialized precision instruments will be provided where accuracy and response demand them.

(b) Temperature Instrumentation: Temperature measurements will be made by using platinum-resistance thermometers. Approximately 70 thermometers installed in several survey rakes with supports will be provided. The temperature instrumentation system will also include permanently mounted sensors for test parameter determination.

(c) Special Flow Instrumentation: Flow measurements will be provided for all flows into and out of the tunnel circuit. Special instruments are required for LN_2 flow and for GN_2 exhaust flows. One of a number of newly developed flow sensors (ultrasonic, magnetic induction, or LDV) will be employed for LN_2 flows and pitot-static and temperature measurement for the exhaust flow.

(d) Dew Point: Dew point measuring instruments will be provided to measure moisture level in the tunnel circuit.

(e) Model Attitude: High-precision servo-type accelerometers with a thermal control jacket and signal-conditioning instrumentation will be provided for model attitude sensing.

7. Buildings and Associated Structures.

a. Building Configuration and Size. In addition to the new building area required to cover the tunnel, space will be required for (1) receiving the test model, (2) initial preparation of the test model, (3) final model preparation, (4) access to the tunnel test section, (5) control consoles, and (6) data acquisition and processing equipment.

The new building height will be dictated by the diameter of the test section plenum, the elevation of the test section, and the clearance above the tunnel shell for the operation of bridge cranes. The large diameter of the test section will require that the test section leg of the tunnel be raised above the fan leg in order for the test section to remain above the first floor level. The elevation of the tunnel test section floor will create a need for a second floor level in the new addition. The second floor in the existing laboratory building is such that the new second floor of the new addition can be located at the same level. Connections will thereby be made to the laboratory building at both the first and the second floor levels without the need of additional stairs and ramps.

The configuration best suited for the new building is an L-shaped structure. One leg of the L will house the tunnel test section, and the other leg will house the supporting operational functions and provide access to the existing laboratory area at the first and second floors. The building height will be a minimum of 19.4m (63.5 ft) to the top of the roof beams. The height will provide the necessary space above the wind tunnel for bridge cranes and equipment being handled. The total heights of the building to the top of the parapet walls will be approximately 20m (65.5 ft) for the high portion.

Based on significant cost savings to the project, the electric drive motors used for the existing wind tunnel will be utilized as prime movers for the new tunnel fan. These motors are presently located in the motor drive building at the northwest corner of Building 1236. A new synchronous motor, low and high-speed gear boxes, and associated shafts and bearings will supplement the existing drive system. The new tunnel fan axis will parallel the existing drive axis and be oriented so that the fan section will be as close to the drive motors as possible, taking into consideration the need for interposition of the gear boxes and the shaft axis separation inherent in the design of the gear boxes. The fan leg of the tunnel will extend south, and is located outside of the building but will be provided with a sun shade. The test leg of the tunnel will be enclosed since this is the area where the model test section will be located. The new building addition, therefore, will generally house portions of the tunnel with a portion of the existing building space being used for the new motor, gear boxes, bearings, electrical rheostats, and switchgear equipment.

b. Utilities. The only exceptional utilities requirement for the NTF is electrical. Other requirements will be of the same order as, or identical to, the existing utilities supplied.

(i) Electrical: Electrical systems required will include lighting, power, communications, emergency power, grounding, fire detection alarm, the low-oxygen alarm and purge subsystems. The new synchronous motor will be the major new consumer of electricity. The drive system will require about 105,000 kW of electrical power.

Electrical power to the new facility will be supplied predominantly from an existing 22.5/30/37.5 MVA power transformer located in a substation adjacent to the Drive Control Building 1241.

The existing power transformer will be used on an alternating basis between the 16 ft Tunnel Boundary Layer Removal Compressor and the National Transonic Facility. The larger load requirement for the new facility will be above the rated capacity of the existing power transformer. However, a preliminary study indicates that these loads above rating can be safely carried under limited time conditions without a drastic reduction of life expectancy of the power transformer.

Switchgear A will consist of a metal-clad, 15 KV class outdoor unit to be installed adjacent to Drive Control Building substation and will accomodate four power air circuit breakers for the new primary power distribution.

It is believed that the new 44,760 kW (60,000 hp) synchronous drive motor will be constructed with a double motor winding in order to divide the total amperage into two motor breakers and feeders. The other two feeder breakers located in the switchgear A will supply power to new 750 KVA and 3750 KVA substation transformers. All large motor loads will be supplied from the 3750 KVA transformer and switchgear B.

(ii) Water: Water requirements for the NTF will be essentially unchanged from the present. The existing tunnel cooling tower and piping system will be used to supply the liquid rheostats and other equipment coolers.

(iii) Sewerage System: The existing gravity-type sewerage system is adequate for the new addition to the existing building. Because of the location of the tunnel, it will be necessary to relocate parts of the existing sewer.

(iv) Storm Drainage: Maximum use will be made of existing drainage conduits and structures. New channels and/or conduits will be provided as required.

(v) High Pressure Air: The existing high pressure air system will be adequate for the NTF.

(vi) High Pressure Condensate Return: The existing condensate line is adequate for the NTF.

D. DESCRIPTION OF THE AFFECTED ENVIRONMENT

1. General Description of the Site

The LaRC Institutional Environmental Impact Statement (1971) describes in detail LaRC location and facilities and their relationship to the environment.

Located approximately 160 air km (100 mi) south of Washington, D.C., Langley Research Center (LaRC) is adjacent to the runway facilities of Langley Air Force Base (LAFB) and within the political subdivision of the City of Hampton, Virginia. Geographically, LaRC can be described as near the southern extremity of the lower Virginia Peninsula (lat. 37° 5' N; long. 76° 21' W), and between the northwest and southwest branches of Back River, a tidal estuary of Chesapeake Bay (See Figures 5 and 6).

LaRC occupies 313 hectares (773 acres) of government-owned land, divided into two areas, which are approximately 6 km (4 mi) apart, by the runway facilities of Langley Air Force Base. The West Area consists of 304 hectares (750 acres) owned by NASA. The East Area comprises 9.3 hectares (23 acres) under Air Force permit. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition, there are 44.5 hectares (110 acres) of NASA-owned land located in the City of Newport News, Virginia, 1326 hectares (3,277 acres) under permit from other government agencies, and 3.6 hectares (9 acres) under lease. The total area presently owned, under permit, or leased is 1,687 hectares (4,169 acres).

Langley Research Center comprises 219 buildings and structures located in the two major areas. The East Area contains 22 structures, most of which are major wind tunnels with their supporting facilities, the balance being administrative and project office space. The West Area, the major portion of the Center, is comprised of buildings which are generally two to three stories high, of permanent construction (brick, concrete, and masonry block), and well maintained.

Figure 7 indicates the site of the proposed National Transonic Facility, at the site of existing Building 1236, in the West Area near the Main Gate. The site is presently occupied by the 4 ft x 4 ft Supersonic Pressure Tunnel, Building 1236, and associated facilities, located approximately 244 m (800 ft) north of the main gate entrance to Langley Research Center. The site is bounded on the east by Taylor Road and on the west by the fenced property boundary of the center. Virginia State Highway No. 172 runs immediately outside the property boundary. The greater portion of the property to the west and southwest of the facility is undeveloped, but two developments occupy land immediately across the above road, namely an automobile racetrack and residential trailer park, which lie some 183 m (600 ft) south of the facility.

2. Natural Systems.

a. Geology. The NASA Langley Research Center and Langley Air Force Base are located in the embayment of the Atlantic Coastal Plain physiographic province, an elevated sea bottom characterized by low topographic relief and numerous large, marshy areas (Hunt, 1967). Geologic formations underlying the site consist of approximately 610 m (2000 ft) of sedimentary deposits ranging in age from Cretaceous to recent overlying igneous and metamorphic basement rocks (Division of Mineral Resources, 1963). These sedimentary deposits are predominantly of marine origin, although deposits of non-marine origin are also present. The sedimentary strata dip gently from west to east at an angle of approximately one degree.

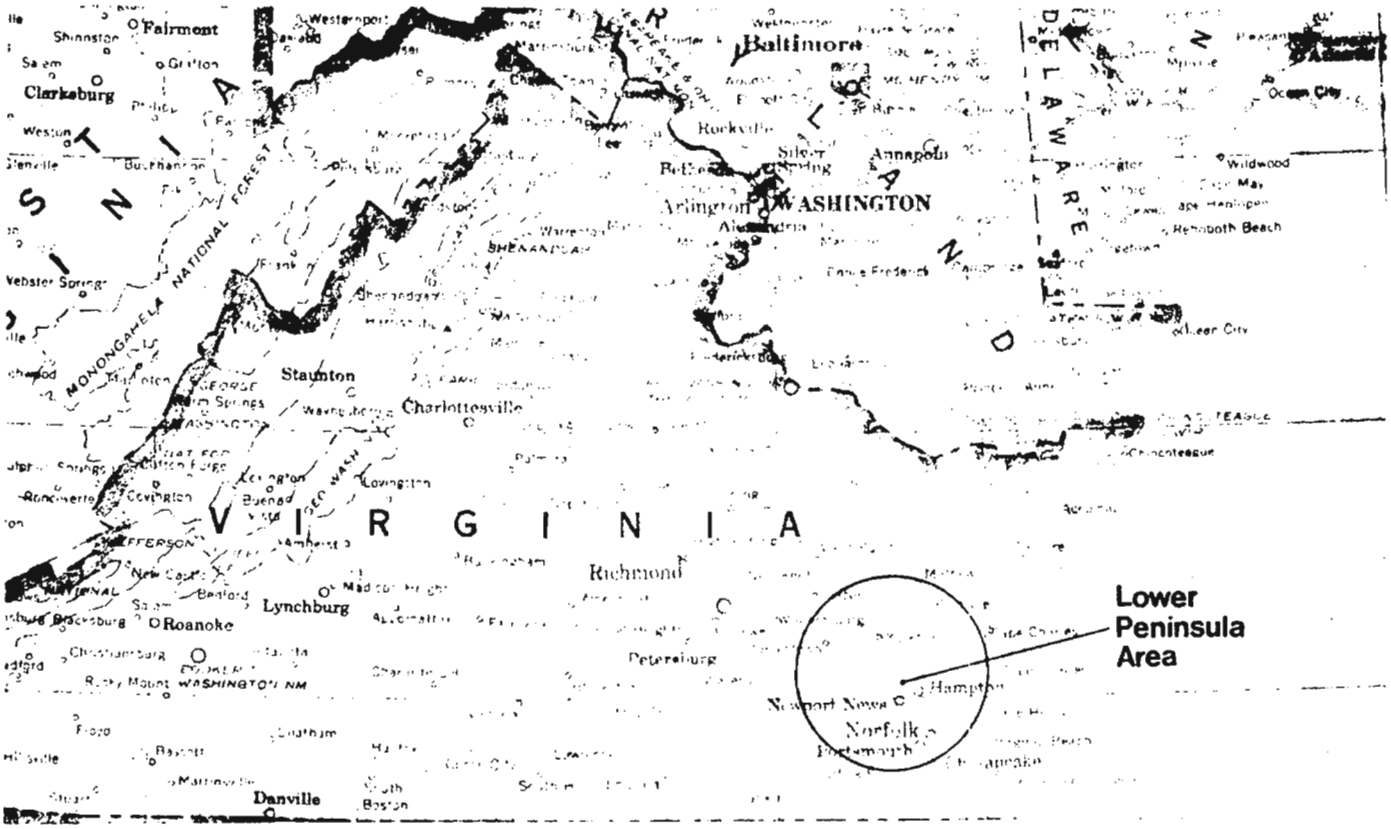


Figure 5
Chesapeake Bay Region

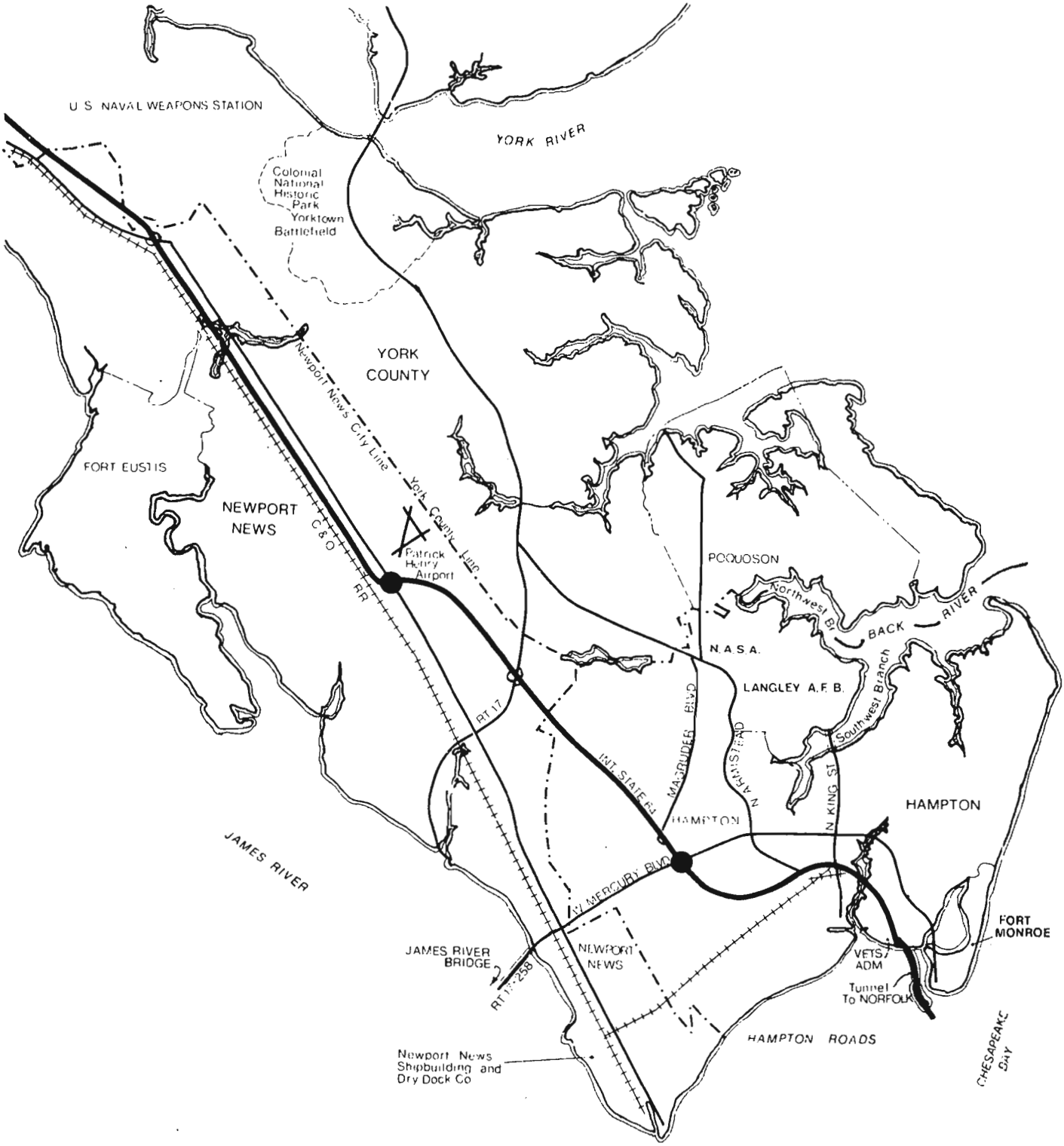


Figure 6

The Hampton-Newport News Area

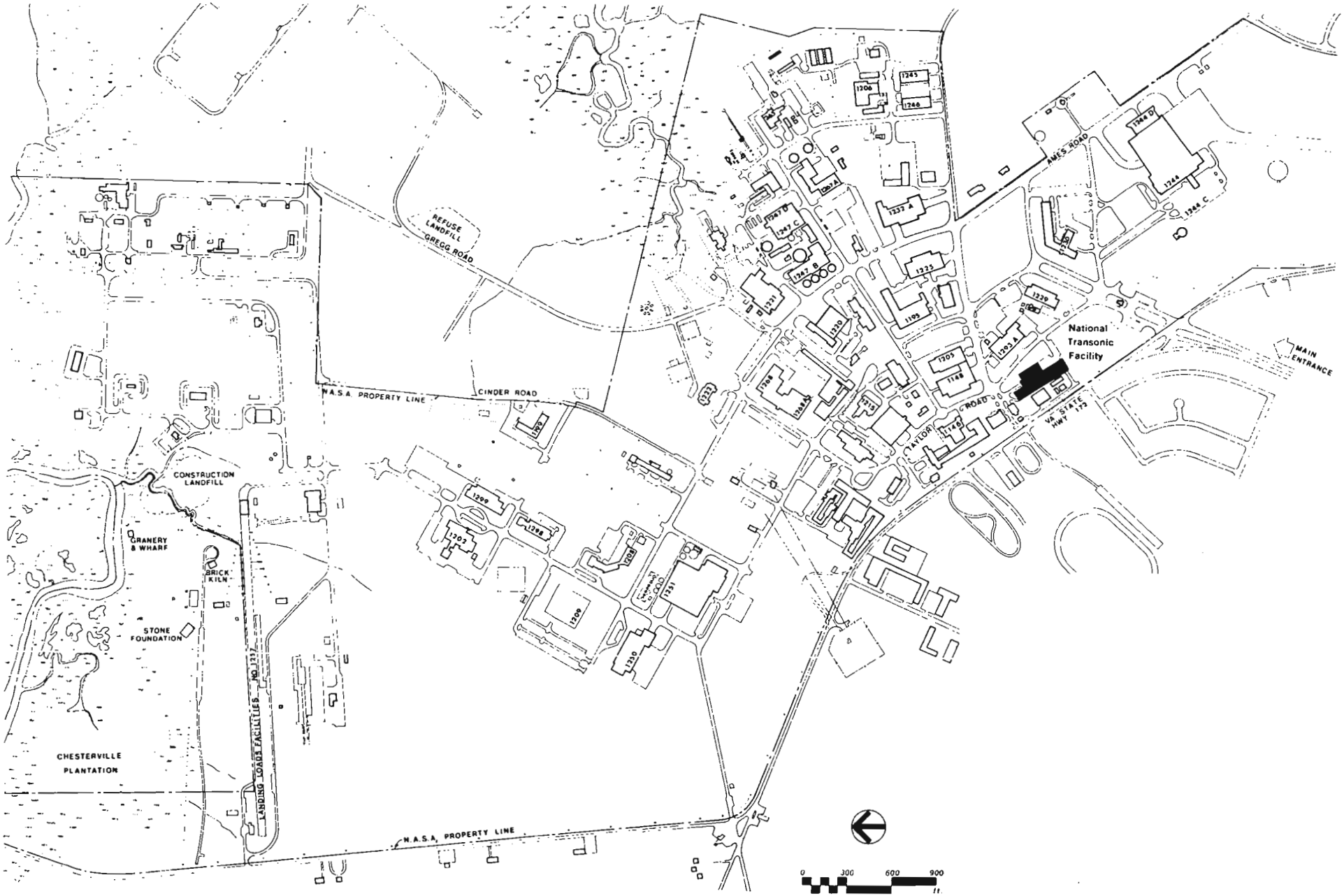


Figure 7
Proposed Site of the National Transonic Facility

Surficial deposits in the area consist predominantly of the Miocene-Pliocene age Yorktown Formation, composed of grey shelly, silty fine-grained sand with layers containing large amounts of clay and silt, overlain by the Pleistocene age Norfolk formation, composed of light-colored (yellow-brown) sandy clays, clayey sands, and silty sands (Woodward-Clyde, 1976). In the vicinity of the site, the Norfolk formation is approximately 3.1 m (10 ft) thick, while the Yorktown formation is estimated to be approximately 122 m (400 ft) in thickness. The geologic map and a typical stratigraphic section for the area are presented in Figures 8 and 9.

Although Virginia is a state with considerable seismic activity, earthquakes are of low intensity (VI or less on the Modified Mercoli Scale) and concentrated in the central and western portions of the state, the piedmont, valley, and ridge areas. The study area is located in an area designated as seismic risk zone 1, i.e., an area with minor damage expected (Coffman and von Hake, 1973). Only one earthquake with its epicenter near the study area has been reported; however, many small shocks with epicenters outside of the area have been felt in the study area. On April 19, 1918, an earthquake of magnitude III occurred with its epicenter located near Norfolk. Two distinct shocks occurred, and tremors associated with the earthquake lasted approximately fifteen minutes (Bollinger and Hooper, 1972). A magnitude III earthquake would cause minor property damage, having sensations similar to the vibrations of a passing truck.

Groundwater is not utilized for municipal or industrial water supply purposes in the lower peninsula area; LaRC/LAFB obtains water from the nearby, federally owned Big Bethal Reservoir. On the site, groundwater is found at depths ranging from 1.5 to 3.1 m (5 to 10 ft); however, seasonally high water table conditions cause depths to groundwater to be less than 1.5 m (5 ft). In the vicinity of the City of Hampton landfill, groundwater levels range from 3.1 to 4.6 m (10 to 15 ft) below the surface. Groundwater is often brackish because of proximity to Chesapeake Bay and because the soils are marine deposits. However, there are a few individual water wells in the area. General groundwater chemical characteristics are presented in Table 2.

Table 2. General groundwater chemical characteristics

pH	7.8 (standard units)
alkalinity (methyl orange)	208.0 mg/l as $CaCO_3$
chloride	12.0 mg/l
sulfate	88.0 mg/l
dissolved solids	410.0 mg/l

Source: Woodward-Clyde, 1976.

The National Transonic Facility will be located in an area which drains south into a tributary of Tide Mill Creek which discharges into Southwest Branch River.

b. Climate. Langley Research Center is located in the Tidewater Climatic Division of Eastern Virginia. The climate is determined by its latitude and its close proximity to the Atlantic Ocean. The Peninsula's irregular shape and numerous indentations give it a long shoreline relative to its size.

Monthly mean temperatures range from 5.3°C (41.5°F) in January to 26°C (79°F) in July. The Peninsula is very flat, so there is little chance of air trapping due to changes in terrain.

During the summer season, the westerly storm track is well north of the area; and southerly light winds prevail (SW, SSW, S about 30 percent of the time). During the late summer season, it is in the mean path of tropical moist air from the southwest Atlantic and Gulf of Mexico. Since air movement is minimal during this time, there is a great tendency for stagnation to occur. Around 20 percent of the wind velocities during the early morning hours are less than 1.6 km per hour (1 mph).

During the winter season, northerly winds are very common (NNW through NNE about 28 percent of the time), with frequent storm and outbreaks of cold polar air. Southwesterly winds are also very common (SSW through WSW about 25 percent of the time).

During the late spring, the surrounding bodies of water are cold relative to the adjacent land masses. This difference is greatest in mid-afternoon due to rapid solar heating. If the general air flow results in a long passage of air over the water before it reaches shore, the air will cool, and an inversion will take place in the air reaching the shore line. The practical result is that any pollutants released into this inversion tend to spread horizontally, but little vertically. As the land temperature heats the lower layers of this cool air, the inversion will lift. Pollutants emitted into the inversion can then reach an area of inversion break up and fumigate downward. Pollutants emitted below the inversion will not mix significantly into the inverted layer. The result is that pollutants tend to sink and remain at ground level.

Precipitation is well distributed throughout the year without distinct wet and dry seasons. The annual rainfall in the 1931-1960 period averaged about 107 cm (42 inc). Excessive rainfall usually occurs in the fall season with the passge of hurricanes, and in late fall through early spring with the passage of middle lattitude storms, often referred to as "Northeasters." Hurricane rainfall has occasionally been known to occur in excess of 20 cm (8 in). Rain in excess of 25 mm (0.01 in) occurs on about one day in three, cloud cover averages around 50 percent, and monthly average relative humidity varies between 67 and 76.4 percent, depending on the month. Fourty-four percent of the hourly relative humidities are below 70 percent, and sixteen percent are above 90 percent.

For further details on local climatology, see Appendix A.

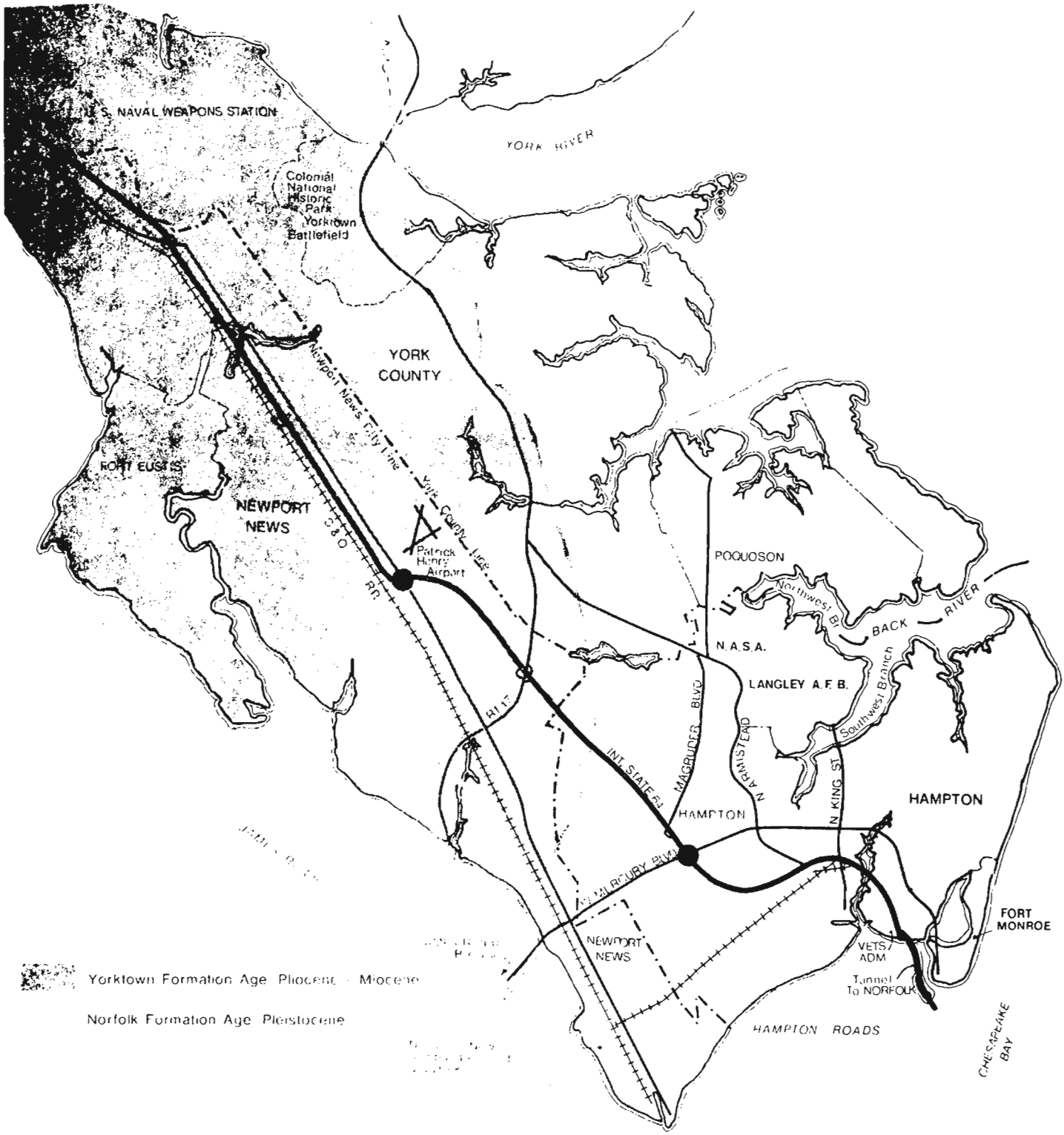
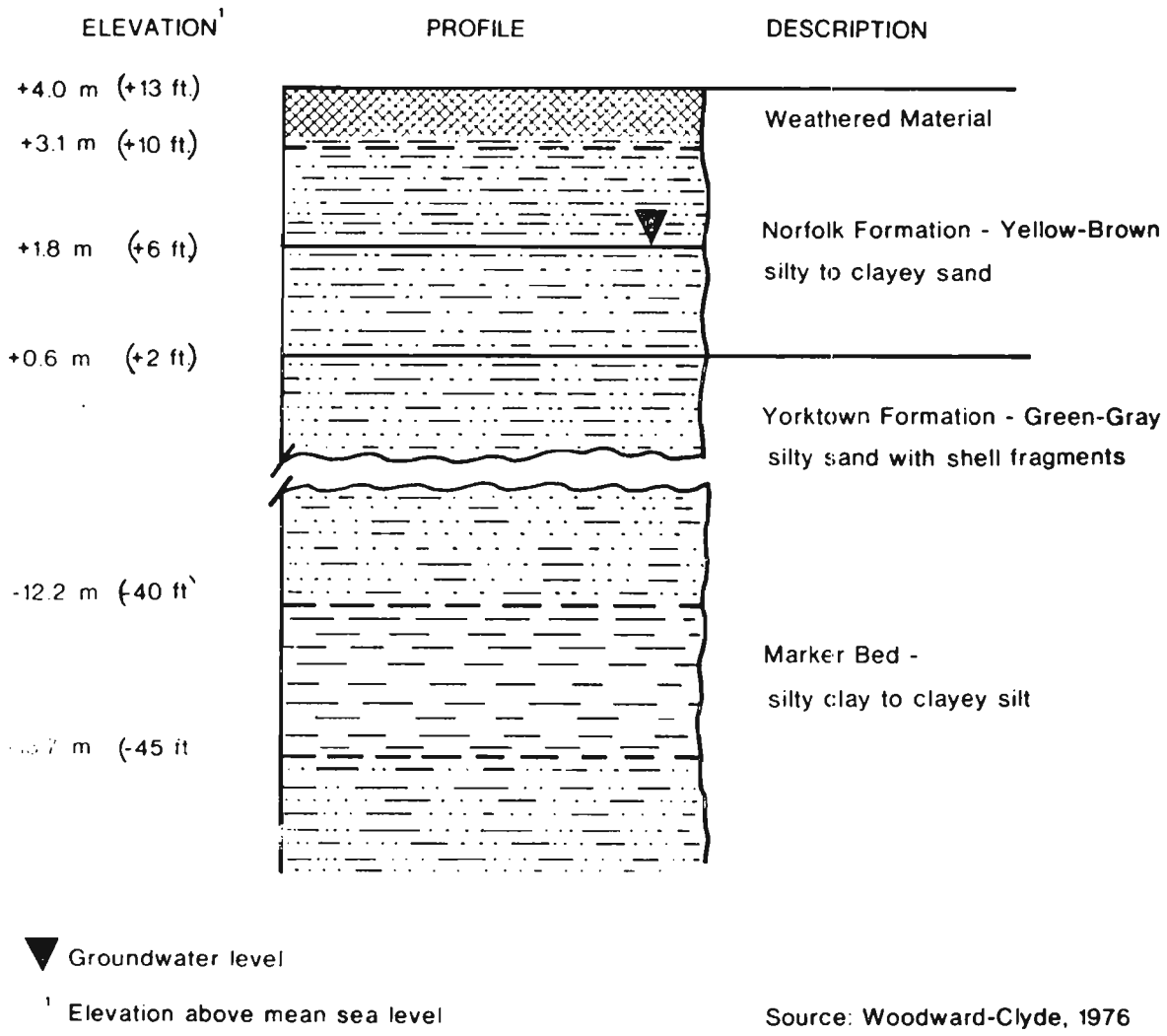


Figure 8

Geologic Map of the Lower Peninsula

Figure 9

Typical Stratigraphic Section, NASA Research Center, Langley, Virginia



c. Water Quality. LaRC is located between the Northwest and Southwest branches of the Back River, a tidal estuary of Chesapeake Bay. Stream quality and stream utilization standards established by the Commonwealth of Virginia, State Water Control Board, became effective July 20, 1970, and are set forth in the publication "Water Quality Standards."

The requirements for all basins is that the waters be satisfactory for public or municipal water supply, primary contact recreation, and the propagation of fish and aquatic life. Special standards have been established for the tidal portions of all three basins (James River, York River, and Chesapeake Bay - Atlantic Ocean) due to their use for shellfish production. Stream quality standards applicable to the Back River are shown in Table 3. The Back River is an important source of shellfish, crabs, and fish.

Table 3. Water Quality Standards

Basin and Section:
Chesapeake Bay and Atlantic Ocean, Section 2

Location:
Chesapeake Bay and its tidal tributaries from Thimble Shoal Channel north to Virginia-Maryland state line between Longitude 76° 10' W and east-west divide boundary on the Eastern Shore of Virginia.

Water Use Class:
IIB

Water Use Designation:
Generally satisfactory for use as public or municipal water supply, primary contact recreation (prolonged intimate contact: considerable risk of ingestion), propagation of fish and other aquatic life, and other beneficial uses.

Dissolved Oxygen:
Minimum: 4.0 mg/l Daily Average: 5.0 mg/l

Coliform Organisms:
Fecal coliforms (multiple-tube fermentation or MF count) within a 30-day period not to exceed a log mean of 200/100 ml. Not more than 10 percent of samples within a 30-day period will exceed 400/100 ml.

Monthly average not more than 2400/100 ml. (MPN or MF count). Not more than 2400/ 100 ml in more than 20 percent of samples in any month (sic).

pH:
6.0 to 8.5

Temperature °F:
Rise above Natural: Sept. - May 4.0
June - Aug. 1.5

Maximum: None

Special Standards
In those sections where leased, private or public shellfish beds are present, the median MPN shall not exceed 70/100 ml, and not more than 10 percent of the samples ordinarily shall exceed an MPN of 230/100 ml for a 5-tube, decimal dilution test (or 330/100 ml where a 3-tube decimal dilution test is used). The shellfish area is not to be contaminated by radionuclides, pesticides, herbicides, or fecal material so that consumption of the shellfish may be hazardous.

Source: Peninsula Planning District Commission. Interim Metropolitan/ Regional Water Quality Management Plan. Hampton, Va., 1971.

Water quality data for the Back River are shown in Table 4. The sampling locations are shown on Figure 10. Dissolved oxygen and temperature do not exceed the water quality standards; pH values are only slightly exceeded, apparently due to natural causes. Total coliform bacteria standards are generally exceeded, and fecal coliform standards are exceeded in Brick Kiln Creek. The sources of contamination are unknown but are probably combined sewer overflows, since there are allegedly no municipal sewage discharges into Back River (Little, 1974).

There are no major sources of water pollution originating at LaRC. Potential sources of pollution among the major research facilities at LaRC are listed in Environmental Impact Statement for Langley Research Center, August 1971.

Sanitary sewage is collected in separate sanitary sewers and conducted to the Hampton Road Sanitation, District James River Treatment, Plant in Newport News for treatment.

The other principal potential sources of water pollution at LaRC are blowdown from boilers and cooling towers, and area drainage from certain facilities. Blowdown of the boilers discharges approximately 9,462.5 m^3 (2.5 million gal) of wastewater per month. This water has a high alkalinity and large solids content because of treatment with chemicals to protect the boilers. This water is discharged into the municipal sewerage system.

An investigation made in 1965 (reported in Investigation of Waste Disposal Practices at Federal Installations by the U.S. Department of Health, Education, and Welfare, September 27, 1965) and subsequent investigations conducted by LaRC personnel indicated that no significant contamination of the storm sewer effluent originated from surface water or from the small amount of subsurface water in the storm sewer effluent. Therefore, continuing efforts toward eliminating storm water contamination have been focused on finding ways to prevent the introduction of contamination from facility drains.

The principal environmental concern with respect to the storm sewer system is blowdown from 47 cooling towers that use chromates as corrosion inhibitors for the water which is recirculated through the cooling tower system. The water in 5 cooling towers is maintained at an average of 170 mg/l of a chromate based inhibitor. The chromate level maintained in another 42 cooling towers has recently been reduced to the range of 5-10 mg/l. Samples of water from storm sewer outfall have revealed chromate concentrations as high at 15 mg/l in the past. A plant for the removal of cooling tower blowdown chromate by reduction and precipitation has recently been installed. Precipitated chromate is presently stored in a 0.21 m^3 (55 gal) drum pending final decision on disposal or possible recovery. The production rate is less than one drum per year.

Table 4. Water quality data for Back River and Brick Kiln Creek for 1975. (All data are in mg/l unless otherwise noted.)

Parameter	Back River								Brick Kiln Creek		Applicable Standard
	Main		NW Branch			SW Branch					
	1	2	3	4	5	6	7	8	9	10	
Dissolved Oxygen	7.9	7.7	7.8	7.8	7.8	7.4	7.7	7.1	5.6	5.9	Min: 4.0 Daily Mean: 5.0
Temperature (°C)	23.4	23.4	23.9	25.0	21.1	25.0	23.9	25.0	25.0	25.0	No maximum
pH	9.0	8.9	8.4	8.7	8.6	8.4	8.4	8.4	7.5	7.4	Min: 6.0 Max: 8.5
Fecal Coliforms (log mean/100 ml)	100	100	100	100	100	100	100	100	131	234	Mean: 200 in 30 days Max: 400 in 10% in 30 days
Total Coliform (MPN) (mean/100 ml)	40	80	95	137	1165	108	128	123	1943	6743	Mean: 70 in month
Total Kjeldahl Nitrogen	0.40	0.40	0.43	0.30	0.30	0.45	0.63	0.53	1.30	1.20	
Ammonia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.25	0.1	
Nitrite	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Nitrate	0.07	0.06	0.06	0.05	0.11	0.06	0.07	0.07	0.07	0.07	
Total Phosphate	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

Source: Virginia State Water Control Board, Tidewater Regional Office. Data are means for four dates: May 5, June 10, June 20, and July 18, 1975.

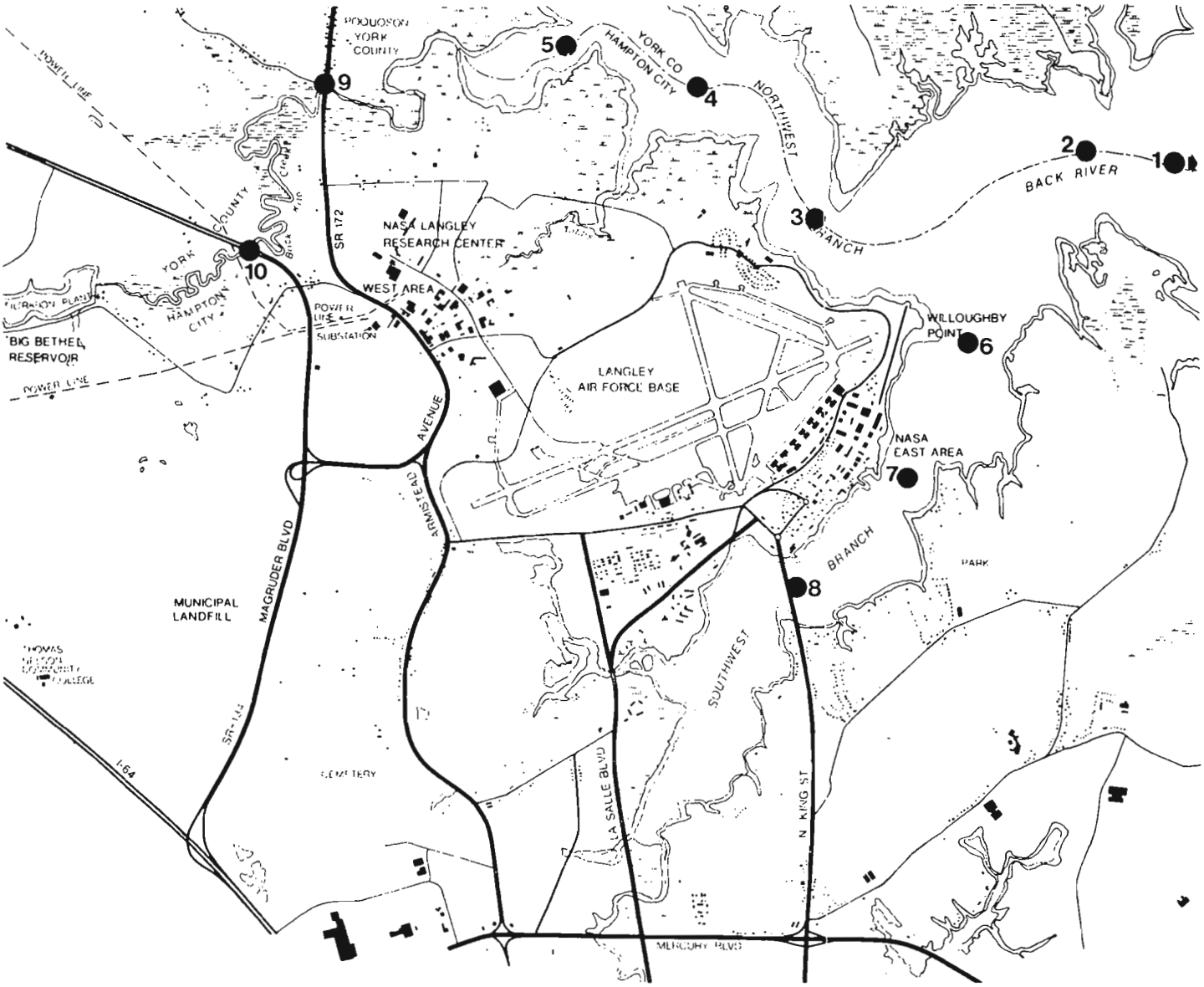


Figure 10

Water Quality Sampling Stations

Other sources which introduce small quantities include the following:

- Chemicals from chemistry and photographic laboratory drains;
- Oil from machinery drains and hydraulic system leakage to floor or drains;
- Chemical from drains in laboratories for materials processing, such as plastics, coatings, forming and bonding, electroplating, and cleaning;
- Paint from paint spray booths.

Four oil skimming basins remove oil from LaRC storm sewer effluent. This oil is collected and disposed of by a commercial cleaning service.

Other potential sources of water pollution in the Langley area are the sanitary landfills operated by the City of Hampton and by LAFB. Although high water table conditions exist in the vicinity of the City landfill (the approximate depth to groundwater is 3 meters (10 ft), migration of groundwater and, therefore, leachate pollution is limited by the low permeability of the silt and clay surficial deposits. Pollution problems at the existing facility appear to be related to impoundment of surface drainage in open cells and infiltration through surface cover of closed areas and discharge into neighboring open cells. Cells containing surface runoff are pumped dry and the water is discharged to the surface water drainage system.

Groundwater occurs at depths of less than 3 meters (10 ft) in the LAFB landfill area; however, landfill cells are excavated above the water, usually at depths ranging from 1.5 to 2.4 m (5 to 8 ft). Pollution problems identified in the Back River are believed to be partly related to landfilling operations on the base; however, whether or not pollution actually results from the landfill operation has not been determined (Smithsonian Institution, 1973). There is no reason to suspect that either landfill is the source of coliform bacteria pollution since sanitary sewage is not deposited in either.

d. Fisheries. Trawl surveys made by the Fisheries Department of the Virginia Institute of Marine Science (VIMS) during the summer of 1975 showed the presence of bay anchovies (Anchoa mitchilli), Striped anchovy (Anchoa hepsetus), spot (Leiostomus xanthurus), Atlantic croaker (Micropogon undulatus), oyster toadfish (Opsanus tau), harvest fish (Peprilus paru), weakfish (Cynoscion regalis), hogchoker (Trinectes maculatus), scup (Stenotomus chrysops), silver perch (Bairdella chrysura), Atlantic spadefish (Chaetodipterus faber), pinfish (Lagodon rhombodies) lookdown (Selene vomer), dusky pipefish (Syngnathus floridae) and northern pipefish (Syngnathus fuscus) in the Back River system (Jones pers. comm.). Nomenclature follows VIMS Special Scientific Report No. 65.

The benthos and shellfish of the York River have recently been studied by the Virginia Institute of Marine Science (VIMS, 1972). The mouth of the York River is approximately 8 km (5 mi) north of Back River. These

two rivers are reported to have similiar faunal elements because of their close proximity and similar tidal water flow from the Chesapeake Bay. The most characteristic benthic species are Nephtys incisa, Ogyrides limicola, and Retusa canaliculata (copepod crustaceans), and the numerically abundant Mulinis lateralis (a bivalve mollusk). Table 5 lists the decapod crustaceans and bivalves taken in the study by VIMS. Commercial oysters (Crassostrea virginica) occur throughout the lower York River system. Salinity measurements suggest that similar populations occur in the Back River. Presently oysters are extremely scarce in the lower half of the York River due to MSX (a virus). Oyster drills (Urosalpinx sp.) cause damage at Green and Page's Rock upstream in the York River. The maximum strike of oysters occurs in August or September with the maximum set occurring in September. Commercial oyster fishing is light in the region and has contributed little to the decline of the oyster beds.

The highest catch of blue crabs (Callinectes sapidus) took place in July (14.1/tow) with few if any caught between January and March. Similar values could be expected for Back River.

Recent stress on the shellfish and finfish habitat has come from several sources. Large amounts of freshwater draining into the rivers of the lower Chesapeake Bay from Hurricane Camille in 1969 caused a rapid and measurable decrease in estuarine population of the region. In addition, discharges from manmade sources have caused increasing pressures on this wildlife resource, contributing to the decreases and closures along sections of the Back River, James River, and York River.

e. Vegetation.

(i) Wetlands: A tidal marsh inventory (Barnard, 1975) has been prepared for the City of Hampton. This inventory describes 48 hectares (120 acres) of "extensive marsh" along the south shore of Brick Kiln Creek. An additional "extensive creek marsh" of 38 hectares (95 acres) is described along Tabbs Creek. Table 6 summarizes the characteristics of these marshes.

(ii) Terrestrial Vegetation: The remaining units of woodlands located on the property of LaRC are young forests which are part of the oak-pine forest region (Braun, 1950). Several hickory species are also important components of this forest (Kuchler, 1964).

This region has flat topography with slow-moving streams lined with marshes throughout the area. Along the northern border of the LaRC property, Brick Kiln Creek drains eastward to the Northwest Branch of the Back River, while Tabbs Creek drains the central area of the western section of LaRC. Sweetgum (Liquidambar styraciflua), northern red oak (Quercus rubra), swamp white oak (Quercus bicolor), red maple (Acer rubrum), and loblolly pine (Pinus taeda) are the common tree species of this region. These species are adapted to local high water tables. The existing vegetation reflects succession from former crop and pasture land. There are also extensive landscaped areas around developed facilities at LaRC.

Table 5 . Selected Shellfish Taken In VIMS Study Of The Lower York River, Virginia, 1972.

Decapod Crustacea (crabs, shrimps, etc.)		Pelecypod Mollusks (clams, oysters, etc.)	
Species Name	Common Name	Species Name	Common Name
Ogyrides limicola		Nucula proxima	nutshell
Euceramus praelongus		Yoldia limatula	
Pagurus longicarpus	common hermit crab	Anadara transversa	transverse arc
Cancer irroratus	common rock crab	Anadara ovalis	blood arc
Neopanope texana	mud crab	Mytilus edulis	common edible mussel
Pinnixa chaetopterana	parchment worm crab	Lucina multilineata	apricot shell
Pinnixa retinens		Mysella bidentata	
Pinnixa sayana	mud crab	Mercenaria mercenaria	quahog
Libinia dubia	spider crab	Pitar morrhuana	pitar hardshell clam
		Astarte sp.	astarte clams
		Tellina agilis	sunset shell
		Macoma balthica	little macoma
		Macoma mitchelli	
		Macoma tenta	little macoma
		Ensis directus	common razor-shell clam
		Spisula solidissima	surf clam
		Mulinia lateralis	dwarf surf clam
		Mya arenaria	soft shell clam
		Lyonsia hyalina	glassy lyonsia
		Pendora trilineata	pandora shell

Authorities for common names: Minor, R. W., 1950.
Smith, R. I., 1964.

Table 6 Marshes of the Northwest Branch of Back River.

Marsh Number	Place Name	Area		Marsh Type	Evaluation
		hectares	acres		
190	Tabbs Creek	38	(95)	Extensive Creek II*	Group Two. Buffer to coastal flooding. Should be preserved ahead of all but Group One marshes.
193	Brick Kiln Creek	31	(76)	Extensive Marsh II	Group Two.
194	Brick Kiln Creek	18	(44)	Extensive Marsh XII**	Group One. High value in productivity and wildlife utility. Should be preserved.

* Saltmeadow Community: Productivity 1-3 tons per acre per annum; food and nesting areas for birds; effective erosion deterent; assimilates flood waters; filters sediments and waste material.

**Brackish Water Mixed Community: Productivity 3-4 tons per annum; wide variety of wildlife foods and habitat; deterrent to shoreline erosion; serves as sediment trap and assimilates flood waters; known spawning and nursery grounds for fish.

Source: Barnard, 1975

Byrd and Ware (1973) surveyed the flora and selected fauna of the LaRC and LAFB. This survey indicates that forests dominated by red maple occur northwest of the Gate 5 road and from Freeman Road to the Bush Road adjacent to the Lunar Landing Facility. Southwest of Stratton Road, there is a mixed hardwood forest with a small area of pine-dominated forest east of the VEPCO substation and switching yard. Additional vegetation types listed by Byrd and Ware include: ragged, weedy, mixed hardwoods; red maple-dominated, oak-dominated marshland; and golf course. The distribution of plant communities at LaRC/LAFB is depicted in Figure 11.

(iii) Vegetation at the Proposed Site: The proposed site for the National Transonic Facility is located on a developed and landscaped site. No natural vegetation currently exists on the site.

f. Wildlife. A list of terrestrial wildlife observed at LaRC and LAFB and the lower peninsula area of Virginia is given in Appendix B. The list includes 25 species of amphibians, 42 reptiles, 51 birds, and 31 mammals. There is a resident white-tailed deer (Odocoileus virginianus) herd on LaRC/LAFB, estimated at 150 animals in 1973.

The list of rare and endangered species for the area includes three birds of prey, the bald eagle (Haliaeetus leucocephalus), the osprey (Pandion haliaetus), the peregrine falcon (Falco peregrinus), and also the Ipswich sparrow (Passerculus princeps); the last two are uncommon visitors to the area. The nearest reported nests for the osprey are on a branch of the Poquoson River northeast of LaRC. The golden plover (Pluvialis dominica) and buff-breasted sandpiper (Tryngites subruficollis) are also seen during migration. These two shorebirds are infrequently sighted in Virginia.

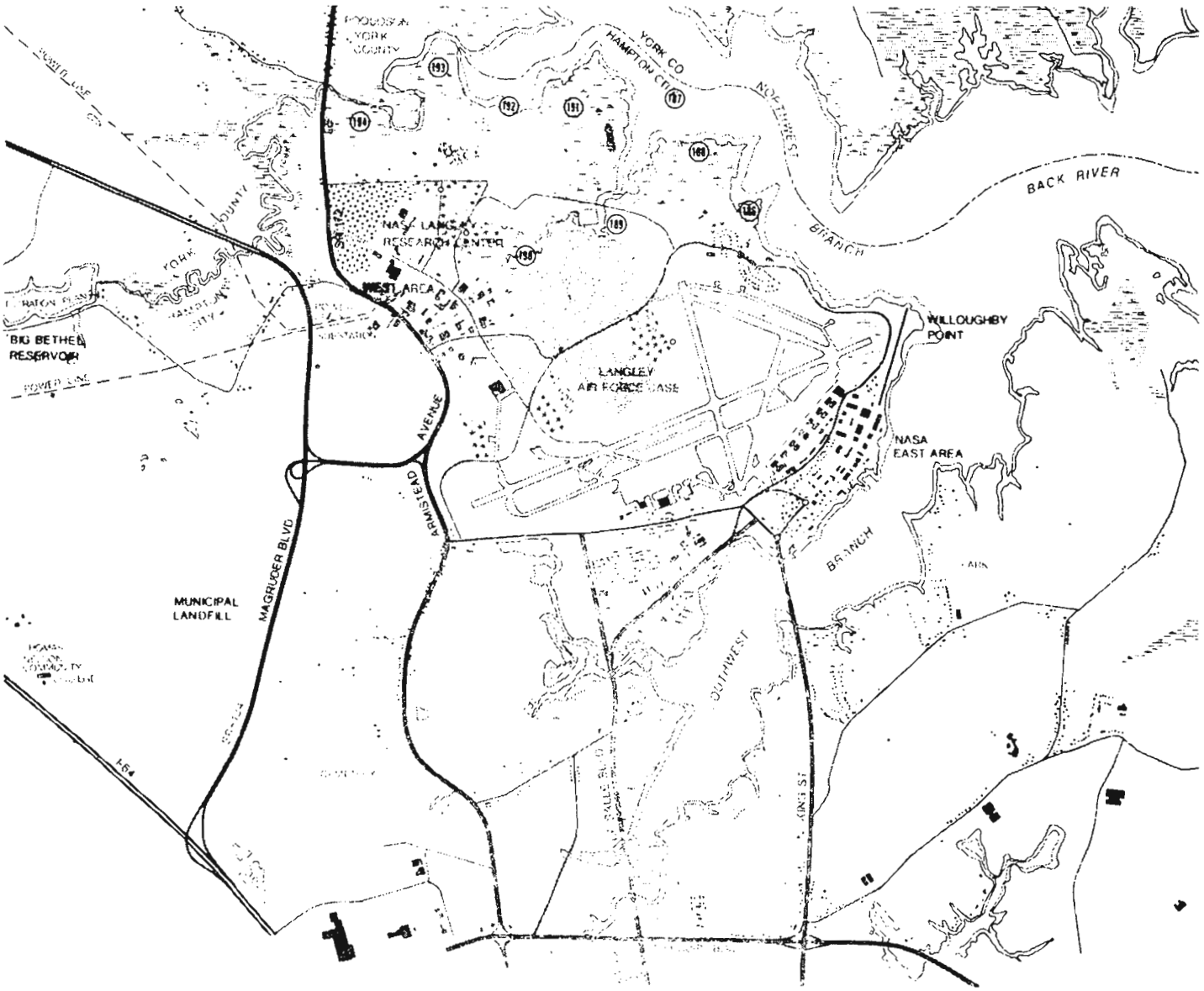


Figure 11

Distribution of Plant Communities at LaRC/LAFB

g. Noise. The current noise environment on, and around, Langley Research Center is a product of many sources. The principal concern of this study is the effect of noise produced by the LaRC on the neighboring communities. Since impact is directly related to amount of change as well as absolute level, the initial step is to describe a baseline from which change can be established.

The ambient noise data for communities surrounding LaRC show a typical distribution of noise levels for communities of this kind. Common community noise sources, local traffic, and major traffic routes were the major contributors to the overall noise exposures. However, activities on Langley AFB and aircraft flyovers also contributed significantly to these levels at times.

The representative noise levels found in some of the communities around LaRC are summarized in Table 7.

Table 7. Representative Community Noise Levels.

Location/Time	Noise Levels (dBA)	
	Range	Mean
Poquoson		
2:00a to 3:00a	42 - 52	45
7:00a to 8:00a	42 - 60	48
10:00a to 11:00a	44 - 59	49
8:00p to 9:00p	42 - 55	47
Tidemill Farms		
2:00a to 3:00a	40 - 44	42
7:00a to 8:00a	48 - 68	53
10:00a to 11:00a	54 - 68	59
8:00p to 9:00p	44 - 52	47
Riverdale		
2:00a to 3:00a	41 - 57	43
7:00a to 8:00a	51 - 60	54
10:00a to 11:00a	44 - 76	53
8:00p to 9:00p	45 - 58	49
Sinclair Farms, River Terrace and Willow Oaks		
2:00a to 3:00a	41 - 51	45
7:00a to 8:00a	47 - 60	52
10:00a to 11:00a	49 - 56	52
8:00p to 9:00p	44 - 62	52

Source: Michael, 1973.

All the measurements used in the above summary of data were taken at least one block from major traffic routes. Locations close to major traffic routes may be expected to have higher levels depending upon the time of day and traffic density. Also, infrequent short-term sources such as trucks and cars passing nearby and aircraft flyovers have been omitted in the data summary (Michael, 1973).

It should be noted, however, that aircraft flyovers can raise the noise levels a significant amount. For example, an aircraft flyover in the Willow Oaks section produced 65 dBA which is 13 dBA higher than the average for that time of day. Also, activity on the airfield such as the warm-up of a C-130 can affect nearby areas. For example, a C-130 warm-up on LAFB produces about 66 dBA at the LaRC West Gate and about 57 dBA in Tidemill Farms. The highest level noted from LAFB was during a jet engine test when levels of 88 dBA were measured in Tidemill Farms and 56 to 60 dBA in Sinclair Farms. This jet engine test lasted only a few minutes and happened only once during the measurements.

Noise measurements were also made in other communities, including Hunt Club Terrace, Winchester Park, and Farmington, about three to four miles southwest of LaRC. Noise levels of 49-52 dBA produced in Winchester Park and Hunt Club Terrace (about 8:00 p.m.) obviously were coming from the traffic on Route 64. In the Farmington area, the levels were relatively low--about 43-46 dBA--at 8:30 p.m.; however, this community is on the approach path to Langley AFB, and when a jet aircraft approached the field, the noise levels were raised to 65-67 dBA (Michael, 1973).

Measurements made within one mile of LaRC when none of the major LaRC noise sources were operating showed a large range of levels that depended upon local traffic, activities on Langley AFB, and aircraft flyovers. Only within a few blocks of the LaRC West Area did the general acivities from LaRC contribute significantly to the community noise levels (Michael, 1973).

With this general idea in mind, it is most productive to limit further description to the areas adjacent to the proposed project area where possible impact may occur.

The noise levels produced by the High Speed 7 x 10-Foot Tunnel (B-1212B), the V/STOL Tunnel (B-1212C), the Mach 6, 20-Inch Tunnel (B-1247D), and the Unitary Plan Wind Tunnel (B-1251) are all generally above ambient levels for about one block within LaRC and in some cases can be detected outside LaRC; however, none of these sources produce levels in the surrounding communities that exceed recommended levels (Michael, 1973).

The noise levels produced by the 16-Foot Transonic Tunnel, B-1146, are considerably higher than ambient both within and outside of LaRC over an area extending several blocks from the facility; however these

noise levels are not high enough, nor of sufficiently long duration, to be considered as potentially harmful to the hearing of persons exposed. The noise levels are not an annoyance problem within LaRC because the tunnel operates only from midnight to 8:00 a.m. when persons are outdoors infrequently and for short times. Also, most of the area over which the tunnel noise exceeds ambient levels outside LaRC consists of industrial parks and wooded areas that are not inhabited during the times the tunnel is operating.

However, there is a trailer court consisting of, at present, over 100 trailers located outside the West Gate about 300 m (1000 ft) southwest of the 16-Foot Tunnel. In the court, at a point nearest the 16-Foot Tunnel, ambient levels at 1:00 a.m. varied from 40-57 dBA with an average level of 44 dBA. By comparison, when the tunnel was operating at Mach 1.2 with its compressor running, the levels in the trailer court at a point nearest the tunnel, in the center of the court, and at a point farthest from the tunnel were 65-67 dBA, 62-66 dBA, and 58-64 dBA respectively (Michael, 1973). See Figure 12.

In the parking lot of the West Gate Lounge, the noise levels from the tunnel are much louder since it is located nearby. At the time and under the operating conditions described above, the noise varied from 82-85 dBA with an average level of 83 dBA (Michael, 1973).

These levels, then, are approximately 22 dBA above the ambient level when the tunnel is off, but this is not atypical for the area. As previously noted, aircraft flyovers and other aircraft operations and tests at Langley Air Force Base frequently produce noise levels equivalent to the tunnels. Additionally, there is an auto race track and a go-cart track next door to the trailer court, and these activities also produce similar or greater noise levels.

All of the above noise conditions predated the existence of the trailer court. The construction went ahead despite strong recommendations that the noise conditions were incompatible with residential development. It may be assumed that the people who are living there are for one reason or another very tolerant of higher-than-normal noise levels.

The trailer court area and some of the immediately surrounding lands are also considered to be extremely marginal for residential development because of the activities of the F-106 and F-15 squadrons based at Langley Air Force Base. According to both the Air Installation Compatibility Use Zone (AICUZ) concept developed by the Air Force and the Noise Exposure Forecast (NEF) contours as evaluated by the Department of Housing and Urban Development, these areas are normally unacceptable for residences and will become acceptable only if specially sound-proofed construction is used.

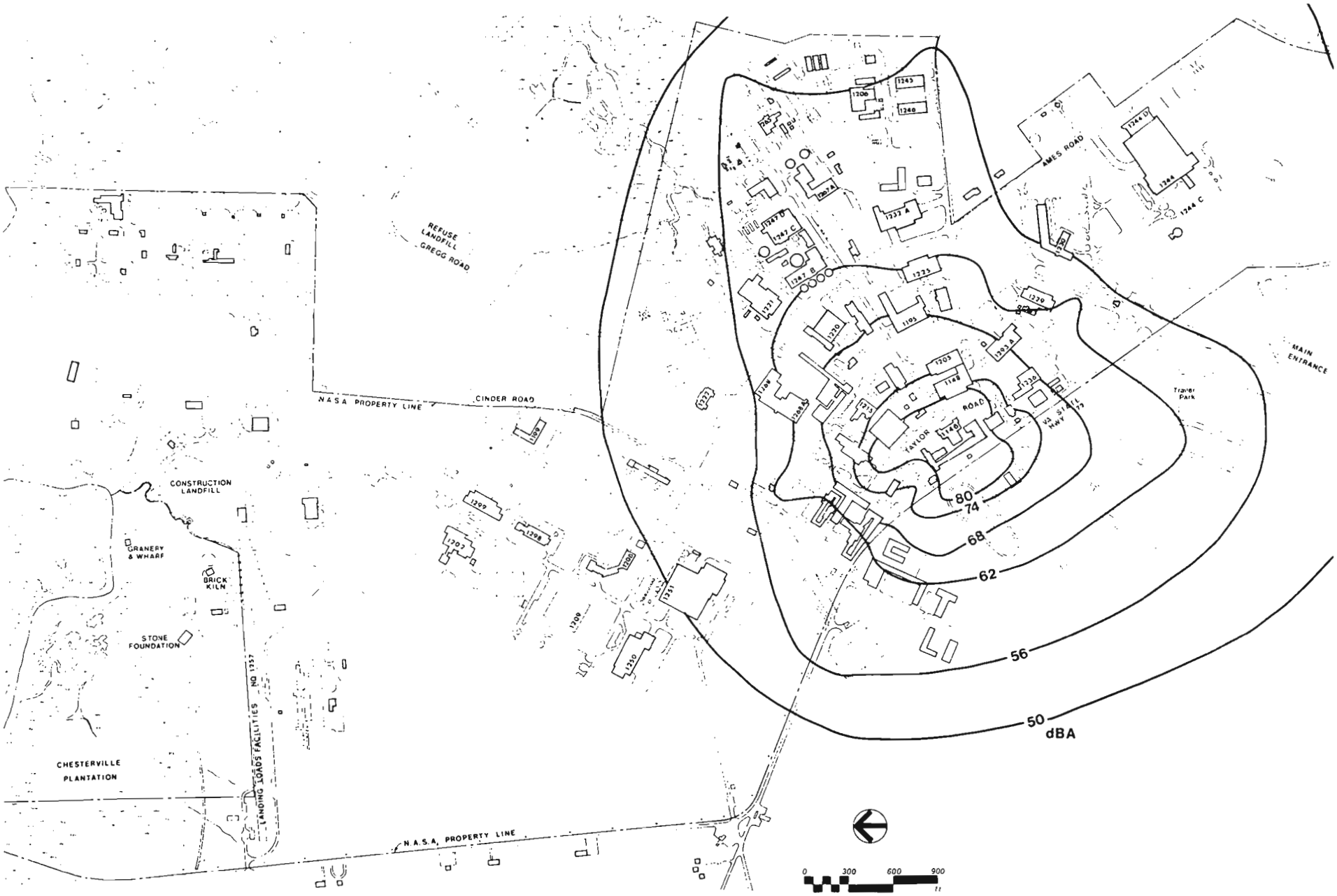


Figure 12

Noise Levels from Existing 16-ft Wind Tunnel

Parenthetically, traffic noise is also a factor, albeit a relatively minor one. Readings taken in mid-morning along Armistead Avenue show L_{10} (level exceeded 10 percent of the time) levels between 69-73 dBA at 7.6 m (25 ft) from the highway. The average level due to traffic was 65 dBA (Figure 13). Relative to the majority of land uses in the area, this is of no particular importance. It is rather high for a residential area, but in this environment it is so overshadowed by other sources as not to be significant.

It is clear, then, that the area around Langley Research Center is often quite noisy. Between the operations at LaRC, LAFB, the auto race track, and normal traffic and other minor sources, the noise levels created over a 24-hour day are often high. Fortunately the areas where the noise levels would be excessive for residential uses are largely vacant. The operations of the air base create more significant noise exposures than do LaRC sources generally. The exception is the condition at the trailer court outside the West Gate where the 16-Foot Transonic Tunnel is a major noise source. However, the significance of this is to some degree mitigated by the fact that the construction of the court postdates all of the major noise sources, and the residents have made informed decisions to live as they do in a noisy environment.

Although the wind tunnels do not typically create significant effects outside the LaRC property, they are often determinative of the noise levels on the Center grounds. The 16-Foot Transonic Tunnel produces levels of 64-70 dBA in the site area, while the high speed 7 x 10-Foot Tunnel can generate 56-62 dBA there. Additionally, the V/STOL Tunnel is capable of producing 54-60 dBA and the Unitary Plan Wind Tunnel 50-54 dBA at the proposed site. Since typically these units do not operate simultaneously, there is usually no reinforcing of the individual noises. These sources are the predominate ones in the area, however, and therefore the noise levels produced by these tunnels vary from 50-70 dBA on site.

h. Air Quality. The Virginia Air Pollution Control Board operates an air monitoring station at the Virginia State School, about 9.5 km (6 mi) southwest of the LaRC. It is this station, at Shell Road and Pembroke Avenue, that is closest to Langley. During 1975, air monitoring data taken at this station showed no violations of the Federal and State of Virginia primary and secondary air quality standards for total suspended particulates and sulfur dioxide.

Carbon monoxide levels exceeded the standard (nine parts per million (ppm), eight hour average, not to be exceeded more than once per year) six times during 1975. Eight hour average carbon monoxide levels reached as high as 13.5 ppm at this location. No violations of the one-hour standard of 33 ppm were observed at this site. Ozone was found to exceed the one hour standard (0.08 ppm, not to be exceeded

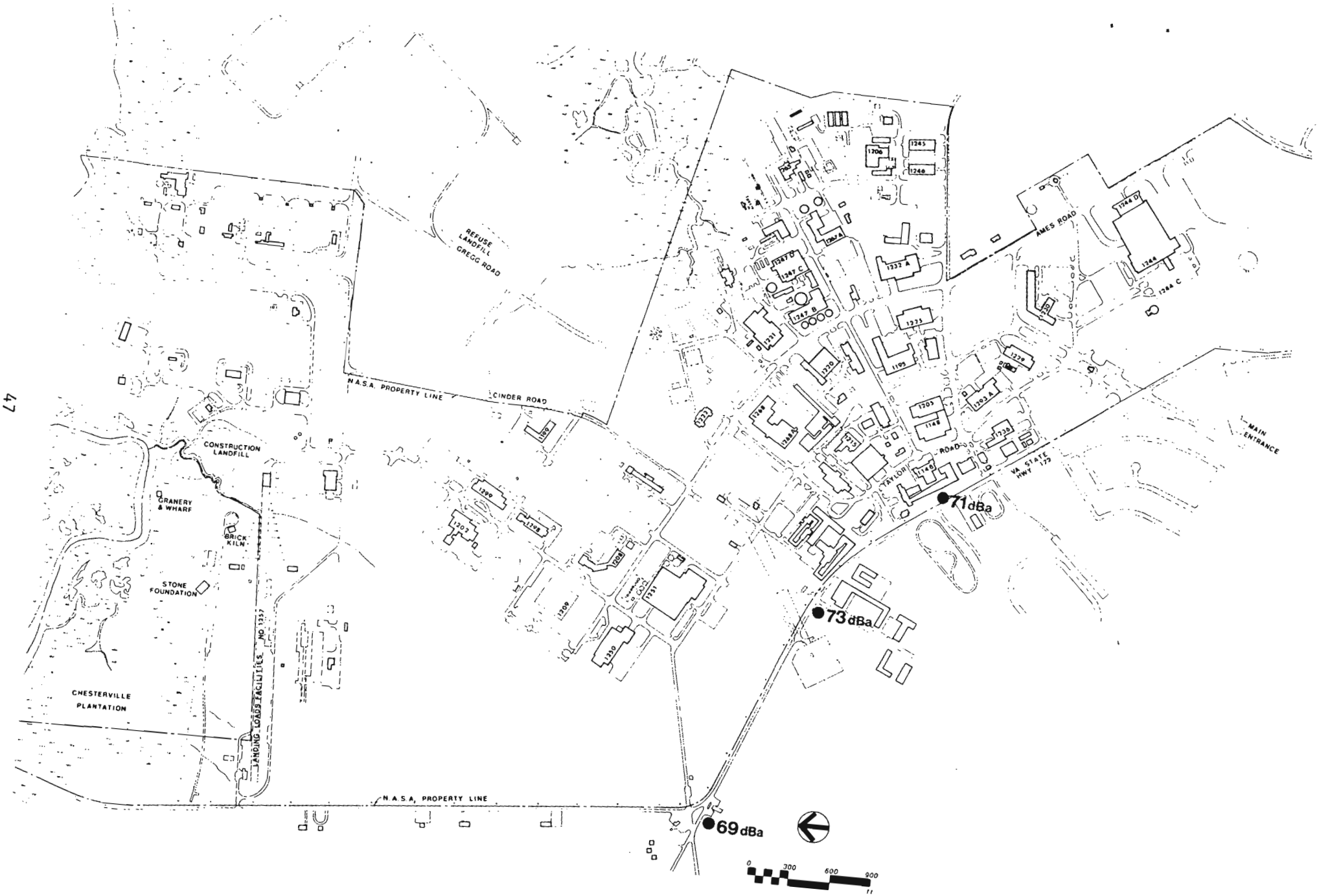


Figure 13
Existing Traffic Noise Levels

more than one per year) 213 times, the highest observed ozone level was 0.145 ppm.

No recent NO_2 data is available for Hampton, because the Virginia Air Pollution Control Board considers the area to be in compliance with the standards, and under the circumstances, NO_2 monitoring is not necessary there.

Some limited non-methane hydrocarbon monitoring has been performed by the Virginia Air Pollution Control Board in the area around Hampton, Virginia. These data are not being used because the Federal Reference Method used to monitor hydrocarbons has been shown to give inconsistent results, since different flame ionization detectors give different results for the same level of non-methane hydrocarbons in the ambient air. The Federal Reference Method currently calls for the use of gas chromatographs equipped with flame ionization detectors.

The Virginia ambient air quality standards are identical to the Federal Standards. Table 8 presents a summary of these standards and the amounts of pollution observed at Shell Road and Pembroke Avenue, in Hampton.

Table 8. Air Quality Standards - State of Virginia and Federal

POLLUTANT	DURATION	RESTRICTION	CONCENTRATION STANDARDS† [in ug/m^3 (and ppm)] PRIMARY	SECONDARY	Levels Observed at Virginia School, Hampton, Va. During 1975, in ug/m^3 (and ppm)+
Suspended Particulates	Annual Mean (G)	Not to exceed	75	60	47
"	24-hour concentration	Not to be exceeded more than once per year.	260	150	Highest observed level 136.
Sulfur Dioxide	Annual Mean (A)	Not to be exceeded.	80 (0.03) **		26 (0.01)
"	24-hour concentration	Not to be exceeded more than once per year.	365 (0.14)		Highest observed level 157 (0.06).
"	3-hour concentration	"	--	1,300 (0.5)	Not available.
Carbon Monoxide	8-hour mean (A) concentration	Not to be exceeded more than 1 eight-hour period per year.	10* (9.0)	10* (9)	10 exceeded 6 times. Highest 15.2 (13.5).
"	1-hour mean	Not to be exceeded more than once per year.	40* (35)	40* (35)	Highest 21 (18.5).
Photochemical Oxidants	1-hour mean (A) concentration	Not to be exceeded.	160 (0.08)	160 (0.08)	Exceeded 160 213 times. Highest level 290 (0.145).
Non-methane Hydrocarbons	3-hour mean (A) concentration	Not to be exceeded between 6 am to 9am.	160 (0.24)	160 (0.24)	Not available, method of measurement not consistent.
Nitrogen Dioxide	Annual mean (A)	Not to be exceeded.	100 (0.05)	100 (0.05)	Not monitored because region in compliance with standards.

(A) Arithmetic (G) Geometric

+Virginia Air, 1975, 1976 and personal comm.

†Federal Register. Nov. 23, 1971.

*Only standard expressed in milligrams per cubic meter.

**Values in parentheses are equivalent values in parts per million by volume.

3. COMMUNITY/INFRASTRUCTURE SYSTEMS

a. Transportation

The Virginia Peninsula was originally attractive to early settlers because of the large and protected harbors for ocean and coastal transportation, and the navigability of both the York and James Rivers for considerable distances inland. Current water transportation activities center around the ports of Newport News, Norfolk, and Portsmouth. The Intercoastal Waterway passes between Hampton and Norfolk and serves as a major navigation and shipping channel along the eastern coast of the United States. The Chesapeake and Ohio Railway company has tracks down the Peninsula from Richmond to the shipyards at the shore in Newport News. The passenger station, now part of the Amtrak system, is in the same general location, and handles passenger and freight service. An extension of the C & O line travels from this area east across the end of the Peninsula, through Hampton to its end at Fort Monroe.

Interstate Highway 64 comes southeast down the Peninsula from the state capitol at Richmond, through York County near Williamsburg, and on through Newport News and Hampton. In combination with Virginia State Route 168 and U.S. 60, I-64 crosses Hampton Roads Bridge Tunnel to Norfolk to connect with the rest of the Tidewater area of southeast Virginia. The Chesapeake Bay Bridge Tunnel, 35.7 km (21 miles) long, can be used to travel north from the Norfolk area and east to the Delmarva Peninsula on U.S. Route 13. Newport News is also connected with southern Virginia by the James River Bridge, which carries U.S. 258.

An interlacing of a variety of state routes, both two- and four-lane, and U.S. Routes 60 and 17 provide the major arteries for vehicular traffic in the more populated lower Peninsula region. Rush hour jamming of traffic near the gates of the major employment centers is the expected norm.

Greyhound Bus Lines serves the area, with the main station in Newport News and suburban stations in Hampton and Fort Eustis. Citizens Rapid Transit provides local scheduled public transportation between LARC/LAFB and other major areas in the more densely populated sections of Newport News and Hampton. Several charter bus companies are also available in the region.

Norfolk Regional Airport serves the Hampton-Langley area, and is located across Hampton Roads in Norfolk, Virginia. For more local needs and feeder service, Patrick Henry Airport in Newport News is used.

b. Utilities.

(i) Water Supply: The Newport News Waterworks system provides water for Newport News and the City of Hampton through two major reserviors. Newport News City Reservior, with two filtration plants, is in the Newport News Park System between Colonial National Historic Park and Fort Eustis. Harwoods Mill Reservior, with one filtration plant, is formed by a dam across the Poquoson River, which flows into the York River north of the Town of Poquoson.

Water for all of LaRC and LAFB use comes from the government-owned Big Bethel Reservior, which is west of Langley about 2 km (1.2 mi). This reservior is formed by a concrete dam and spillway on Brick Kiln Creek, which flows along the north border of NASA property and into Northwest Branch Back River. The system is operated by the U.S. Army, which superintends the filtration and purification plant at the spillway. Water from this system also is supplied to Fort Monroe.

Langley has built a ground-mounted water tank with a 7.58×10^3 m^3 (2×10^6 gal) capacity, and three elevated tanks totaling 3.22×10^3 m^3 (8.5×10^5 gal) capacity. These storage tanks serve to stabilize water supply and need throughout the seasons. LaRC/LAFB also has an emergency tie into the Newport News Waterworks system.

(ii) Wastewater Treatment: Wastewater on the Virginia Peninsula is handled by the Hampton Roads Sanitation District and the three plants it operates. The Williamsburg Treatment Plant in James

City County serves the northern region. The James River Sewage Treatment Plant in Newport News on the west shore of the Peninsula on the James River serves the central area, including LaRC and LAFB. Boat Harbor Treatment Plant is in Newport News at the southern tip of the Peninsula, and serves that region and most of the City of Hampton.

The James River facility, where the LaRC sewage goes, uses treatment by both biological and chemical means, and the product is discharged into the James River. Originally built to 18.9×10^3 m^3 (5×10^6 gal) per day, it was treating 36.3×10^3 m^3 (9.6×10^6 gal) a day by 1974. Expansion to increase capacity to 56.8×10^3 m^3 (1.5×10^7 gal) a day is underway.

(iii) Electric Power: Electric power is provided to Peninsular Virginia by the Virginia Electric and Power Company (VEPCO). The primary source of power for the southern Peninsula comes from the VEPCO Yorktown Power Plant, an oil-burning facility. The plant is located near the confluence of Wormley Creek with the York River south of Yorktown. Through connections with a regional grid, the flow of electricity can be regulated as needed throughout the region from other power plants further away. Through a system of substations, electric power is distributed to the cities of Newport News and Hampton.

The VEPCO Peninsular substation which serves LaRC is located in North Armistead Avenue across from NASA facilities. Power from this station is sent by way of two 500 MCM copper overhead transmission lines (110 kV each, and protected by 240 MVA circuit breakers) to another substation on NASA property, next to Building 1233.

Peak use loads in the VEPCO system in the Hampton area are approximately from 8:00 a.m. to 11:00 a.m. and from 3:00 p.m. to 8:00 p.m., subject to seasonal modifications. Through arrangements with VEPCO, power is available to LaRC on the basis of 50,000 kWh during peak time, and 100,000 kWh during off-peak time.

(iv) Solid Waste Disposal: Various systems are employed on the Peninsula for disposal of solid wastes. Garbage disposers are present in a small percentage of the private residences, but have no appreciable effect on total refuse volume (Miller, pers. comm.).

Landfill is the preferred method, and is the way employed by York County. It operates a fill area near Williamsburg, and a second one near Grafton off U.S. Highway 17 between Yorktown and Hampton.

In Newport News, refuse collections totaling an average of 363 mtons (400 tons) per day are made. The system serves many large industrial users, as well as regular residences, all out of general city revenues with no special charges to users. As much of the refuse as possible is burned in the City incinerator. This facility has a wet-baffle washing system, but no electrostatic precipitator on its stack. Residue from the incinerator is taken to the city landfill in

the Menchville neighborhood, and used as cover for non-burnable wastes such as appliances. It is estimated that with present volume and judicious use, the landfill has a life expectancy of about 20 years (Ellis, pers. comm.).

A feasibility study has already been made for a cooperative agreement with Fort Eustis to have a refuse-fired steam generating plant located there to burn the trash from Newport News and to provide steam for Fort Eustis. The proposal is similar to that already underway between LaRC and the City of Hampton.

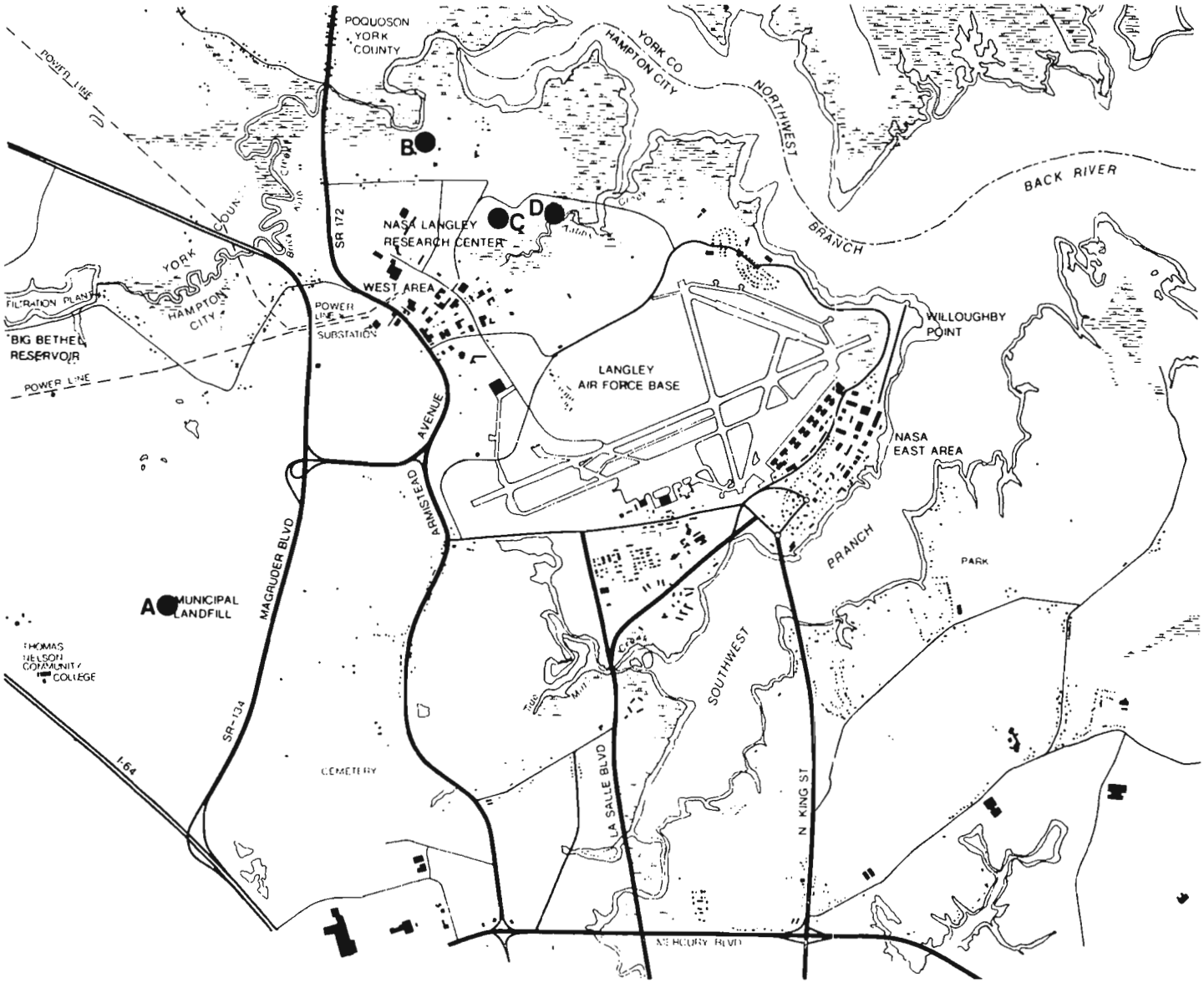
Three landfills currently are utilized for solid waste disposal by the agencies participating in the proposed refuse-fired steam generating facility. The three are shown in Figure 14. The City of Hampton disposes of this solid waste in a city-owned and -operated landfill approximately 0.9 km (1.6 mi) west of the main runway of LAFB, off Magruder Blvd. This landfill receives approximately 181 mtons (200 tons) of trash per day and has an expected life of 10 to 14 years at this rate. It has an estimated remaining capacity of 4.72×10^5 mtons (5.2×10^5 tons) to 6.6×10^5 mtons (7.28×10^5 tons).

In Hampton, garbage is picked up from residential areas twice a week. Cost for this service comes out of the City general fund received through taxation. Service to commercial users is arranged by contract between the City and the user. Heavy duty City refuse trucks make from one to four trips per week to empty dumpster carts left at the users site. The charge for this service varies according to the number of dumpster carts and the number of trips per week. Bulky items like appliances and mattresses are picked up by special truck operating where the need exists, based on calls from residents.

The Air Force is currently operating two landfills on the base, one for trash and the other for construction wastes. The former is approximately 182.8 m (200 yd) southwest of the Air Force Ordnance Depot. This trash landfill receives refuse from NASA, the Air Force, Bethel Housing Development, Fort Monroe, and the Veterans Administration Hospital. The refuse from the latter is supposedly free of pathological materials. These sources generate approximately 22.7 mtons (25 tons) of trash per day. The landfill has an expected life of 2 to 3 years and an estimated capacity of 1.18×10^4 mtons (13×10^3 tons) to 1.77×10^4 mtons (1.95×10^4 tons), operating at the existing delivery rate.

The construction landfill receives construction waste and large-sized solid waste like appliances at variable rates during an annual period. These wastes are placed in an open dump, and not covered with soil as with a regular landfill operation.

c. The Regional Economy. Historically the economy of the Virginia Peninsula has been dominated by government activities, predominantly military. The other major source of economic activity and growth has been the commerce centered around the area's greatest natural



A City of Hamptor

B Construction Landfill

C Present Langley Landfill

D Old Langley Landfill

Figure 14

Location of Landfill Sites

resource: the surrounding waters of Chesapeake Bay and Hampton Roads. These remain the major sources of basic employment serving external markets on the Peninsula.

In 1971, the nearly 37,000 employees of the federal government accounted for approximately 50 percent of the area's basic employment and 26 percent of the total employment (29.4 percent of the dollar payroll). In 1973, nine military installations, the NASA Langley Research Center, the Hampton Veterans Administration Center, and the Colonial National Historic Park employed 22,714 military and 14,623 civilian personnel. As indicated in Table 9, government payroll dollars totalled over $400 million; purchases and new construction expenditures were $418 million and $28 million, respectively.

Port and port-related activity is the other dominant economic activity on the Virginia Peninsula. Increased demand for ocean shipping, particularly importation of petroleum and exportation of coal have resulted in a boom for both the Port of Hampton Roads and the shipbuilding and repair industry. Shipbuilding activity is dominated by one company, the Newport News Shipbuilding and Drydock Company (the "shipyard"), a subsidiary of Tenneco. In 1973, the shipyard had 26,500 employees, a total annual payroll of nearly $700 million, and was the largest single employer in Virginia. Shipbuilding for the private sector has increased in recent years, although military contracts accounted for 46 percent of the dollar volume total in 1973. Other port activities are related to the area's waterborne commerce; major employers include the Chesapeake terminals and storage warehouses, and oil storage and handling companies. Manufacturing industries other than shipbuilding include food and kindred products, printing and paper, chemicals, and electrical machinery.

The travel trade industry employed over 4,000 persons in 1971; during peak travel periods (July and August), employment in this sector swells by an additional 400-500 persons, predominantly in the Williamsburg area.

Supporting non-basic employment--consisting of locally oriented activities such as utilities, transportation, real estate, and wholesale and retail trade--totalled more than 67,000, in March 1971 (47 percent of all employment).

The two dominant economic forces--the Federal Government and the shipbuilding industry--have provided a stable economic base for the Virginia Peninsula. On the other hand, the dominance of these two activities means that major shifts in them will have a direct and immediate effect on the area's economy. Location of major employers in the lower Peninsula are shown in Figure 15.

d. Population And Employment. The Newport News-Hampton SMSA is one of the fastest growing areas in Virginia; its population has doubled since 1940 and maintained a 30 percent growth between 1960 and 1970 to 290,000 people. As seen in Table 10, each governmental unit in the SMSA shared substantially in the 1960-1970 growth. The present population has an above-average family income of $9,554 and also has

Table 9. Selected Indicators of Government Economic Activity Virginia Peninsula, Fiscal Year 1972.

Installations	Number of Employees Military	Number of Employees Civilian	Total Payroll	Total Purchases	New Construction
Fort Monroe	1,965	1,521	$ 37,319,550	$ 10,000,000	$ 0
Langley Air Force Base	8,744	2,116	104,627,408	42,968,424	7,772,296
NASA Langley Research Center	0	3,305	61,562,704	320,371,000	6,912,000
Fort Eustis	7,110	3,278	121,118,016	29,838,925	1,012,700
Military Reserve Units	1,225	18	1,295,000	0	0
Camp Peary	41	243	3,065,000	398,000	0
Cheatham Naval Supply Annex	366	334	5,400,000	3,300,000	0
Coast Guard Reserve Training Center	699	104	4,893,500	217,500	3,600,000
Naval Weapons Station	695	2,114	35,877,000	7,349,000	3,046,813
Hampton Veterans Administration Center	0	1,056	11,849,509	3,409,555	3,558,050
USN Shipbuilding, Repair, and Conversion	1,869	402	21,980,584	500,000	0
Colonial National Historic Park	0	132*	810,942	220,000	61,000
TOTAL	22,714	14,623	$409,799,213	$418,572,404	$25,962,859
		37,337			

*80 of these are seasonal

Source: Peninsula Chamber of Commerce. 1974-1975 Statistical Data for Hampton, Newport News, Poquoson, and York County, Virginia. Hampton, Virginia: Peninsula Chamber of Commerce, 1974.

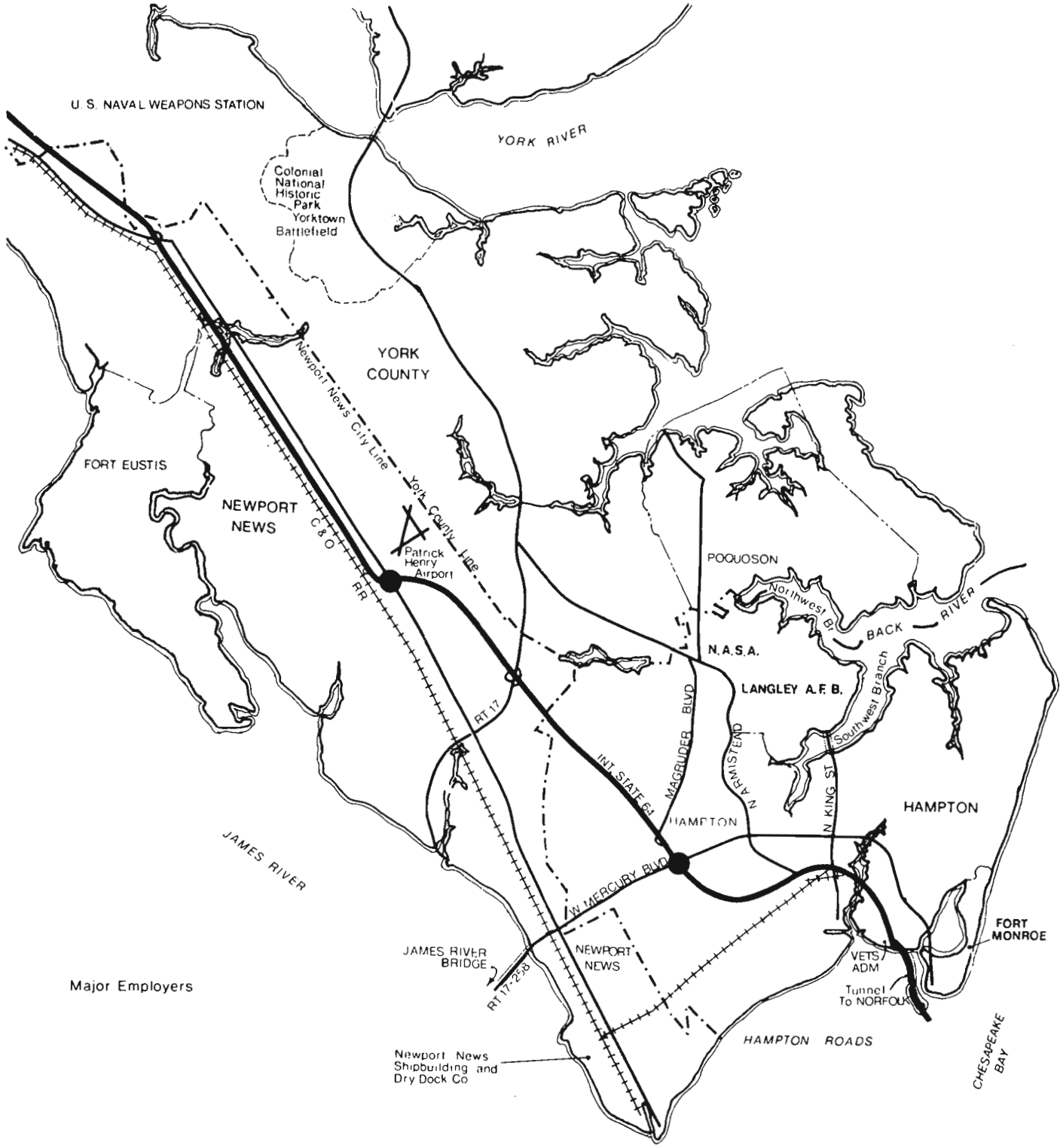


Figure 15

Location of Major Employers

Table 10. Selected Socio-Economic Characteristics Newport News-Hamptons SMSA.

Category	Hampton City	Newport News City	York County	SMSA (Total)
Population				
1970	120,779	138,177	33,203	292,159
1960	89,258	113,662	21,583	224,503
Occupation (1970)				
Professional	7,500	8,702	2,183	18,385
Managerial	2,879	3,425	787	7,091
Clerical	8,132	7,851	1,578	17,561
Craftsmen & Foremen	7,633	8,228	1,979	17,840
Sales	2,759	3,235	545	6,534
Operatives	4,440	5,591	1,165	11,196
Service Workers	4,703	5,386	1,374	11,463
Laborers, Household Workers	2,191	2,835	666	5,692
Total Employed	40,232	45,253	10,277	95,762
Median Family Income	$ 9,685	$ 9,325	$ 9,902	$ 9,554

Source: U.S. Census, 1970

an above-average education, with a median of 12.1 years of school completed for persons 25 years of age and over.

The occupational characteristics of the resident population, also shown in Table 10, are similar to most urban areas, with nearly one-half of the employment found in white collar positions. There is, however, a relatively larger proportion of employment of craftsmen, foremen, and operatives; conversely, there is a relatively smaller amount of employment in the sales occupations.

e. Housing. Residential land space in Hampton is overwhelmingly devoted to single-family and duplex housing units, as can be seen in Table 11 (Land Use in Hampton, 1970). On the lower Peninsula, residential expansion has shown a trend to increased multifamily housing, especially when developed for the more transient employees of the military and federal installations in the area.

Langley Air Force Base provides a total of 3,549 housing units for its personnel and visitors. Approximately 800 of these units are off base about 1.8 km (1.1 mi) west of the NASA property line, at Bethel Manor. Another 7,800 Langley military and civilian personnel and 3,300 more civilians at LaRC find housing in the various neighborhoods within commuting distance of the base. Military housing facilities are not available to NASA personnel.

The Tidewater area has numerous apartment developments with vacancies and mobile home parks with frequent vacancies which can accomodate construction workers for the duration of the project. Two mobile home parks exist within one mile of the site. One of these is directly across the road from LaRC West Gate and has 125 living units with planned expansion potential for almost 275 more units.

f. Government and Public Services.

(i) Government: The present City of Hampton began as an English settlement in 1610 on the Indian village site of Kecoughtan, which became its first name. The community was called Elizabeth City County in 1620, and acquired its present name in 1680. The present city, as consolidated in 1952, includes the former Elizabeth City County and the Town of Phoebus.

The City of Hampton is governed by a City Council which is composed of seven members. They are elected to serve for four years in staggered terms. Every two years the Council elects one of its members to serve as Mayor. The Council appoints a City Manager, a seven-member City Planning Commission, and other persons as required by law. The Council also appoints a Zoning Administrator, who enforces the zoning ordinances and approves building permits within the city.

The same basic governmental structure exists for the City of Newport News. They have a seven-member Council serving four year terms, a Mayor elected from the Council for two years, and an appointed City Manager. The Council serves as the planning body, with zoning administration assigned to the Development Department.

(ii) Police and Fire Protection: Police and fire protection on Air Force and NASA property and in the local communities are considered adequate.

Langley Air Force Base has a Security Police Squadron for security and law enforcement on the base. Fire-fighting activities on the Air Base are coordinated by the Commander's Fire Protection Council, according to need by crash, rescue, or structural category.

Langley Research Center is partly on Air Force property, but the employees are civilians. Routine traffic management, control, and accident investigation are provided by the Air Force Security Police. A civilian, independent Security Police is under contract with NASA to provide building security, gate, patrol, and night watchman services. In case of offenses committed at the Center, the Federal Bureau of Investigation is called, since a federal reservation is involved. Fire protection is provided by the City of Hampton, under contract with NASA. The city maintains personnel, runs the station and an ambulance service, and keeps two fire trucks at LaRC at all times. A third fire truck is usually there too, but it is available to answer alarms elsewhere in Hampton should the need arise.

Police and fire stations operate in the cities of Hampton, Newport News, and in York County at Poquoson, Seaford, and Yorktown.

The United States Coast Guard maintains on emergency Search and Rescue station in Portsmouth, across the harbor. The Coast Guard also has a Reserve Training Center and an emergency fire department in Yorktown, north of Langley in York County.

(iii) Education: Educational facilities in the Tidewater area are abundant such that no overcrowded conditions exist. Newport News and Hampton schools total more than 50 at the elementary level and more than 20 at the junior high and high school level and are more than adequate to serve some 60,000 students.

Christopher Newport College, a new branch of the College of William and Mary in Williamsburg, is located in Newport News. In the City of Hampton, Hampton Insitute (founded in 1868), is located in the old town area. Thomas Nelson Community College, a new junior college (1967) with approximately 2,580 students in 1974, is located west of the main runway of Langley Air Force Base. This location places the college within a medium noise contour, with a Noise Exposure Forecast (NEF) of 35-40 resulting from landing, takeoff, and runup testing operations on the base. The college is also about 0.6 km (1 mi) from the Hampton sanitary landfill site.

There are 37 elementary and high schools in Hampton. An elementary school (Machen) is located in the new Tide Mill Farms residential area just south of Langley AFB, with an NEF of 35-40. Bethel High School, with an enrollment of about 1,590 students in 1974, is located west of Langley approximately 5.9 km (3.5 mi), in the noise contour of NEF 30-35 (Little, 1974).

Across the border in York County, there is an elementary school in a new Air Force dependent residential area called Bethel Manor. The school is approximately 2.7 km (1.6 mi) west of Langley. Also in York County, across the Northwest Branch of Back River, there are two public schools in Poquoson, north of the base about 3.4 km (2 mi).

Because of the large number of military dependents in the three public school systems of the lower peninsula (Hampton, Newport News, and York County), Federal Impact Funding is utilized by the systems to assist in the accomodation of these students. A total of over $4.37 million was received by the three systems in 1973-1974 (Little, 1974).

A wide variety of trade schools, beauty colleges, nurse's training institutions and other educational and training opportunities exist on the peninsula and across Hampton Roads in the other part of the Virginia Tidewater country.

(iv) Recreation and Open Space: The Virginia Peninsula contains over 30 principal parks covering almost 6,885 hectares (17,000 acres). One of the largest of these is Colonial Historic National Park, run by the U.S. National Park Service. A section of the park on the southern shore of the Peninsula includes the original site of Jamestown. The main park headquarters is located in the larger section, in the Yorktown area on the northern shore of the Peninsula. Here is located the battlefield where the British Army surrendered to General Washington. The two sections of the park are connected by the scenic Colonial Parkway, which passes through Williamsburg along the way.

The extensive shoreline and open natural areas in the region present many opportunities and locations for hunting, recreational boating, and sport fishing. Swimming is made popular by the famous sandy beaches on the shore. There are eight main golf courses, four of which are located on military property, including one at Langley AFB. A portion of the land immediately surrounding Langley AFB and the LaRC is estuarine marsh, and is likely to remain as open space.

(v) Health Care: Military personnel and their dependents receive free medical services at one or more of the many base clinics

and hospitals in the region. Veterans have access to the Hampton Veterans Administration Center, which includes a hospital and a domiciliary, and is located near Fort Monroe in Hampton.

Civilian employees of the military and the rest of the residential population on the lower Peninsula do not have access to these military services. The exception is in the case of job-related injuries for civilian employees of the military. In the case of NASA personnel being badly injured on the job, emergency care is available at the hospital on Langley Air Force Base. Later a transfer to a civilian hospital is arranged. There is a wide variety of public hospitals and clinics in the region, including Hampton General Hospital (Dixie Hospital) with 400 beds, in Hampton.

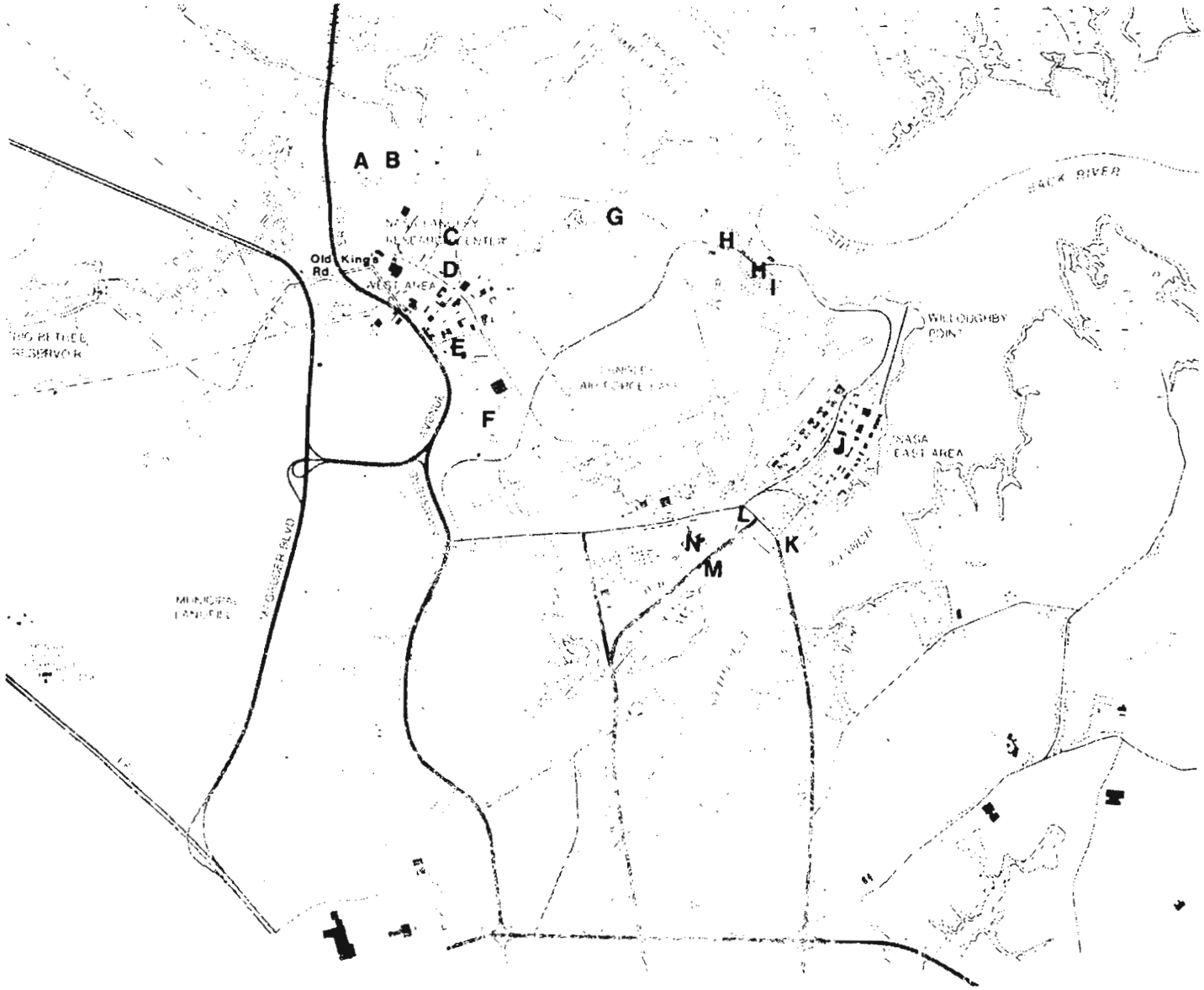
g. Historical and Archaeological Values. On the Virginia Peninsula, there exist many locations of national historic interest. Of special note are Colonial Williamsburg, the settlement of Jamestown (1607), and the Yorktown Battlefield. The latter two are now part of the Colonial National Historical Park, with headquarters in Yorktown.

Hampton and Newport News both have maritime museums containing items from the days when activity in the two communities centered even more on the water, port, and shipping enterprises. Fort Monroe, at the southern tip of the Peninsula in Hampton, has a historical fortress which pre-dates the Civil War and is listed in the National Register of Historic Places. Hampton Institute, whose most famous graduate was Booker T. Washington, is also listed in the National Register. Other entries from Hampton in the National Register are the Chesterville Plantation (see below), Fort Wool, the Herbert House, Old Point Comfort Lighthouse, and St. John's Church.

On the building location for the proposed facility, there are no sites of special historic interest which are registered with the state or federal authorities.

Within a 1.7 km (one-mile) radius of the project on Langley property, the following historical features are to be noted. They are also shown in Figure 16.

1) Chesterville Plantation: Listed as a Virginia Historical Landmark in 1972, and in the National Register of Historic Places in 1973. It contains the homesite and probable birthplace of George Wythe, member of the Constitutional Convention and one of the signers of the Declaration of Independence. He was also a lawyer, member of the House of



A Winder Cemetery

B Chesterville Plantation House Site

C Site of Syms School

D Site of Collier House

E Site of Moore House

F Site of Elmwood

G Tabbs House Site

H Sites of Pool and Lamington Plantation Houses Under Housing Development

I Hollier Cemetery

J Building 'One' TAC Headquarters

K Site of Sherwood Plantation House

L Site of Shellbank Plantation House

M Farm House

N Barn Constructed by Hampton Intitute

Figure 16

Historical and Archaeological Features of LaRC/LAFB

Burgesses of the State of Virginia, and gentleman farmer. The plantation was in the Wythe family since at least 1676, when it was owned by George's great-grandfather, who was also active in politics and public service. Tobacco was an early crop, to be followed in later years by various grains and a variety of livestock and orchard trees (LaRC-HAS, 1974). Major features of this historic site are the remains of a stone house foundation (c. 1648), probable birthplace of George Wythe; a brick house foundation (c. 1771), the Wythe homesite; a family cemetary; a granary and wharf, in use in 1795; and a brick kiln, which probably provided the bricks for the main house. The Langley Research Center Historical and Archaeological Society is actively excavating at the stone and brick house foundations, under the supervision of an archaeologist from the Virginia Landmark Commission (Farmer, pers. comm.).

2) Syms School Site (c. 1730) Originally founded c. 1647 as the local "free school" it was the beginning of Syms-Eaton Academy, the oldest free public school in America, and now named Hampton Academy.

3) Collier House site, Cloverdale Plantation (an addition built c. 1830).

4) Elmwood site.

5) Moore House site, Moorefield Plantation, (c. 1750).

6) Old King's Road: The former name and now a former segment of the currently named Armistead Avenue. Originally built about 1730, this short segment was in use concurrently with the present Armistead curved section, as determined from aerial photographs taken in 1932 (Farmer, pers. comm.). It was fenced off by NASA in the 1950's, and remains as an earthen berm in a wooded area, and as a NASA access road.

The Langley Research Center Historical and Archaeological Society plans to provide a self-guided tour for the public, beginning May 15, 1976, entitled "A Drive Through Past and Future." The tour will feature the two house foundation sites on the Chesterville Plantation, the Syms school, Collier and Moore sites, as well as many contemporary NASA sites (Farmer, pers. comm.).

h. Aesthetic Characteristics. There is no single description appropriate to define the visual character of the LaRC; the views and the impressions change as one moves along the perimeter of the West Area.

The West Gate area is one of visual contrasts. The roadway approach to the gatehouse and beyond into the research area is very formal in

design. The monumental boulevard is landscaped, well-manicured, and pleasant. Its axial design combined with the fact that the roadway eventually branches around an open space with no buildings to immediately terminate the view presents a very inviting and appropriate entrance to LaRC.

In contrast, the trailer court immediately across Armistead Avenue from the gate has no similar aspects of visual formality or monumentality of design. On the contrary, it has a very ad hoc aura about it. The trailers are placed in a very tenuous-looking way and without the benefit of plantings or landscaping of any sort. The LaRC entrance seems all the more pleasing for the contrast.

Moving North on Armistead Avenue, one finds the view dominated by the wind tunnels on the right. The present Supersonic Pressure Tunnel is set back from the road and is shielded from view by the trees and bushes that extend down the road from the gate area. This building is quite unobtrusive, especially in comparison to the 16-foot Transonic Tunnel and the V/STOL Tunnel that are just beyond it.

These structures dominate the view for a number of reasons. They are close to the road, they are very large, and there are no trees or other plantings to shield and soften the view. Furthermore, the land across the street from the 16-Foot Tunnel is vacant and does not attract the eye at all. The tunnel seems all the larger for having to stand so exposed.

A similar problem exists with the V/STOL Tunnel. It too is exposed, but more than that, Armistead Avenue turns westward slightly, and since the tunnel is at the curve, it acts as a closure element apparently terminating the view down the road. It fills the view and, though not particularly unpleasant, is an overpowering sight.

Directly across the street from the V/STOL Tunnel, there is a small research/office complex and an electrical substation. These are visually neutral for the most part--not out of keeping with the rest of the area but not memorable either. Furthermore, the complex is bounded by trees on both ends so that it is not really visible from the road from any distance, but only when one passes directly by.

Farther north along Armistead Avenue to, and along, Wythe Creek Road, the land is undeveloped. The road is bounded by heavy woods on one or both sides for the whole length. Areas that are not wooded are largely open and undeveloped. The land in this vicinity is very flat and featureless in general, and this heavily treed area is a pleasant contrast.

The flat, rather featureless landscape precludes really spectacular siting of buildings, but on the other hand visual disapppointments are not as widely noticeable either. The LaRC is generally a pleasant

visual environment. The grounds are well kept and quite well planted. The buildings are not offensive, though some definitely have an industrial cast to them. Some of the buildings are interesting to look at. The site has the roads laid out in a concentric circle plan bisected by radials. Except along the radial drives, views are short and usually softened by trees and other plantings. The LaRC has the feel of a campus about it, and is generally a pleasant aesthetic environment.

The proposed National Transonic Facility will replace the Supersonic Pressure Tunnel already in existence. The current facility is set back from the Armistead Avenue and its shielded from view from the street by trees and by a cooling tower and dynamometer building. This tunnel is one of the smaller ones at LaRC and is not readily visible outside the building either from Armistead Avenue or from within the research center. The building itself is basically a two-story red brick building like many others on the site. It is rather undistinguished and, by comparison to many of the more imposing structures (like the one immediately across from it), it is definitely a visual "background" building.

II. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE POLICIES, PLANS, AND CONTROLS

A. LANGLEY RESEARCH CENTER

Present land use in the West Area of LaRC reflects the research activities and can be seen in Figure 17. The major concentration of buildings is located near the West Gate. Activities in these buildings include general research and support and contain users of high-pressure air and high electric power. To the south towards cleared land for the main Air Force runways are NASA flight operations testing facilities. North of the older main building area, newer research buildings for electronic instrumentation support and solar energy systems have been built. NASA engineering offices and a Visitor Center are also located here. Beyond to the north, in an undeveloped wooded section is the full-scale simulator area where practice lunar landings were made. Further north is the Chesterville Plantation Historic Site, containing ruins of two homes from the 17th and 18th centuries. They are currently in a grassy area that becomes marshy at Wythe Creek, the north border of NASA property. West of the plantation site is the hypersonic physics test area, bordering on Air Force property; more marshes; and the Northwest Branch of Back River. Across the boundary, the Air Force maintains the present Langley sanitary landfill and a construction materials dump in a large, open, undeveloped area.

Proposed land use for the West Area is shown in Figure 18. A secondary entrance is to be added, to ease traffic congestion at the West Gate. The wooded area to the northwest of the Center are planned for future expansion of general research facilities and for those which would require large amounts of electrical power. Facilities for full scale simulation could expand into the area of the Chesterfield Plantation site.

The proposed site of the NTF occupies less than one percent of LaRC. Use of the land for construction of the NTF is within the scope of present land use policies, plans, and controls of LaRC. The land use plans will not be altered from its present use of accomodating aeronautical research facilities. The existing facility, the 4' x 4' Supersonic Pressure Tunnel (SPT), will be removed and its associated building modified for accomodation of the NTF. Other new structures on the site will be a liquid nitrogen storage tank and a gaseous nitrogen vent building. The abandoned Propeller Static Test Stand Enclosure will be removed. Other existing structures will remain unchanged.

B. REGIONAL LAND USE AND PLANS

Located between the York and James Rivers at their confluence with Chesapeake Bay and Hampton Roads Harbor, the Virginia Peninsula includes the cities of Hampton, Newport News, and Williamsburg, and counties of York and James City. The federal government owns about 20 percent of this land area.

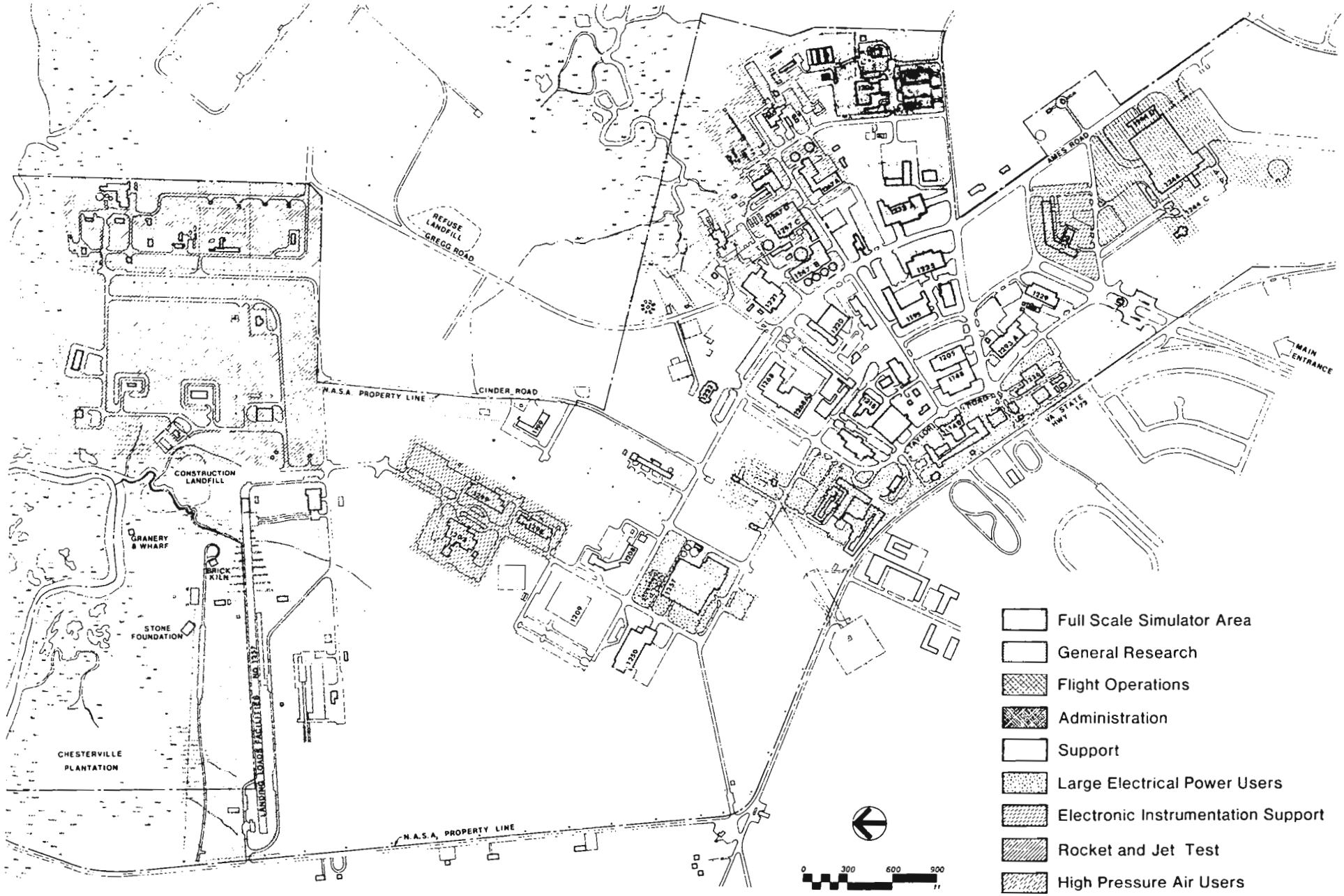


Figure 17
Existing Land Use at LaRC West Area

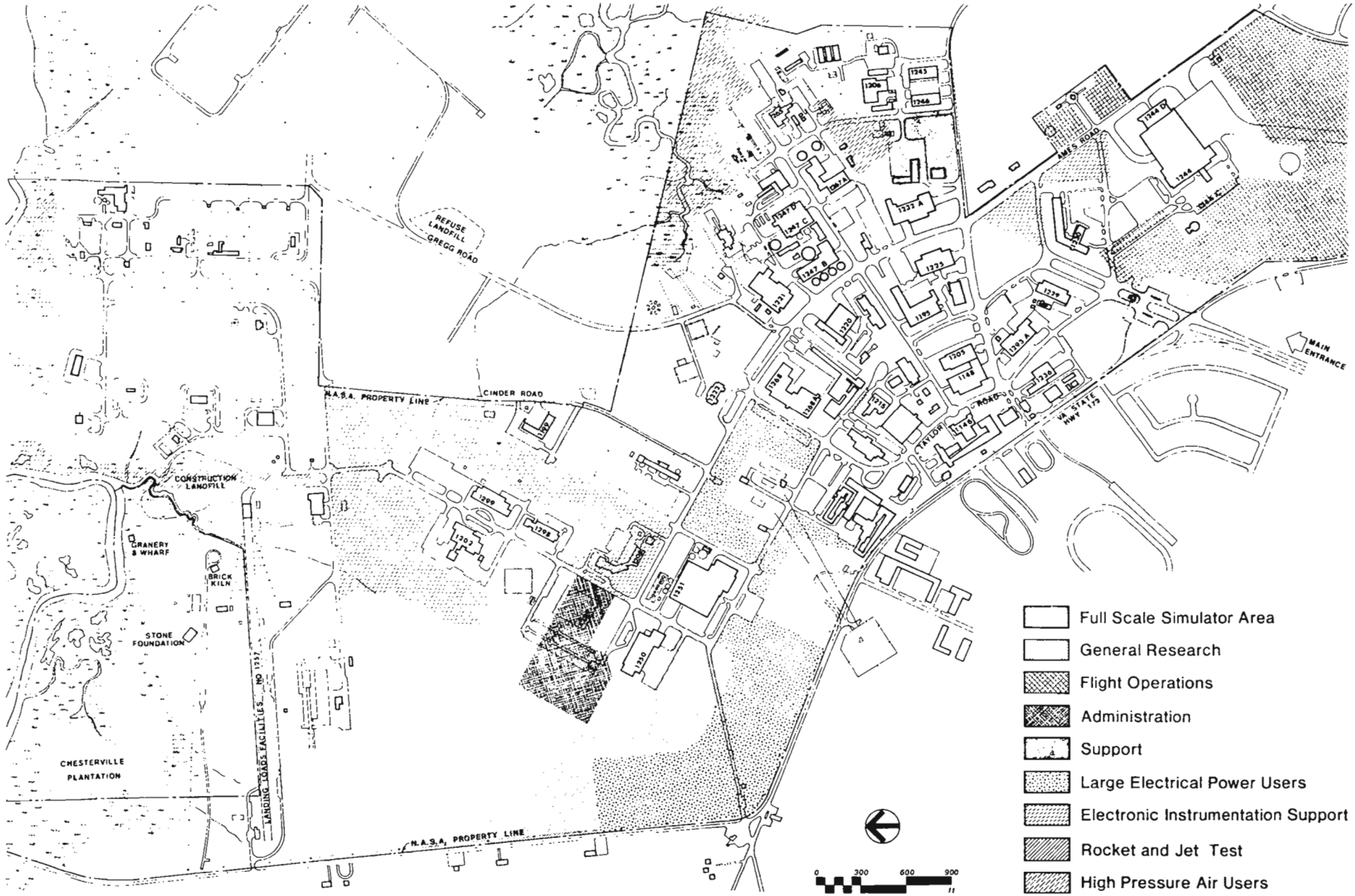


Figure 18
Proposed Land Use for LaRC West Area

A Peninsula Planning District has been established, and includes representatives of all governmental jurisdictions on the peninsula. The Peninsula Planning District Commission has prepared various studies and publications showing projected growth and future needs.

The Hampton-Newport News Standard Metropolitan Statistical Area (SMSA) covers approximately the lower half of the Virginia Peninsula. Most of this area is shown in Figure 5. It includes the independent cities of Hampton and Newport News, and York County to the north and east of the cities. Within this area are Langley Air Force Base, the NASA Research Center, Fort Eustis, where the U.S. Army Transportation Center Headquarters is located, and Fort Monroe, now the U.S. Army Training and Doctrine Command.

In 1970, developed land comprised 60 percent of the SMSA, of which over half (37 percent) is in public or semi-public use, mainly the military and governmental establishments. The remaining 40 percent of the land is listed as agricultural, vacant, or wetlands and water (PPDC, 1974).

The Peninsula Chamber of Commerce is organized to coordinate commercial and promotional information for the two cities and York County of the lower peninsula.

The largest employer in the State of Virginia, Newport News Shipbuilding and Dry Dock Company, was established in 1886. In 1974 it employed over 26,000 persons. Much of its business is under government contract, especially for the U.S. Navy.

The expansion of existing industrial and military enterprises is expected to cause a continuation of the movement of the population from the urbanized southern tip of the Peninsula towards the more rural northern regions, where considerable open space remains. This projected expansion is also expected to cause a need for growth in other economic and social services for the total area.

The City of Hampton can be called the "oldest continuous, English speaking town in America," having been established in 1610. In 1972, it was named an "All America City" by the National Municipal League. The city serves as a residential and service center for the governmental institutions and the shipyards located near or within its boundaries. It also serves a large tourist industry, catering in particular to those seeking a link with the early history of the country, and to those having fishing or crusing interests in the nearby waters.

The Hampton City Planning Commission has developed a Comprehensive Plan for Land Use, published in 1971. Included are plans for the development of libraries, thoroughfares, and fire stations in the city, as parts of the Comprehensive Plan.

Land use in Hampton, as of 1970, is shown in Table 11. As can be noted, agricultural and vacant land use is greatest in total area, while residential use predominates the developed sector. Government-owned lands occupy an unusually high percentage of space for a city of this size.

Zoning districts are recommended by the Planning Commission, and enforced by the Zoning Adminstration after being approved by City Council. Deveopment has been restricted within the aircraft approach districts of Langley Air Force Base, allowing only those buildings with a low structural profile and with an assembled occupancy of less than 50 persons. Zoning districts for the section of Hampton including LaRC are shown in Figure 19. Against the recommendation of the City Planning Commission, and in some cases against the recommendation of LaRC, multifamily areas are being zoned close to the Air Base and the Research Center. Zoning to allow two new mobile home parks near LaRC West Gate and residential development (Tide Mill Farms) near the major runway has been approved. Construction and occupancy is well under way in most of these new zones. The area just west and south of LaRC is zoned for private limited manufacturing, and is expected to attract new businesses to the immediate vicinity.

Table 11. Land Use in Hampton, 1970.

	Hectares	Acres
One- and Two-Family Residential	2,895	7,147
Multifamily & Mobile Home Parks	168	416
Public, semi-public (Ft. Monroe, NASA, Langley AFB, etc.)	2,542	6,276
Agricultural, Vacant	5,613	13,860
All Other (roads, commercial & business, parks, etc.)	2,033	5,020
Totals	13,251	32,719

Source: Hampton Planning Commission. Comprehensive Plan, Land Use; Hampton Virginia, 1970.

As with the Peninsula generally, Hampton expects to experience some growth as it absorbs some of the housing and service needs of the major governmental and ship-building institutions. Much of the present open land is not easily developed, however, because it is marshy, or has drainage problems.

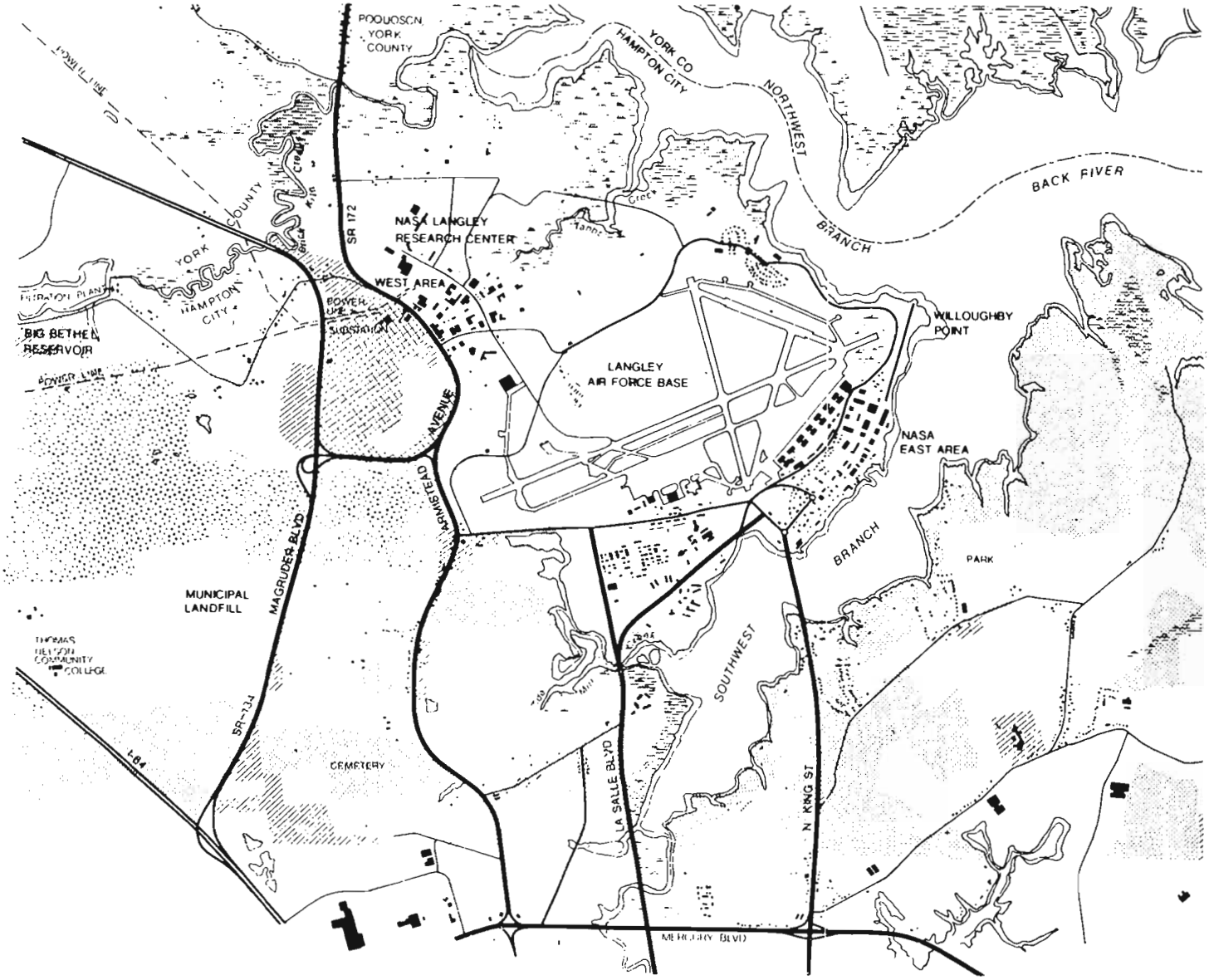


Figure 19

Zoning in the Vicinity of LaRC

In the immediate vicinity of LaRC along the western boundary where the proposed facility will be located, the following zones and features are noted from north to south and shown in Figure 20.

- Wythe Creek Road (Virginia State Route 172): It is zoned multiple family (R-M). It comprises a vacant marsh at the north end, with a few small, older, single-story houses scattered along the remainder of the strip to the intersection with Armistead Ave. A trailer park exists in this zone. In 1971, approximately 50 trailers were located there. The area represents a potential for further population expansion should it become developed as zoned. The road also serves as the main traffic route north to the developing community of Poquoson, which had a population of 5,441 in 1970.

- North Armistead Avenue (State Route 172): Zoned Commericial (C-1) and Limited Manufacturing (M-1), it currently contains a small bar, a gas station, an electric power sub-station, two light industrial plants, and a wooded area. South of the woods there are a motorcycle sales shop and dirt practice track, a tavern, a go-cart track with out-buildings, and the Langley Speedway. This one-mile drag race track also has bleachers for audiences; races are held every non-rainy Saturday night in season from April through October. While a peak night with low-cost admission drew as many as 6,000 persons, normal attendance is much less when admission ranges from $3.50 to $7.00.

The City of Hampton Master Plan includes an extension of Floyd Thompson Drive east to Armistead Ave. from its present location part way towards Armistead from Magruder Blvd. This would cut off a segment of the speedway track, necessitating its closing, relocating, or moving. Proposed activities for this zone include the development of an industrial park.

- Mobile Home Park (Langley Field Mobile Home Village): The park opened in 1973, long after the Air Force and LaRC were conducting their operations across the road. It currently contains about 125 occupied trailers, most of which are used by personnel from the Air Base and Navy, or by workers at the Newport News shipyards. Younger families predominate, but a few retired persons and single persons are also present. A school bus comes into the park to transport younger children to Hampton city schools. Older youngsters catch city buses on Armistead Ave. to school. There is a dirt play yard with equipment in the park area. Organized activity among the residents is virtually non-existent, partly because there is no appropriate meeting place. Residents did circulate a petition once to protest parking by speedway audiences in the park area, and steps were taken to alleviate this problem.

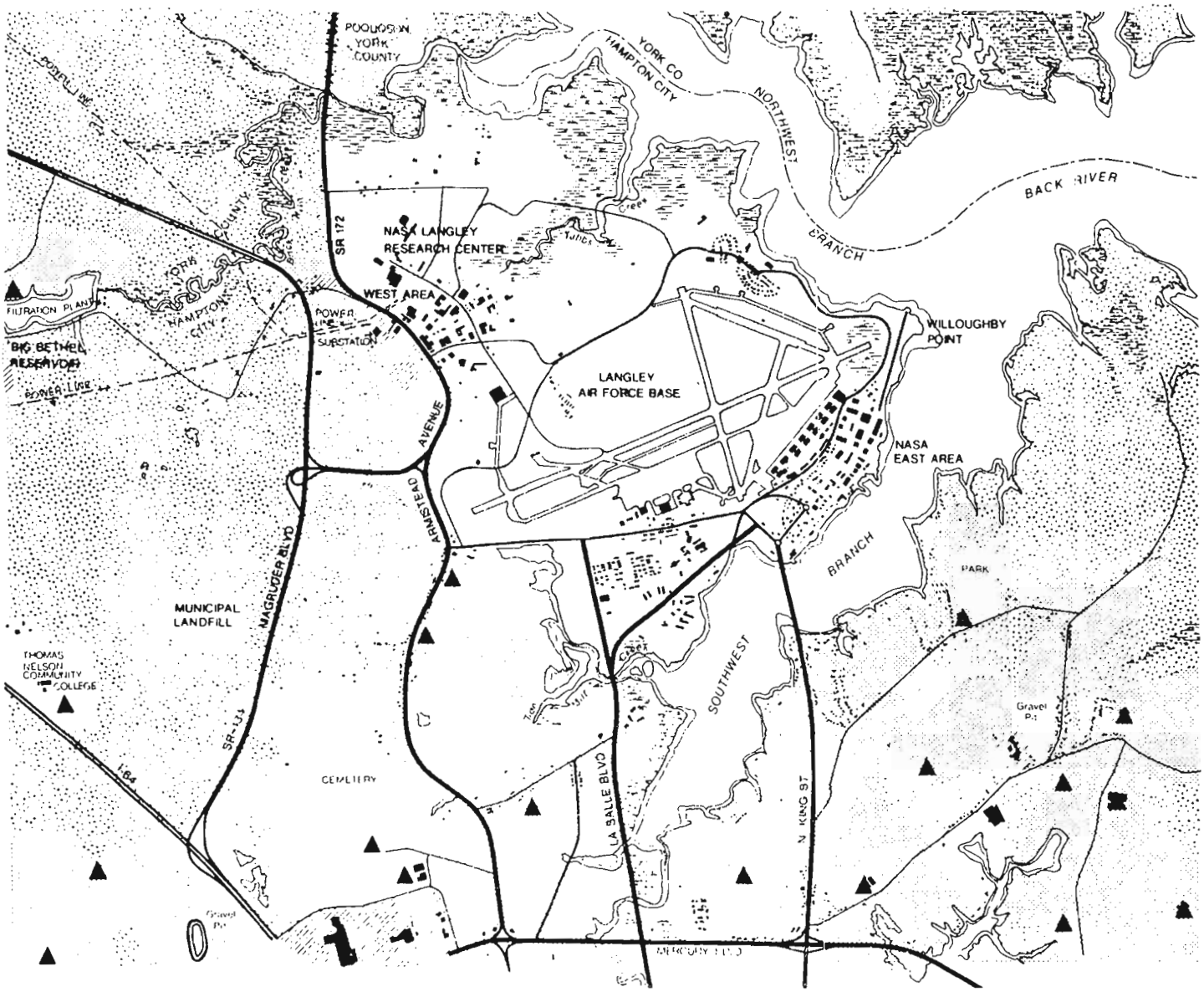


Figure 20

Existing Land Use in the Vicinity of LaRC

Expansion plans are underway, with a requirement by the City of Hampton to complete another portion of the road system by 1976. By spring of 1977 about 100 additional trailers are expected to be moved in and occupied. Final stages of the expansion plan include a total occupancy of 399 mobile homes. This would include utilization of a portion of the land now containing the speedway track. Except for grass, there are virtually no green plantings or trees in the present or proposed trailer site area. However, a small recreational park with trees and shrubs is on the plans. No use of natural vegetation or fencing as a sound or visual barrier from Air Force or LaRC operations is planned at the present time (Langley Mobile Home Village staff, pers. comm.)

The proposed action will not affect regional land use policies, plans and controls. The NTF will be located on government property such that construction will not affect land use external to government property. Operation of the new facility will result in noise production, but within existing levels in the areas adjacent to the site such that no change in land use policies, plans and controls are anticipated.

III. PROBABLE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

A. DIRECT ENVIRONMENTAL EFFECTS

1. Of Construction of the Proposed Facility.

a. On Operations. Some minor dislocations of on-going operations at LaRC are expected during construction of the NTF. All or most of the office and laboratory operations will have to be moved from Building 1236 during demolition of the existing 4 ft supersonic pressure tunnel and construction of the new facility. These activities will be moved into other existing space at LaRC not yet designated.

There also will be interruption of utilities in the West Area while electrical, water, sewer, air, steam, and other connections are made. These activities will be coordinated with on-going research and other functions at LaRC to result in minimum disruption.

The foundation for the NTF will require driving of piles. Sensitive research instrumentation in the vicinity may be adversely affected by pile driver vibrations conducted through the ground. Pile driving will also be coordinated with on-going activities to avoid or minimize such problems.

b. On Water Quality.

(i) Earth Moving: The amount of excavation and other earth moving required by this project is minimal. Soils in the area are not highly erosable because the terrain is flat. In addition, the site is not near any surface waterways; consequently, no significant soil erosion and sedimentation impacts are anticipated. Nevertheless, proper construction practices will be followed to minimize erosion.

(ii) Pressure Test: It is presently proposed to test the pressure shell of the NTF by either hydrostatically or pneumostatically to a pressure of at least 25 percent greater than working pressure. For a hydrostatic test, this would require at least 8410 m^3 (2.22 X 10^6 gal) of water. If one or more leaks are discovered, the tunnel will have to be partially or completely drained, repaired, and refilled to test again. This water will be drained via the storm sewer system into Back River in all probability, although consideration is being given to means of re-using the water, which will no doubt pick up some polluting materials from the interior of the tunnel. The environmental impacts of this activity are considered insignificant.

Pneumostatic testing of the pressure shell would eliminate the possible impacts of using and releasing large volumes of water, but would substitute those of noisy (but brief) air release at blowdown and an increased hazard potential should the pressure shell fail.

(iii) Tunnel Degreasing: One of the final construction-related activities would be the cleaning of the interior of the tunnel. Of greatest potential for water pollution would be degreasing the interior surfaces with organic solvents such as trichloroethylene. Such cleaning solvents will not be released into sanitary or storm sewers. Rather, contaminated solvents will be collected into tank trucks and conveyed to a commercially operated disposal service for reclamation or disposal in an environmentally acceptable manner.

c. On Vegetation and Wildlife. Owing to the lack of natural vegetation and wildlife at the proposed site, no impacts are expected for either.

d. On Noise. The construction of the proposed facility will produce noises in two major ways--traffic noise from construction-related vehicles and noise from equipment and machinery used in demolition or construction.

(i) Construction Traffic Noise: This will come from the workers' personal cars or trucks at the beginning and end of each day, as well as from trucks delivering equipment and materials to the site. The construction workers will be coming to and from work on essentially the same schedule as the LaRC and LAFB employees. Approximately 200-250 construction workers would be the maximum employed at any given time, so their vehicles would be added to the rush-hour volumes. Even if each individual drives a car, these vehicles will produce no noise impact since they will amount to only about 10 percent of the peak-hour traffic volume and will not change the noise level. Also, since employment at LaRC has been dropping, these construction vehicles will really not represent an increase in total traffic but rather will maintain the status quo or merely slow the rate of decline. When all the proposed facilities for this area of LaRC are simultaneously under construction (probably 1977 and 1978), the number of construction workers may be as many as 300, but even this number is too small to produce significant noise impacts at rush hour.

The trucks delivering materials and equipment and taking away waste will typically operate in the daytime, off-peak hours. Traffic volumes on the surrounding streets vary from 200 to 600 vehicles per hour during the day. An additional 50 vehicles per hour would be required to produce a significant change in the noise level at these times. The construction vehicles will not be that numerous, so no impact is projected from this traffic.

(ii) Construction Machinery Noise: Noise produced by construction/demolition equipment generally varies with the type of job and the construction phase involved. Typically the early phases--demolition or ground clearing, excavation, and foundations--are the noisiest. It is entirely feasible today to specify the use of quiet construction equipment whose noise level at 15 m (50 ft) from the item is 75-80 dBA. (This is the typical specification for all GSA construction jobs.) When combined with scheduling procedures that maintain the minimum amount of

equipment on site and prevent groupings of equipment that reinforce the noise levels, a relatively quiet construction period will result. For isolated high-noise sources such as pile driving (95 dBA), enclosures and/or noise shields may be erected as needed. Since the proposed construction site is over 46 m (150 ft) from the property line and is partially shielded by buildings, the noise levels typically reaching the property line will be 65-70 dBA. No noise-sensitive areas will be exposed to more than 60 dBA due to construction noise. This will produce no noise impact in the area.

The construction period projected for the transonic facility is four years. The noise levels will fluctuate during this period, probably being higher at first and lower toward the end. In any case, the construction is of limited duration: noises produced can be controlled to the point where no community impact will occur.

e. On Air Quality. Construction-generated impacts on air quality will be minor. Trucks and construction equipment will generate engine exhaust. Welding operations will generate some metallic oxide fumes, and the pouring of granular perlite insulation between the walls of the nitrogen storage tank will generate some non-toxic dust.

Between 50 and 250 people will be involved in the construction and assembly of the wind tunnel. The vehicles that they take to work will generate engine exhaust and fugitive dust, the total effect being insignificant.

f. On Traffic. The construction of the proposed plant will have no impact on the local traffic situation. During the working day there will be no major construction disruption to the local roads, and the additional traffic attributable to construction activity will be too little to produce any significant effects. In the rush hours the roads are already overloaded at the approaches to the various gates into LaRC and LAFB. The construction traffic will contribute perhaps an additional 10 percent to the peak hour volumes on the surrounding roads, and that will not produce any significant change over the current situation. During the off-peak hours, traffic is light and free-flowing, and the addition of the construction traffic will create no problems.

In short, no impact to the traffic situation is expected. Even if it were however, two factors would tend to mitigate any such effects. First, the problem would, by its very nature, be temporary. It would disappear with the completion of construction in a couple of years. Secondly, the number of employees at LaRC has been declining and is expected to continue to do so. The amount of traffic therefore drops in proportion, and any increases due to construction really only go to maintaining the current level for a short while longer. In light of these facts and circumstances, no impact to the traffic system is probable as a result of the construction of the proposed facility.

A related problem is parking of the construction workers' vehicles. Although there is currently no space sufficient for this need, it should not be any real problem. Fortunately there is a large open space between the NTF site and the West Gate that could easily be converted to a temporary construction parking lot and then replanted at the end of the job. No construction parking problems are anticipated.

g. On the Economy. The construction of the proposed facility will generate impacts on two major levels: national and metropolitan. These short-term impacts result from changes in employment, wages, and purchases of materials and equipment.

(i) Construction Employment: Construction of the transonic facility is estimated to last four years, including demolition of the existing facility. During the various construction stages, employment will range from 30 to a peak six month requirement of 250 employees. Of the peak 250 employees, about 80 percent or 200 will come from the local metropolitan area. About 50 non-local workers may be required for a short period because their specialized occupations are not available or are in short supply locally. The 200 local construction workers represent about three percent of all construction workers available in the metropolitan area. This peak employment should not cause any short-term labor shortages or changes in the wage rate. A direct positive impact is the approximately $10 million of construction wages paid over the four-year period, nearly all of which will be spent locally. During the third year of construction, when most activities are occurring, the annual wage bill for all 250 workers will be about $5 million. In addition to the direct impacts, there are indirect benefits which result from the purchases by the workers. These purchases generate additional demands for goods and services, thus multiplying the economic impact of the area to between $16 and $19 million of local purchases.

(ii) Capital Investment: The value of the capital goods investment (total construction costs less labor costs) is estimated at approximately $52 million, to be spent over a four-year period. The majority of these materials and equipment will need to be purchased from outside the local area. Local purchases of about $5 million may be made for buildings and portions of the tunnel structure. Therefore, the major economic impact of the purchase of materials and equipment will be on a national basis. However, the $5 million of local purchases, after portions are spent and respent locally, should multiply to a total direct and indirect positive impact of about $7 million of local expenditures.

h. On Local Social Structure. An estimated 50 to 250 persons will be needed to construct and assemble the NTF over a projected period of about four years. Two hundred of these workers are expected to be available locally from the Hampton-Newport News-York County Metropolitan area, which in 1970 had a combined population of 292,159. The other 50 members of the needed work force belong to specialized trades not normally in residence in the area. Therefore, an immigration of about 50

persons (possibly with dependents) is anticipated for short periods of time when their special skills are required on the project.

Even during the peak construction period in the third year, the addition of 250 persons to the work site would not have a measurable impact on the local social structure. About 200 of these workers would merely commute from their place of residence to this construction site instead of to another site. The other 50 specialized persons would probably be in and out for short periods of time over the four years. This number, even if some were to bring their families, would not have a significant social impact on the communities within commuting distance.

i. On Local Governmental Services and Housing. The shift of from 50 to 200 local workers from one job site to another, as referred to above, is not expected to cause a need for change in the services provided by the local government, schools, hospitals, etc. in the area. The other 50 persons, coming in for short periods of time over the four-year period, even with some dependents, would not be of sufficient numbers to put measurable new demands upon the local government, schools, hospitals, etc. of the region.

The Tidewater area has numerous mobile home parks and apartments which can easily accomodate the construction staff. The apartment developments are very rarely filled to capacity. Mobile home rental units are less available but with advance notice can be made available. Two mobile home parks exist within one mile of the construction site.

j. On Historical and Archaeological Sites. No historical or archaeological sites are known to exist at the location of the proposed expansion of the building which will contain the NTF. Across the street from the facility, as shown in Figure 20, there used to be a plantation manor house called Morefield (Moore House site), dating from about 1750. It was burned about 1895 (LaRC-HAS, 1974). Now on its site, NASA Building #1293 is located. Other sites of historic interest are farther away, and outside the range of environmental disruption anticipated in the building of the transonic facility.

Construction plans for the facility will involve some earth moving, but this earth was undoubtedly already disturbed in the construction of the original building and parking lot. Therefore, the chances of uncovering any features of archaeological or historical value are remote, although such a possibility can never be totally excluded.

In this very unlikely eventuality, Public Law 93-291; 88 Stat. 174 would be applicable. This Act provides "for the preservation of historical and archaeological data (including relics and specimens) which might otherwise be lost as the result of any Federal construction project...."

2. Of Operation of the Proposed Plant.

a. On Noise.

(i) Fan Noise: The analysis of noise to be generated by the NTF fan was based on a study done for NASA entitled Preliminary Noise Analysis of the Proposed NASA Langley High Reynolds Number Transonic Research Wind Tunnel by Bolt, Beranek and Newman Inc. (BBN) and a subsequent memo prepared by the Senior Acoustical Engineer at NASA Langley entitled NTF Fan Noise which evaluated and commented on the BBN report. These reports varied somewhat in estimation of the noise levels that the tunnel might be expected to generate, so they were re-analyzed for this environmental impact statement along with additional information not previously available in order to estimate the fan noise output. This analysis and the noise methodology used to predict NTF impacts for this draft environmental impact statement are presented in detail in Appendix C. The results are summarized here.

The method for estimating fan noise used by BBN is one common in the field. It is based on data for a large family of fans including both centrifugal and axial fans. The method used in the NTF Fan Noise memo for estimating sound power of the NTF fan is based on scaling aircraft fan noise data taken at near standard atmospheric conditions to the tunnel conditions.

In the NTF Fan Noise memo, it was stated that the differences between the two fan noise estimates are due to three factors.

1. Differences in input data account for about 2dB of the difference.

2. Safety factors have been introduced by BBN to correct for inflow conditions. It is obvious that the inflow to the NTF fan will be distorted by turning vanes, etc. However, it is questionable whether inflow to the fans considered by the empirical method can be assumed to be clean. This assumption then does not seem reasonable, and the 3 dB added for inflow is unjustified.

3. BBN did not scale fan noise results at atmospheric pressure to the high pressures in the tunnel.

In short, the noise-estimating method presented in the NTF Fan Noise memo is a more accurate model of the NTF fan. This should be preferred in comparison to the method for evaluating noise generated from HVAC fan units.

The sound pressure levels outside the tunnel sections have been estimated taking into account the tunnel wall characteristics. In the immediate

area of the tunnel the aggregate noise level will be approximately 104 dBA. At the property line this level would be attenuated by distance and intervening buildings to approximately 80-85 dBA. NASA currently has a plan for further attenuating this noise. The plan involves incorporation of a bulk absorber to the outer skin of the nacelle in the fan region to reduce noise transmitted to the test section. This reduction may result in satisfactory external noise levels. If external levels need to be reduced further, a thin lead sheet will be incorporated in the internal insulation system adjacent to the inner surface of the tunnel shell. This would reduce levels outside the tunnel to approximately 78 dBA with proportional reductions at the property line and so forth. Both of these design measures appear feasible and practical, and they are being studied in more detail. In any case, the tunnel noise will not be such that people will typically have an opportunity to be exposed to levels that could be physically harmful to them. Even without the lead insulation, the noise level at the closest edge of the trailer court due to operation of the NTF would be 58 dBA compared to 65 dBA from the existing 16 ft wind tunnel. With the lead lining, the noise level at the trailer court would be further reduced to about 44 dBA as a result of NTF operation, if only fan noise is considered. Furthermore, it will be shown that this noise is in fact only secondary to the vent stack noise and will not be determinative of the noise impact of the NTF facility during cryogenic operation.

(ii) Gaseous Nitrogen Vent System Noise: The noise at ground level generated by the vent stack is greater than the contributions from fan noise. Because of its opening at the top, the vent stack cannot take advantage of the high transmission loss provided by the walls of the tunnel and hence becomes the major noise source.

The range of sound pressure levels to be generated by the GN_2 vent system was estimated for various operating conditions. This system noise has a number of components. The valve noise is basically a function of turbulent mixing noise and shock noise. These levels were calculated and were then used to develop an estimate for the total noise level to be generated at the top of the stack. The typical noise level at the stack opening would be 133.5 dBA with a maximum level of nearly 140 dBA.

It can be shown that the main valve will generate the highest noise levels. However, for an observer at ground level in the vicinity of the stack, the major source of noise will come from the stack opening and not from the enclosure for the valve. This is because the high transmission loss of the pipe and of the enclosure for the valve will eliminate noise transmitted directly from the valve.

To verify this, the transmission loss of the pipe walls, valve enclosure, and stack walls were estimated. The combined transmission loss of the pipe and walled enclosure will limit the noise radiated directly from the valve housing. Thus, the major noise source, even at ground level, will appear to originate at the opening of the vent stack.

It is also a reasonable assumption that the transmission loss through the vent stack walls will be greater than the transmission loss provided by the interior space of the stack between inlet and outlet. Again, the source of noise will appear to emanate from the stack opening rather than from the base of the stack.

In order to predict the impact of this noise source, an adjustment to the predicted noise level of 133.5 dBA must initially be made to account for the fact that the noise emitted from the stack opening is highly directional and the noise transmitted radially is not equivalent to that of a non-directional source. The equivalent non-directional level is 125.5 dBA.

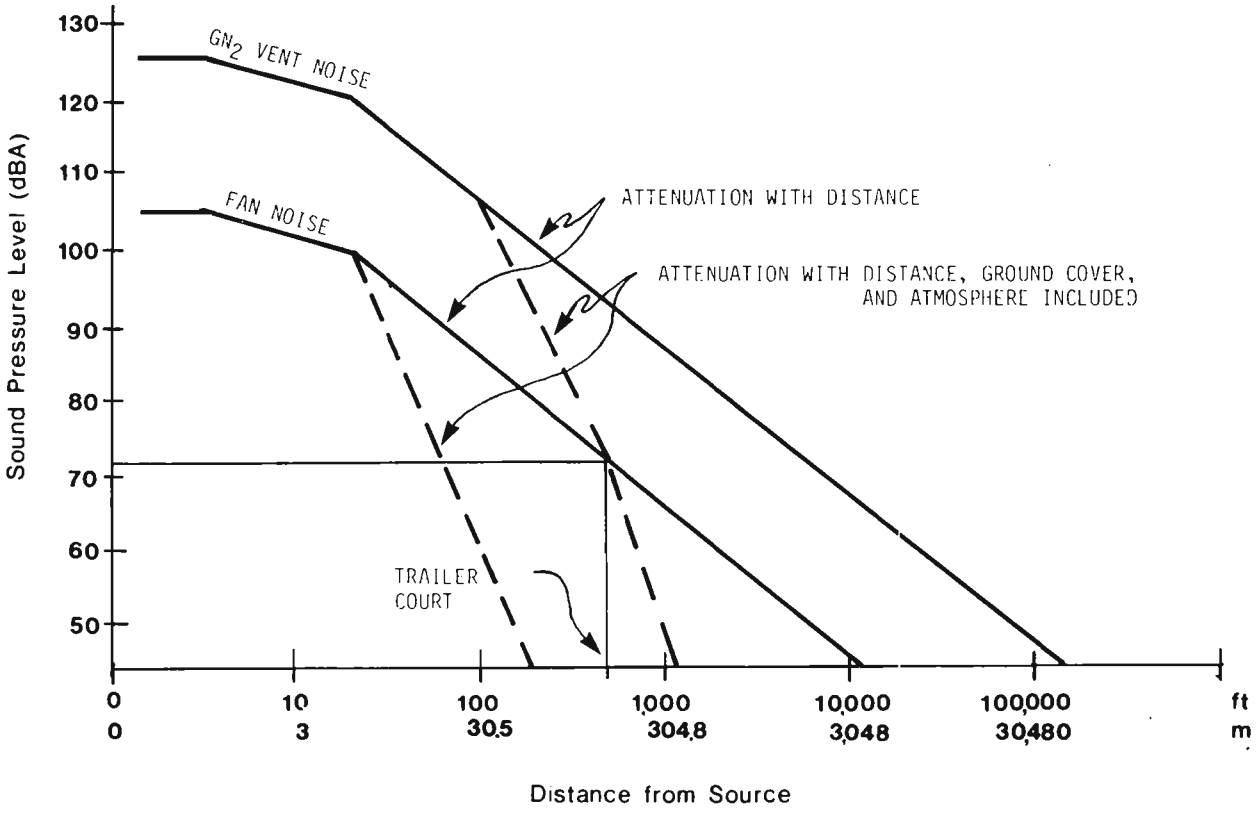
This noise will be attenuated as a function of distance from the source, ground cover, and atmospheric conditions such as relative humidity and temperature. An estimate of resultant stack noise is given in Figure 21. The noise level at the trailer court across from the facility is indicated since this area is the most sensitive noise receptor in the vicinity.

As shown, it is likely that a level of approximately 73 dBA will be routinely produced at the trailers nearest the NTF. This level may rise to 80 dBA on the relatively rare occasions that the tunnel is operated at its maximum. As noted previously, other sources in the area occasionally produce similar noise levels but they are typically during the daytime and are of a less intermittent character than the vent valve noise is likely to be.

The most comparable noise, and the one against which impact is most properly assessed, is that of the 16 foot Transonic Tunnel. As previously mentioned, this tunnel and the NTF will use the same power supply and thus cannot operate simultaneously. It is the difference between the noise levels produced by these tunnels, then, that represents the true measure of impact. That difference is 8 dBA (73 minus 65), and it is significant.

Not only is this amount of change considered to be significant in itself, but the new level of 73 dBA also represents an important impact. Currently the level of 65 dBA is not such that it would preclude typical outdoor residential activities. Inside, nighttime noise levels should be held below 46 dBA. Therefore, noise transmitted through the walls of a trailer would have to be attenuated by 19 dBA to achieve this goal. A light structure with windows closed will provide 20 dBA attenuation and a 45 dBA interior level. Many people may consider this too noisy,

Figure 21
Noise Profile of the National Transonic Facility



especially if they like open windows, but it is not unreasonable. The new levels will be such as to disrupt normal outdoor residential activities, however. The nighttime indoor levels will also probably be at least 50 dBA and could be as high as 63 dBA if windows are to remain open. In a normal residential area located remote from common noise sources such as highways, industrial plants, etc., these levels would be unacceptable even during the day, and they will probably be unacceptable and a source of complaint here, too.

Noise levels at the base of the stack will be quite high, approximately 107-110 dBA. People are not expected to be in this area during tests, but even if they were, this will not cause hearing damage as a result of short exposures. For comparison, OSHA rules limit exposure to these levels to 30 minutes per 8-hour period. Also at the line of Armistead Avenue, the level will be approximately 95-97 dBA. This could startle passing drivers and may cause accidents.

In sum then, the new NTF will create noise impacts of significant magnitude both on a relative and an absolute scale. Compared to the current major source (the 16 foot tunnel), it will be 8 dBA louder at the trailer court. Also, the predicted level of 73 dBA (80 dBA at maximum operation) is too loud for the nighttime hours of operation. This is a noisy area

with many contributing sources, and the people who live in the trailer court knew that when they moved in and must be considered to have an above-average tolerance to noise; even so, the majority of area noises are daytime noises, and this new, loud nighttime noise would create a significant impact if uncorrected. Design measures will be taken to reduce these noise levels.

(iii) Other Sources of Noise: The contribution of additional noise sources in the tunnel and the vent valve system was considered. These include noise from turning vanes, duct elbows, and exhaust fans. However, the noise contributed by these sources is negligible in comparison with the major noise sources previously noted. The noise from exhaust fans was considered and found to be negligible in comparison to the valve noise. The noise generated by high speed flow through the elbow connecting the vent valve to the exhaust stack has also been estimated based on air flow at the same velocities. Although the noise levels generated are significant, they are again negligible in comparison to the valve noise.

These additional noise sources merit attention only if noise from the major sources--the fan, slotted test section, and exhaust valve--are controlled to the extent that these secondary sources become objectionable. In view of the levels generated by the major sources under present design conditions, these secondary sources need not be considered.

(iv) Summary: At this point it is necessary to take a look at the overall noise picture. The area around the West Area of LaRC is very noisy. Most of the surrounding land is vacant or industrial and not noise-sensitive. Some is residential--of particular concern is the trailer court outside the LaRC West Gate. For a residential area, this is literally buffeted by noise. During the day, peak hour traffic noise is high around the Gate area. Also, frequent aircraft flyovers significantly raise the noise level for short periods, as do jet engine tests at LAFB, which are very noisy. Noises from daytime operations at LaRC are typically not a problem.

The nighttime situation is similar in some ways. The prime night noise offender is the auto race track next to the trailer court. Through the summer season this typically runs once a week, late in the evening, drawing large crowds and making excessive noise. Another nighttime source, though not as loud, is the 16-ft wind tunnel. Its noise occurs for shorter periods but at more frequent intervals than the race track noise. It too is late at night, and it produces about the maximum level that can be attenuated by the typical building shell to the point that a reasonable nighttime interior environment of about 45 dBA exists. The race track is too loud to meet this criterion.

Since the NTF and the 16-ft tunnel will be similar in noise output and cannot operate simultaneously, the change attributable to the NTF will be the increase, if any, over the current levels produced by the 16-ft tunnel. At this stage of the design, that difference appears to be 8 dBA (73 dBA vs 65 dBA). However, this level will almost certainly be reduced by the final design to an acceptable level. This magnitude of reduction appears to be achievable. Currently the detailed design noise

study is being conducted on this system. NASA is committed to designing the NTF such that noise production is controlled within existing levels. It is highly unlikely that the NTF will create a significant noise impact, for the following reasons:

1. Other independent community sources produce equal or higher noise levels.

2. Operational times are short--typically 10 minutes or less at a stretch. The total operational time in the cryogenic mode will be 100 to 400 hours per year, with a maximum of 20 hours per year at the maximum GN_2 venting rate.

3. Studies are now underway to design changes which will lower the noise level produced. Effective changes are possible, and the noise level will be reduced.

b. On Air Quality. The only substance that will be vented into the atmosphere from the NTF will be cold, gaseous nitrogen (GN_2) when the cryogenic mode of operation is used. Of course, air will be discharged from the tunnel when the tunnel is depressurized following non-cryogenic operation, but this air is expected to be essentially the same as ambient air. In addition, GN_2 will be discharged at a low but continuous rate from the liquid nigrogen (LN_2) storage tank. Consequently, only the effects of GN_2 discharges are discussed. Maximum and typical rates of GN_2 discharges from the tunnel vent stack and the storage tank vent are described in Table 12. When the LN_2 storage tank is at ambient temperature, all the LN_2 initially pumped into it will vaporize until the tank temperature reaches the temperature of LN_2, -196°C (-321°F). LN_2 can be pumped into the tank at a maximum rate of 32 kg/sec (70.6 lb/sec), and this amount of cold GN_2 would be vented during cooldown. The resulting average concentration of cold GN_2 in the turbulent wake of the tank would be about 125 g/m^3 divided by the wind velocity. For a wind velocity of 6 m/sec (13.4 mph), the resulting ground concentration would be 21 g/m^3, which would produce local fog unless the ambient humidity were low. Once the tank is cooled down to liquid nitrogen temperatures, emissions from the tank vent will have negligible environmental impact, except in the immediate vicinity of the tank during high humidity conditions, where there could be some localized fog. Discharge rates from the storage tank are sufficiently low as to pose no problems. The tunnel vent stack, however, may discharge as much as 544 kg/sec (1,200 lb/sec) of GN_2 at -157°C (-250°F) for as long as ten minutes at a time. The cold GN_2 will be mixed with up to 454 kg/sec (1,000 lb/sec) of ambient air drawn in by four large fans at the bottom of the vent stack. The resulting mixture will be discharged from the top of the stack at 30.5 m/sec (100 ft/sec). There are three areas of concern regarding these cold GN_2 discharges on air quality.

1. Will the GN_2 displace air to the extent that the oxygen content of the resulting mixture is too low to support life or permit normal neuromotor functioning of humans or other forms of life that may be in the area?

Table 12. Nitrogen Discharge Rates from the Vent Stack and Liquid Nitrogen Storage Tank of the National Transonic Facility

Source or Condition	Maximum Emission Rate (kg/sec)	Typical Emission Rate (kg/sec)	Exit Point	Typical Duration of Emissions
Cryogenic Testing	544		stack	Several seconds between set points
	454	91 to 277		10 minutes at maximum, several hours at lower rates.
Initial Cooldown of Tunnel	454	0 to 454	stack	30-45 min
Standby	9	0 to 9	stack	variable
Emergency shutdown	544	544	stack	6.5 min
Initial Cooldown of LN_2 Storage Tank	32	32	tank vent	up to 2 hours
Filling of LN_2 Storage Tank When Cold	0.7	0.2 to 0.7	tank vent	8 to 24 hours per week if filled by trucks
Cooling of LN_2 Lines from Tank to Tunnel	3	0 to 3	tank vent	30 min
Normal Boiloff in Tank	0.5	0 to 0.5	tank vent	continuous
Boiloff of LN_2 in Tank During Tunnel Operation	2.3	0 to 2.3	tank vent	up to several hours

2. Will the resulting mixture be so cold as to be a health or safety hazard at ground level?

3. Will the mixing of cold GN_2 with humid, ambient air produce fog, snow, or ice to the extent that hazardous conditions will occur at ground level?

(i) Turbulent Jet Model: The answers to these questions are a function of ambient meteorological conditions, especially wind velocity, air temperature, and relative humidity. To find the answers, NASA LaRC turned to computer simulation modeling. Unfortunately, standard Gaussian modeling and the most commonly used plume rise equations are not applicable owing to the very low temperatures and high flow rates of the GN_2 discharges. NASA LaRC, in cooperation with Old Dominion University, has been developing the application of an advanced "turbulent jet" diffusion model, which takes into account the momentum and negative buoyancy of the plume, ambient meteorological conditions, and the effect of plume impact on the ground. Inasmuch as this is a Gaussian model, the chief uncertainty is the value used for the rate of mixing of the plume with ambient air. It was assumed that the rate of mixing would be consistent with the behavior of cold plumes from a 0.635 cm (0.25 in) stack as observed in a wind tunnel under calm conditions, and that mixing is adiabatic, i.e., without loss or gain of heat. The results of this model for conditions on the ground at various

distances from the stack are given in Table 13, for temperatures and relative humidities selected as typical for summer and winter, respectively. It was assumed that the wind was essentially calm and that the vent stack was releasing GN_2 at the maximum rate. It can be seen from the table that the maximum depression of oxygen content would be only one percent, down from the essentially constant 21 percent of normal air. This slight depression is not a threat to health or safety, even with prolonged exposures, and it is the result of mixing GN_2 with air in the stack plus some additional mixing after venting from the stack. The maximum temperature depressions at ground level predicted by the model are 5.7°C (10.3°F) in the winter and 6.8°C (12.2°F) in the summer at 70 percent relative humidity. These temperature drops would be noticeable over the brief periods during which they would occur, but would not pose a direct safety problem. More serious may be the resulting fog or snow conditions induced by mixing cold GN_2 with humid air. As shown in Table 13, some fog in the summer, and some snow in the winter would be produced; in each case the higher the humidity the more fog or snow. The main hazard would be through reduced visibility, especially for motorists using State Highway 172 at night. In addition, snow could adhere to ground surfaces if they are at or below 0°C, increasing the traffic hazard. Fortunately, as the table shows, such hazards would be restricted to a fairly local area, probably not more than 40 to 50 m (130 to 162 ft) away from the stack. With humidities higher than 70 percent, the hazard could extend further from the stack.

Results of two solutions of the turbulent jet model under calm wind conditions are depicted in Figures 22 and 23, which give an idea of the vertical, as well as horizontal, characteristics of the plume. The plume would reach a height of about 115 m (380 ft) and then would descend to ground level, resembling a fountain of fog or snow. The cloud would cover the base of the stack and then spread out along the ground. As it did so, its density would decrease as the GN_2-air mixture approaches its dew point. There might be some light fog beyond the point where the mixture is not saturated with water due to condensation of moisture on dust particles and other "condensation nuclei." Water can remain in the liquid state in significant quantities down to a relative humidity of 93 percent. Since the air around LaRC is relatively particulate free, such residual fog is expected to be very light.

The output of the turbulent jet model shows the plume symmetrically distributed around the stack. Even under calm wind conditions, however, there will be some slight movement of air, and the plume will tend to move somewhat with these air currents. The plume will also bounce off the NTF and other nearby buildings and thus cause greater effects in the open areas than if the buildings were absent.

Old Dominion University is currently developing an application of its turbulent jet model to conditions in which there are subtantial ambient wind velocities.

Table 13. Results of Turbulent Jet Model Under Calm (< 0.6 km/hr) Wind Conditions and with Several Ambient Air Temperatures and Relative Humidities.

	Ambient Temperature = 26.8°C (80°F) Relative Humidity (percent					
	100		80		70	
Plume Characteristic	Distance Downwind (m)		Distance Downwind (m)		Distance Downwind (m)	
	12	100	12	42	12	42
Temperature (°C)	24.4	26.0	21.6	22.4	20.0	22.2
Oxygen Content (%)	20.0	20.5	20.0	20.2	20.0	20.2
Water Content as Fog (gm/m^3)	2.2	0.6	0.8	0.1	0.1	not saturated
Distance for 90% Opacity (m)	1.6 to 17	7 to 75	4.3 to 46	35 to 370	70 to 740	near ambient

	Ambient Temperature = 0°C (32°F) Relative Humidity (percent)						
	100		80		70		
Plume Characteristic	Distance Downwind (m)		Distance Downwind (m)		Distance Downwind (m)		
	12	120	12	42	12	48	52
Temperature (°C)	-3.9	-0.8	-5.1	-3.7	-5.7	-5.5	-3.1
Oxygen Content (%)	20.0	20.6	20.0	20.2	20.0	20.0	20.3
Water Content as Snow (gm/m^3)	1.1	0.2	0.4	0.1	0.1	0.05	not saturated
Minimum Distance for 90% Opacity (m)	3	17	8.6	35	35	64	near ambient

(ii) PTMAX and PTDIS Modeling: Two other Gaussian Models used to simulate the GN_2 discharges of the NTF are the Environmental Protection Agency's PTMAX and PTDIS. PTMAX predicts the distance to the point of maximum concentration of air pollutants from a given source with constant plume height, under varying meteorological conditions. PTDIS maps downwind concentrations. These models consider neither the negative bouyancy of the plume nor its upward velocity. The models were run making the very conservative assumption of an effective plume height from the ground equal to the height of the stack (24.4 m or 80 ft) and a GN_2 discharge of 544 kg/sec mixed in the stack with 454 kg/sec of ambient air (worst-case conditions). The results of PTDIS are presented in Table 14, along with the results of corresponding enthalpy (heat content balance) and opacity calculations, for the wind velocity and atmospheric stability which PTMAX indicated would produce the worst ground level conditions, i.e., low velocity (0.5 m/sec) and very unstable conditions (stability Class 1).

Table 14 shows that oxygen content could be dropped down to 18 percent, which is not hazardous since as little as 10 percent can support life. Temperature depressions would be more severe than shown by the turbulent jet model; as much as 20°C (36°F) in the summer and 24°C (43.2°F) in the winter. Temperatures could reach -24°C (-11.2°F) about 127 m downwind at 70 percent relative humidity, and would be even colder at lower humidities. Thus there is a possibility of exposed tissue damage to personnel, but whereas personnel can take cover, it is more likely some vegetation might suffer frost damage as such low temperatures are extremely rare in southern coastal Virginia. The table also shows that heavy to moderate fog or snow could be

Figure 22
Gaseous Nitrogen Discharge : Profile 1

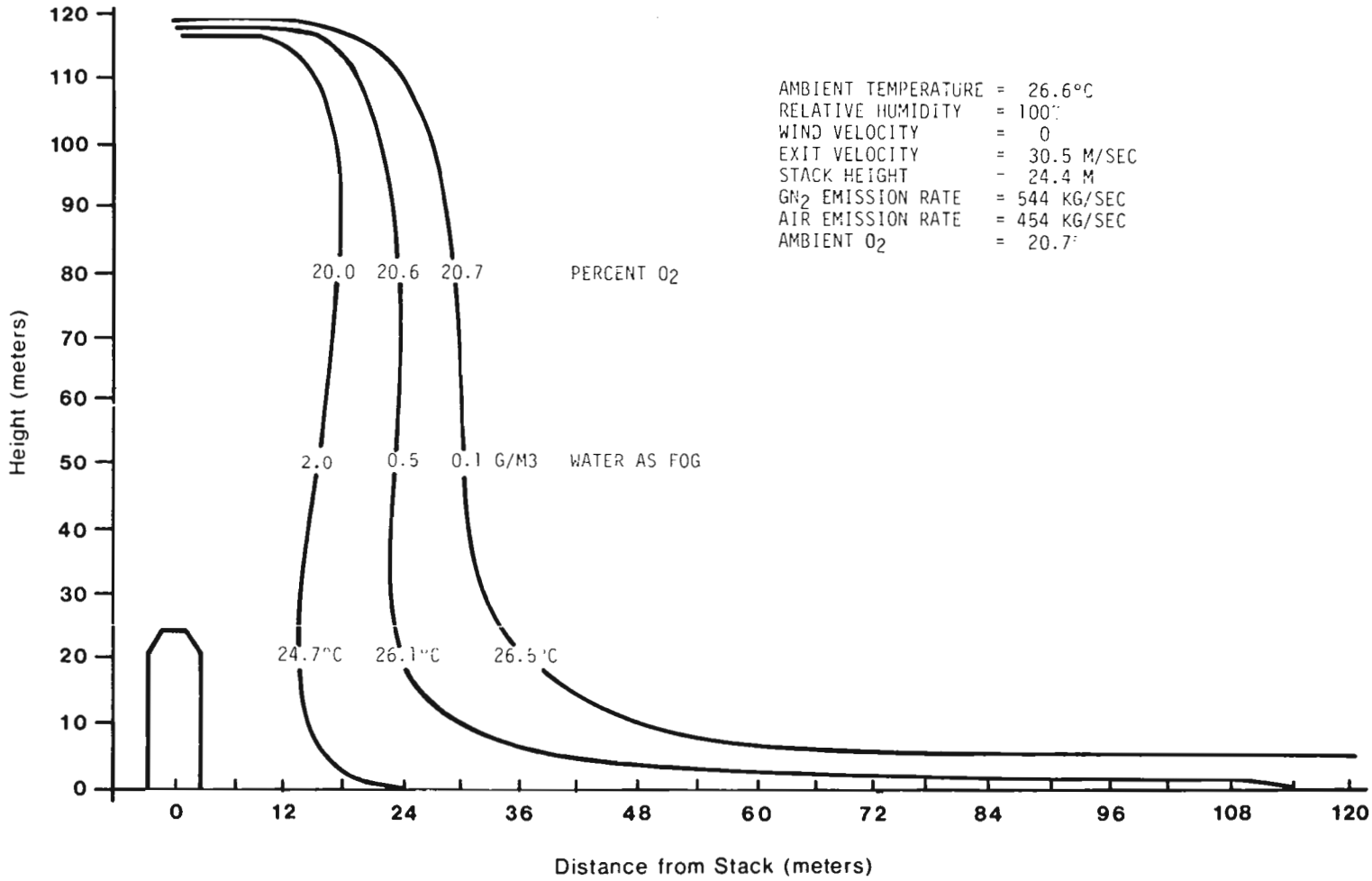
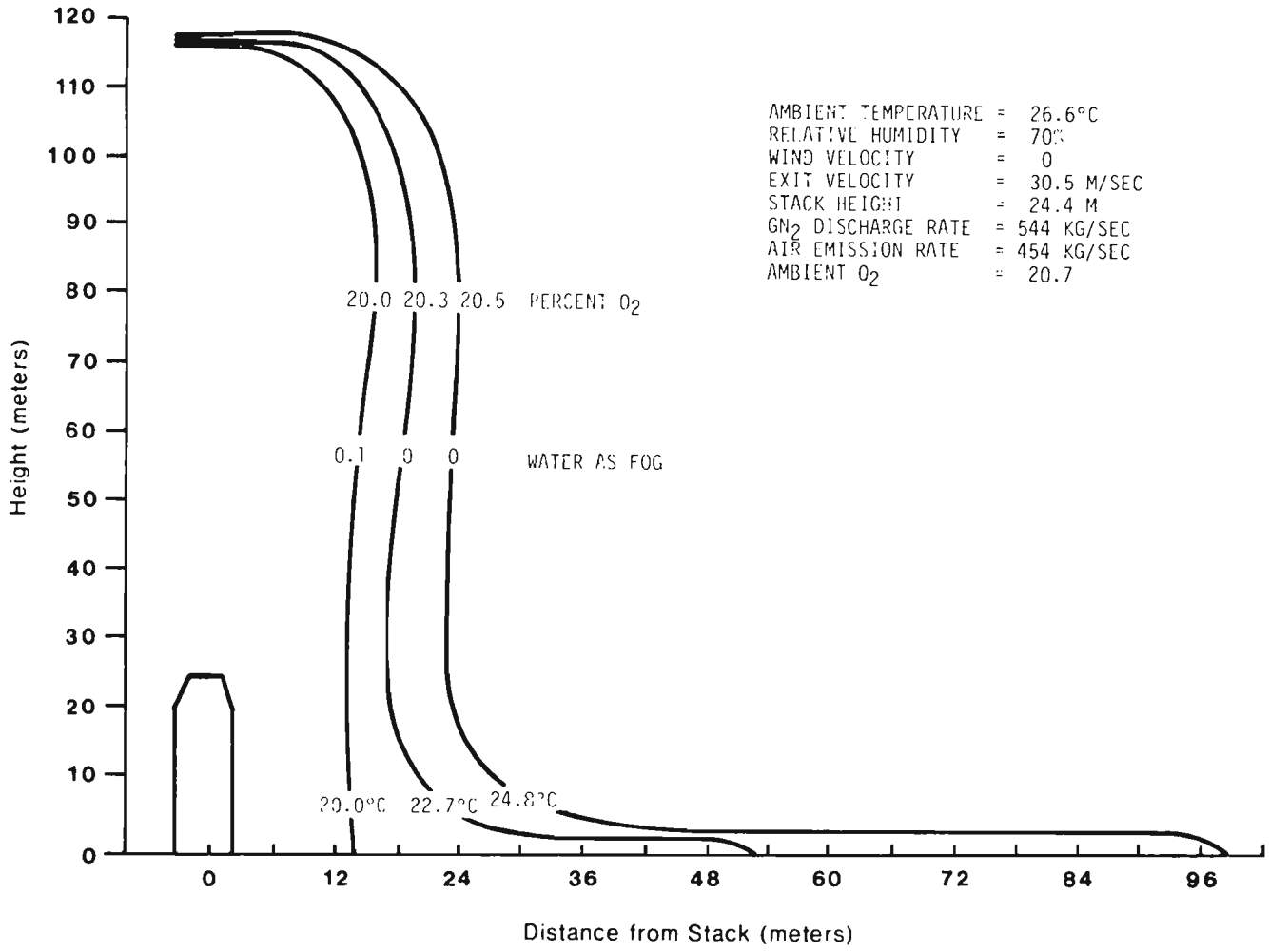


Figure 23
Gaseous Nitrogen Discharge : Profile 2



expected as far as 2 km (1.2 mi) downwind. Fortunately, with a wind velocity of 0.5 m/sec, it would take the plume 66 minutes to travel 2 km and, inasmuch as the assumption of adiabatic mixing is pessimistic, there will be considerable transfer of heat from the ground and surrounding air. The result would be considerably less fog or snow than predicted by the model.

PTMAX also shows maximum stack effluent concentrations of less than 50 g/m^3 with wind velocities above 5 m/sec (11.2 mph). Enthalpy calculations show that if ambient air with a relative humidity at or below 70 percent were mixed with 50 g/m^3 of effluent gas, the resulting mixture would not be saturated with water. Thus, under conditions of high wind velocity and low relative humidity, it is reasonable to expect that there will be no adverse visibility conditions. Wind speeds of 5 m/sec or greater occur 29.8 percent of the time at LaRC,

Table 14. Results of PTDIS Modeling, and Enthalpy Balance and Opacity Modeling with Wind Velocity = 0.5 m/sec and Stability Class = 1 (very unstable) and with Several Ambient Air Temperatures and Relative Humidities.

	Ambient Temperature = 28.3°C (83°F) Relative Humidity (percent			
	100		70	
Plume Characteristic	Distance Downwind (m)		Distance Downwind (m)	
	127	2000	127	700
Temperature (°C)	14.1	27.9	8.3	22.8
Oxygen Content (%)	17.8	20.8	18.0	20.6
Water Content as Fog (gm/m^3)	11.6	0.33	7.94	not saturated
Distance for 90% Opacity (m)	0.3 to 0.8	10 to 120	0.45 to 1.2	near ambient

	Ambient Temperature = 0°C (32°F) Relative Humidity (percent)			
	100		70	
Plume Characteristic	Distance Downwind (m)		Distance Downwind (m)	
	127	2000	127	700
Temperature (°C)	-11.1	-0.6	-24.0	-3.5
Oxygen Content (%)	18.4	20.9	18.4	20.7
Water Content as Snow (gm/m^3)	2.4	0.44	1.6	not saturated
Distance fro 90% Opacity (m)	1.4 to 15.8	8.0 to 22	2.1 to 23	near ambient

and relative humidities of 70 percent or less occur about 44 percent of the time. The combined frequency of such conditions is at least 13 percent of the time. High wind velocities and low relative humidities are not independent meteorological events; rather, they tend to occur simultaneously more often than if they were independent. If necessary, heavy nitrogen discharges from the NTF could be restricted to such favorable meteorological conditions. A run of PTDIS for very stable atmospheric conditions (stability Class 6) and a wind velocity of 0.5 m/sec (1.1 mph) shows a maximum of 300 g/m^3 stack gas at 1,200 m (0.75 mi) downwind. For adiabatic mixing with ambient air at 100 percent relative humidity and 28.3°C (82.9°F), this would produce a very heavy fog. PTDIS and enthalpy calculations show that, for adiabatic mixing, this fog would still be significant 20 km (12.4 mi) downwind. Gaussian modeling is good to a factor of three, at best, for predicting downwind concentrations from point sources and, in the case of applying it to the NTF, it is probably much worse. Plume height can cause large effects on calculated downwind concentrations, and real plume height will vary with downwind distance for the NTF discharge. The plume height used in this modeling represents worst-case conditions.

(iii) Empirical Validation: Empirical data have been sought to validate the above analyses, but none were found for analogous conditions, i.e., downwind of a massive, continuous discharge of cold gas. Some data for ground level spills of cold liquid natural gas were found, but these were of limited applicability. Data were also found from physical modeling of negatively bouyant freon gas discharges from miniature stacks (0.32 to 0.64 cm dia, 7.6 to 15.2 cm high; i.e.,

0.125 to 0.25 in dia, 3 to 6 in high) in a wind tunnel. The gas had a specific gravity relative to air of 1.06 to 3.0, and the tests were made under both calm wind conditions and with various crosswind velocities (Meroney et al., 1973). From this work, equations were derived that describe the plume rise, downwind distance to plume touch down, and the maximum gas concentration at touchdown. These equations were used with NTF stack dimensions and the maximum GN_2 emission rate, producing the results shown in Table 15.

Table 15. Results of Applications of Meroney Wind Tunnel Equations to NTF Gaseous Nitrogen Discharge

Wind Velocity		Distance To Touchdown*		Nitrogen Concentration
m/s	mph	km	mi	g/m^3
0.45	1.0	1.3	0.79	44.0
3.17	7.0	4.1	2.5	18.6

*Point of maximum concentration

These concentrations are much less than indicated by Gaussian modeling, assuming an effective height of emission of 24.4 m. Unfortunately, the validity of extending this wind tunnel modeling to large scale discharges, such as those of the NTF, has not yet been established. More wind tunnel modeling is planned for conditions closely resembling those at LaRC, including the influence of local buildings.

A full evaluation of the potential effects of the NTF discharge on oxygen, temperature, visibility, and snow deposition can best be made after validation and calibration of the modeling techniques used in this study. NASA plans to do exactly that. LaRC is currently constructing a pilot nitrogen discharge stack 30 cm (12 in) in diameter through which mixtures of cold GN_2 and ambient air will be released at velocities and temperatures simulating the conditions of release from the NTF. The resulting plume will be photographed and its behavior under various meteorological conditions analyzed. These experiments will provide data which will be used to calibrate and validate both the turbulent jet and wind tunnel modeling. This information will be considered in the final design of the GN_2 discharge system.

Following construction of the NTF, initial operations will proceed with caution with respect to air quality. Initial runs will be made with GN_2 emission rates of less than 90 kg/sec (200 lb/sec) and there will be extensive monitoring of the plume to ascertain the validity of model predictions. Emissions rates will gradually be increased to maximum with effects being carefully monitored for unexprected plume behavior that could result in hazardous conditions. The NTF will not discharge GN_2 from the vent stack when meteorological conditions are such that hazards could result.

Appendix D contains a description of the turbulent jet model, the method for calculating the opacity of fog, the detailed results of PTMAX

(Table D-3), and a description of the Meroney equations for those who desire more information on the modeling described above.

(iv) Summary and Conclusion: In brief, the above analyses and discussion indicate that under some combinations of maximum venting rate and meteorological conditions unacceptable impacts on visibility could occur. NASA is currently carrying out experiments to validate models which will better predict the nature of these rare cases, which could occur only during maximum venting rate operations and unacceptable meteorological conditions. The maximum GN_2 venting rate and unacceptable meteorological conditions would occur no more than 0.23 percent of the time (20 hours/year) and 39 percent of the time, respectively, resulting in a combined probability of such conditions such that unacceptable effects could occur only 0.09 percent of the time.

NASA LaRC will not operate the NTF when the probability of producing unacceptable visibility or other impacts is high. NASA will use the results of on-going studies described above to define a three-dimensional (temperature, wind velocity, and relative humidity) envelope of acceptable conditions. NTF operations will be restricted to periods of such acceptable conditions.

c. On Safety

(i) Introduction: The NTF will, in some operational modes, discharge to the atmosphere large quantities of cold gaseous nitrogen (GN_2). The behavior of this vented GN_2 is discussed fully elsewhere. In addition to the GN_2, large quantities of liquid nitrogen (LN_2) will be handled at the NTF. The potential hazards of GN_2 and LN_2 on base and off base to personnel will be discussed in this section.

Other potential hazards to personnel during NTF operations are related to mechanical or structural failure of components in the facility itself. By way of illustration, possible failures include fan blade fracture or distortion, ignition of lubricating fluids or other petroleum products during operations, and pressure vessel failure. External to the NTF, personnel hazards may occur with mechanical or structural failure of the LN_2 handling equipment. Finally, human error in LN_2 or GN_2 handling or facility operation may create unexpected and potentially hazardous conditions to individuals in the vicinity of the NTF.

(ii) Effects of Cold GN_2 on Personnel: Two elements of the nitrogen discharge may have impact upon base personnel. These elements are extreme cold and oxygen depletion in the GN_2 cloud. Temperatures at the ground could be depressed as much as 24°C (43.2°F) below ambient temperature in the center of the exhaust plume. These temperature drops, while noticeable to individuals, will not pose a direct hazard except possibly in the winter. Temperatures as low as -24°C (-11°F) are possible, and unprotected tissues could be subject to frostbite if wind velocity were greater than 9.7 km/hr (6 mph) and exposure time were to exceed 30 minutes.

The second element, oxygen depletion by GN_2 displacement in the air mixture, will occur during NTF operations in the vicinity of the exhaust plume. Computer modeling presented in the previous section indicates that this depletion could rarely amount to as much as three percent of the ambient oxygen concentration in air. Based on partial pressures of oxygen in air, this is equivalent to a sudden exposure to 620 mm of mercury barometric pressure or an altitude about 1,545 m (5,000 ft) above sea level, less than the altitude of Denver, Colorado. This effect, under worst conditions, would persist for approximately 10 minutes. Under these conditions no effect on human beings is expected.

(iii) Effects of LN_2 on Personnel: In the event of an LN_2 spill, tissue damage to exposed human flesh will occur. Contact with this very cold fluid causes "cryogenic burns" with the freezing of skin due to the rapidly evaporating fluid. In addition, the rapidly expanding, dense gas can cause displacement of oxygen in confined areas, leading to suffocation. Handling of LN_2 is a common activity at LaRC; the only difference with the NTF will be the greater frequency.

The possibility of actual exposure to LN_2 is considered remote for this facility, except at the storage fill area. Filling of the vessels will be done by personnel experienced in LN_2 handling. Loose-fitting gloves, face protection shield, and similar protective equipment and warning devices will minimize these hazards.

Liquefaction of oxygen takes place at a temperature considerably above the boiling point of liquid nitrogen. It is therefore possible to condense oxygen out of air when air is exposed to LN_2. Such liquid oxygen would accumulate in low places. In a concentrated oxygen atmosphere resulting from subsequent evaporation of the oxygen, some materials that are normally incombustible in standard air become highly combustible. Energy from an electrical arc or from impact are sources of ignition. The only place where these conditions appear to be likely is in the bottom of the wind tunnel. Liquid oxygen might form a puddle upon startup of a tunnel when liquid nitrogen is mixed with the air in the tunnel. At this time, it appears that because of the diluting effect of the nitrogen, the oxygen content will be so low that a hazard will not exist.

(iv) In the Event of Liquid Nitrogen Tank Rupture: Liquid nitrogen (LN_2) will be stored in tanks at approximately atmospheric pressure (a few centimeters of water positive pressure to maintain dry nitrogen). Under these conditions, metal fatigue in the storage vessel is not considered a hazard. The tank will be constructed to American Society of Mechanical Engineers Standards, which require an extensive certification program prior to first storage and a program of recertification at specified intervals of the vessel design life. These precautions reduce this hazard to essentially negligible levels.

With the relatively warm earth temperatures, boiloff of the LN_2 would be rapid, and dilution with standard air would occur quickly. No hazard is expected to individuals outside the NTF facility from vessel rupture. Hazards to NTF personnel would exist as discussed in the previous section of LN_2 spills.

(v) Structural Failure: The NTF will be operated in a cyclic pressurization mode with variation of internal pressure on the tunnel during most test series. Fatigue analyses will be performed for this structure to provide a 50-year lifespan with minimum modifications and corrections at the recertification interval. Recertification is scheduled for 20-year intervals. The original certification will involve the examination of every weld and plate during manufacture, pre-assembly, and assembly at the construction site to determine every critical area. Both certification and recertification using inspection methods of radiography, ultrasonic testing, and magnafluxing will allow the prompt identification of cracks and crack-like defects. All such defects will be repaired and re-examined. Following these inspections, a new life period greater than 20 years would be projected for each weld.

One of the tests which may be required on the new facility for certification is a pressure test to at least 1.25 times the maximum working pressure of the tunnel (follows Section VIII-UG100 of Division 1 for Unfired Pressure Vessels of the American Society of Mechanical Engineers). This pressure test may be performed either as a hydrostatic or a pneumostatic test. If the latter test is performed, special precautions will be taken. A blast curtain is being designed to be draped over the facility, and all individuals in the area (including nearby buildings) would be evacuated from the area. With these precautions, the only hazard which might occur with vessel failure would be broken windows due to overpressure..

During operations a continual mini-recertification program will be in effect. This program will include external examination of the vessel to detect insulation loss, by locating frost on the external shell. If frost is located on the external shell, a thorough inspection and evaluation of the area would be made, and necessary measures for recertification would be performed.

With the programs of fatigue analysis for the NTF which are underway or planned, the detection of potential metal fatigue would occur before any catastrophic failure. Thus, hazards associated with structural failure of the presssure are considered minimal.

(vi) Mechanical Failure: The potentially most damaging mechanical failure would be fan blade failure in the fluid driving mechanism. The NTF will have a protective containment shroud surrounding the fan which would deflect and absorb energy from the fan blade parts without damage to the pressure shell, should this type of failure occur. In addition, the shaft and bearings are designed to accept the maximum of asymmetrical thrust which could be caused by loss of blades on one side of the fan assembly.

Because of the protective structure surrounding the fan, the drive assembly, and the motors, the effects of failure should be confined to the interior of the structure without impact on the surrounding area.

(vii) Ignition of Lubricating Fluids: Design specifications call for the use of lubricants with high flash points. The greatest potential for igniting of lubricating fluid would be in the drive building. This hazard is considered an unlikely event, and no impact on the area's external environment is expected.

d. On Water Quality. The NTF will make use of the existing cooling towers to remove fan drive heating of the tunnel air when it is operating in the non-cryogenic mode. This will result in the evaporation of water from the tower and the development of concentrated dissolved solids content in the water that remains in the cooling circuit, as at present. Among these solids will be substances added to inhibit corrosion and algal growth. Chromate is the most noteworthy of these. From time to time, the water in the cooling circuit is "blowndown" to remove such solids. This blowdown water represents no essential change from the present and will be less in volume because the tunnel will generally be operated in the cryogenic mode. Chromate in the blowdown will be removed by precipitation, as at present. Therefore, no water quality impacts are projected as a result of tunnel operations.

e. On Operations. The NTF is not expected to interfere with any on-going activities at LaRC except with the existing 16 ft transonic pressure funnel which uses the same power supply. This is essentially no change from the present condition because the existing 4-ft Supersonic Pressure Tunnel, which is to be demolished, uses this power supply.

f. On Traffic. The new Transonic Facility will be replacing another wind tunnel currently existing on the same site. Since little or no additional employment is predicted, no traffic change will occur in that regard. Liquid nitrogen may be brought in by truck to a storage tank. It is possible to exhaust this tank's capacity of 947.5 m^3 (250,000 gal) in several hours. Since each truck holds 22.7 m^3, a maximum of 42 truck trips could be required per day to refill the storage tank. Even so, since these trips are spread out over the course of a day, these trucks will not have any significant effect on local traffic. They may occasionally queue up in the parking lot, but that will be off-street. Furthermore, the possibility of building a liquid nitrogen production facility in the industrial park nearby is a possible consideration. If this occurs at a site sufficiently close, the need for tank truck supply will be eliminated in favor of supply via a pipeline, thereby eliminating this traffic situation. No other changes are predicted to occur, and it may be concluded that traffic will not be impacted by the NTF.

g. On the Economy. The operation of the proposed facility will generate impacts on three major levels: national, metropolitan, and municipal. These impacts result from changes in employment, wages, purchases, and governmental operations.

(i) Employment: The proposed transonic facility may be viewed as a replacement of the existing wind tunnel with an advanced technology. As a replacement, the functions requiring operating personnel are not expected to be significantly altered, and therefore no significant employment changes or impact should be anticipated.

(ii) Purchases: The major changes in maintenance and supply purchases would be in replacement parts and liquid nitrogen. The replacement parts for the gearbox, drive motor, and other wind tunnel equipment would not be purchased locally and would represent relatively small amounts, thus having no significant impact. The liquid nitrogen requirements of 40,800-54,400 metric tons would have a market value of $2.19 million. This volume and market value of liquid nitrogen will have a significant positive impact on the local economy through the resulting induced development, as discussed below.

(iii) Financial: The financial impact of the NTF concerns the capital and operating expenditures of the project in relationship to the savings incurred through more accurate aeronautical design information. Today's requirements for improved aircraft performance, efficiency, maneuverability, handling qualities, safety and environmental compatability emphasize good research and development wind tunnels. The high costs of aircraft and aircraft development programs make it mandatory that more accurate information be provided at each stage of development to give assurance of a successful program before obligation of large program funds.

The annual costs of the NTF will be approximately $5.8 million: $3.3 million of capital costs and $2.5 million of operating costs. The savings gained by these expenditures cannot be accurately estimated, but the possible savings to just one program are very large. For example, on the C-141 transport, the flow over the wing during high-speed flight differed markedly from that observed in the wind tunnel and impacted on the aircraft's stability, structural loads, and performance. Fortunately, the problems could be solved, but it required extensive structural reevaluation, testing, and modifications that took millions of dollars and lasted approximately one year.

Recent studies also indicate that a reduction of one drag count for the C-141 (cruise C_D = 215 counts) aircraft alone would result in a fleet fuel cost savings of $2 million per year or $50 million for the projected fleet life of 25 years. Recent NASA-sponsored tests of a semi-span model of the C-141 indicate that test Reynolds numbers less than the full-scale value may not produce satisfactory simulation of flight test results. The C-141 represents just one example of the positive financial impacts that would result from the proposed facility.

h. On Local Social Structure, Governmental Services, and Housing. The specific number of employees needed to operate the new facility has not yet been determined. However, it is estimated to be about the same as is used with the present facility. Therefore, no change in NASA employee level is anticipated with the operation of the NTF, and no impact is anticipated regarding the various social and governmental services needed by these employees.

The land across Armistead Ave. from the proposed facility is zoned for Limited Manufacturing, Limited and Neighborhood Commercial, and Multiple Family Residential by the City of Hampton, as shown in Figure 16. Since the new facility will be in operation only for approximately 200 to 400

hours a year, impact on the neighboring land uses will be less than might be anticipated.

Some of the present commercial activities on Armistead Ave. (motorcycle sales and practice track, a tavern, a go-cart track and a speedway with weekly Saturday night stock car races in season) cause environmental disruption of their own, giving rise to the conclusion that the owners and users will not be unduly sensitive to additional disruption in the area, especially since they have long been accustomed to the present noise levels generated by the Air Force and NASA activities. Plans for an industrial park in the manufacturing zone are in keeping with many of the activities pursued by NASA in general, and the transonic facility in particular.

The existence of a residential trailer park in the Multiple Family zone does merit special discussion. The park was only established in 1973, against recommendation of both the City Planning Commission and NASA development and external affairs personnel. The opinion was that already existent noise levels from the 16-ft Wind Tunnel as well as LAFB activities would cause problems for prospective residents.

At any rate, the park was developed. Residents now do report noise levels sufficiently high at times that articles in their homes rattle and vibrate, the occupants cannot carry on a normal conversation, and they cannot hear their television sets without increasing the volume beyond normal levels. The residents are under the impression that the worst of these noise blasts come from the AFB jet warm-up pads rather than the wind tunnels, although they do hear the wind tunnel operations as well.

i. On Historical and Archaeological Sites. No historical or archaeological sites are known at the location of the proposed facility, and the possibility of uncovering any new ones during construction is very remote. Daytime visitors and workers at existing sites of historical interest in the vicinity (see Figure 20) should not be affected by the intermittent operations of the NTF.

j. On Aesthetics. From Armistead Avenue and from the trailer court, most of the NTF will not be visible; the tree line along the road and the existing equipment and dynamometer building block the views. From the community, the top of the vent stack and the higher parts of the new building addition will be visible over the tree tops. As stated earlier, the 16 foot Transonic Tunnel and the V/STOL Tunnel dominate the view from the road.

Similarly, the views from Taylor Road on the LaRC grounds will not be adversely impacted. The new building addition will be a metal wall structure similar to the one across the street. It will be considerably higher than the existing building to which it will be attached, but it will not be out of character in its surroundings. Part of the tunnel structure will also be visible from Taylor Road though it will be shielded from view by trees and other equipment. Figure 24 depicts the new facility and its relation to the surrounding environment. No adverse visual impact will occur as a result of this project.

k. On Energy Conservation.

(i) Electrical Power:

(a) Facility Machinery: The annual electrical energy consumption of the NTF drive system is estimated at 3 million kWh per year. Two-shift operation is assumed, with a maximum line draw of 105,000 kW. This is a preliminary estimate based on an operational procedures and time constants become better defined, this estimate will be updated.

NTF data acquisition time point-to-point is estimated to be 1 to 3 seconds, whereas the 8-foot transonic pressure tunnel (TPT) typically required 20 seconds. Thus, the NTF should be on line only a fraction

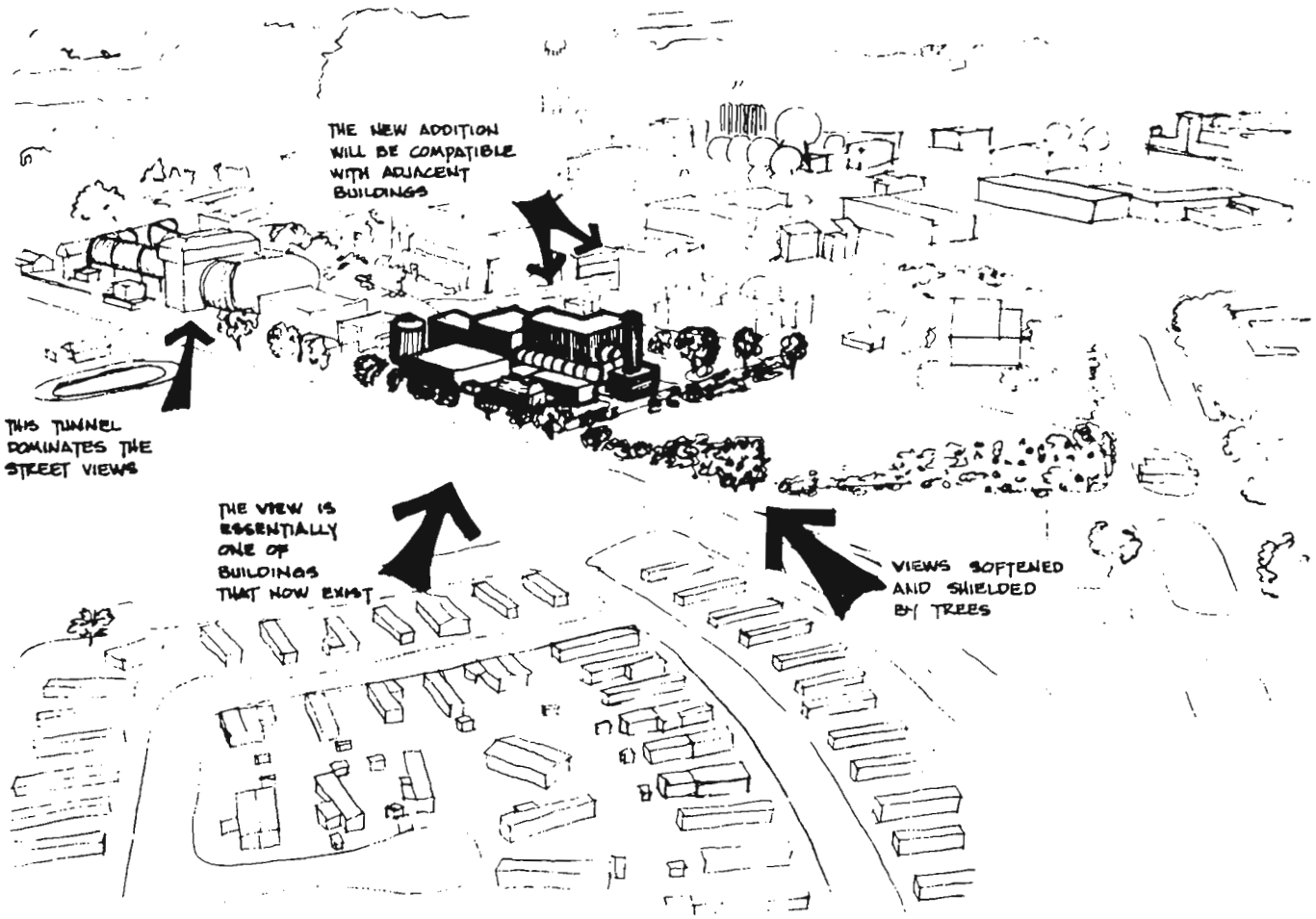


Figure 24
The National Transonic Facility in Its Setting

of the time of a conventional facility in acquiring the same amount of data. The projected NTF electrical energy consumption of 3 million kWh per year is one third the present energy consumption of the LaRC 8-foot TPT. This does not appear to be an inconsistent projection for the NTF in view of the high-speed data acquisition system to be employed.

The introduction of the NTF into the operating plan for the Langley Research Center has been assessed. The wind tunnels which will be impacted by its operation and their current electrical energy requirement as listed in Table 16, which also indicates the plan to compensate for the additional load of the NTF by reducing or deleting the operation of several other facilities. No significant increase in electric energy consumption will result; in fact, a decrease is projected.

Table 16. Present and Planned Electric Power Consumption of Four LaRC Wind Tunnels.

Facility	Present (FY 1975) Operation	Present (FY 1975) 10^6 kWh/yr.	With NTF Operational (1980) Operation	With NTF Operational (1980) 10^6 kWh/yr.
8 ft Transonic Pressure Tunnel	2 Shifts	8.6	1 Shift	5.0
4 ft Supersonic Pressure Tunnel	0.5 Shifts	2.1	Deactivated	0
7 x 10 ft Hypersonic Tunnel	1 Shift	0.2	Standby	0.2
National Transonic Facility	--	0	2 Shifts	3.0
Total		10.9		8.2

For reference, the fiscal year (FY) 1975 electrical energy consumption for the entire Center was 157 x 10^6 kWh, of which 69 percent of 108 x 10^6 kWh was base load and the remainder 49 x 10^6 kWh was used by wind tunnel drive requirements. Past and projected total LaRC electric power requirements are shown in Table 17.

Table 17. Projected Future LaRC Electrical Energy Consumption.

Year	Power (10^6 kWh)
FY 73 (actual)	196
FY 74	171 (before energy crisis)
FY 75	157
FY 85 (target)	117

The estimated NTF energy needs correspond to about 2.5 percent of the total LaRC energy consumption projected for the 1980 time period.

(b) Liquefaction of Nitrogen: The projected LN_2 consumption of (44,000 mtons) per year will require electrical energy in the amount of 45 million kWh per year. This electrical load will be external to

the LaRC distribution system, the LN_2 production will be by commercial sources. The electrical load will probably be drawn from the local VEPCO network because of the economic desirability of producing the LN_2 within the general vicinity of LaRC. The consumption is less than one-half of one percent of the total VEPCO capacity. VEPCO management, from their regional office in Richmond, Virginia, predicts that a user of power with a 90 to 100 percent steady load factor in the amounts necessary for a LN_2 production facility would create no particular strain on their projected power supply. The cost of the electrical energy will, of course, be borne in the LN_2 charges to NASA. This cost is estimated to be about 64 percent of the operating costs for the NTF.

(ii) Vehicle Fuel: The NTF will require 1,916 truck deliveries of LN_2 per year, assuming an annual consumption of 40,824 m^3 (12×10^6 gal) and a truck capacity of 21.31 m^3 (5,500 gal). Since the location of the LN_2 plant is unknown, truck fuel consumption cannot be calculated. If, however, we assume the worst case, that the LN_2 plant would be located at the upper end of the Peninsula, the truck round trip distance would be about 290 km (180 mi). Assuming fuel consumption rates of 1.9 km/l (4.5 mpg) for diesel and 1.7 km/l (4.0 mpg) for gasoline, the annual truck fuel consumption would be 2.92×10^5 l (7.66×10^4 gal), or 3.27×10^5 l (8.6×10^4 gal) per year, respectively.

(iii) Net Energy Impacts: Net energy impacts of the NTF were calculated by converting all energy consumption values to common units, adding the uses and subtracting the energy saved by curtailed operation of existing wind tunnels. The results are shown in Table 18. The production of LN_2 is obviously the overwhelming factor in the energy impacts of the NTF.

Table 18. Net Energy Consumption of the NTF.

Consumer	kWh/yr x 10^6	Btu/yr x 10^{10}	Cal/yr x 10^{10}
NTF			
Fan Drive	3.0	1.02	2.63
Auxiliaries	0.4	0.14	0.35
Building Loads	0.7	0.24	0.61
Compressed Air	0.5	0.17	0.44
Diesel Vehicle Fuel	4.1	1.41	3.64
LN_2 Production	45.0	15.30	39.47
Sum	53.7	18.28	47.14
Cutbacks			
Existing Tunnels	-4.1	-1.4	-3.61
Building Loads	-0.7	-0.24	-0.61
Difference	48.9	16.64	42.92

The 48.9×10^6 kWh per year required by the NTF is enough energy to operate about 1,956 average all-electric homes for one year (assuming such a home consumes 25,000 kWh/yr).

1. Relationship Between the Proposed Action and Other Regional Plans. In addition to the NTF, NASA LaRC is also proposing the construction and operation of a refuse-fired steam generating facility at a nearby site in the West Area. The proposed steam generation will result in more than 20,000 truck trips per year for refuse and ash hauling.

This truck traffic will be combined with that of the LN_2 delivery trucks along State Highway 172, but the combined noise and traffic congestion impacts would still be within acceptable levels. Neither set of trucks will likely be in the area during rush hours.

One of the net effects of the proposed refuse-fired steam generator on air quality will be a marked reduction in the total suspended particulate load owing to the use of an electrostatic precipitator and curtailed operations of the existing steam plant. Since such particulates could exacerbate the fog-producing potential of the NTF by serving as condensation nuclei, the proposed steam plant would somewhat lessen the probability of fog problems from the NTF.

The combined electric power requirements of the two projects will not overload the present power supply to LaRC; however, changes in Federal electrical requirements will have a bearing on present and proposed Virginia Electric and Power Company, power production and expansion plans. The main direction of VEPCO's new development is to use more coal and especially uranium to generate additional electricity. Their Annual Report for 1975 predicts that by 1977, half the power they supply will be generated by nuclear facilities. Federal users in their service area (eastern and central Virginia and northeast North Carolina) consume 7 percent of the electricity they produce.

B. INDIRECT ENVIRONMENTAL EFFECTS

One of the major operating features of the NTF that may induce secondary business development is the use of large volumes of liquid nitrogen, on the order of 0.44×10^5 mtons (45,000 tons) per year. Discussions with liquid nitrogen manufacturers revealed that the break-even point for building a new plant is only 0.49×10^5 mtons of liquid nitrogen annual production. Thus, with the annual consumption of liquid nitrogen anticipated for the wind tunnel, construction of a new liquid nitrogen plant is probable.

The manufacturers estimated that the plant building would require 7432 m^3 (80,000 ft^3) and the total value of plant and equipment would be approximately $3,000,000. Other requirements of the plant would be a continuous load of 5,500 kW of electricity and 380-950 liters of water per minute for cooling purposes. The plant would employ four to five persons for maintenance and monitoring the equipment. These estimates were based on the plant operating continuously with peak demands being satisfied from storage facilities.

The $3,000,000 liquid nitrogen plant, if privately owned and located in Hampton, would be a net addition to the Hampton City tax base, yielding to the City $58,000 in revenue annually.

IV. ALTERNATIVES TO THE PROPOSED ACTION

A. ALTERNATIVE METHODS OF ACHIEVING HIGH REYNOLDS NUMBERS.

The Reynolds number, the ratio of inertial to viscous forces in the air stream, is defined by the following equation:

$$R_{\bar{c}} = \frac{\rho_\infty u_\infty b}{\mu_\infty}$$

where

ρ_∞ = free-stream density
u_∞ = free-stream or flight velocity
μ_∞ = free-stream viscosity
b = characteristic vehicle dimension (often wing span or length).

A transonic wind tunnel with high Reynolds number capability can be designed by manipulating any three of the above four parameters. Velocity cannot be increased sufficiently to achieve Reynolds number at transonic speeds since compressibility effects, which require the simulation of Mach number, are also important.

1. Increased Scale Of Test Model.

Increasing the scale of the test model, or parameter "b," leads to very large test facilities that require prohibitively large drive systems. As the scale is increased, the test section size must increase correspondingly. The achievement of even 50 million Reynolds number with ambient temperature and pressure requires a test section height of more than 5.5 m (18 ft) and over 373,000 kW (500,000 hp) for the drive. The large facility and huge drive power requirement make this approach to achieving 120 million Reynolds number prohibitively costly. Electric motors cost about $112 to $150 (unescalated) per output kilowatt; therefore, the motor alone for the above tunnel would cost at least $41.2 million.

There are also environmental problems with this approach. A fan-driven, non-cryogenic tunnel would have to be water cooled in order to dissipate the heat from the drive system. For a tunnel of the appropriate size, this would require the evaporation of 66.6m^3 (17,600 gal) per minute per an 11°C (20°F) temperature rise. There would be significant noise problems with this tunnel, too, due to the increase in fan power by a factor of eight. Another alternative, the use of a blowdown type tunnel, would avoid the heat dissipation problem, but the discharge of high pressure air through the tunnel to atmospheric pressure would produce a severe noise problem. Blowdown tunnels would also require 3 to 24 times as much total energy to produce the desired Reynolds numbers.

2. Increased Density Of Test Gas.

A second approach involves increasing the density of the working gas, by increasing the pressure. The pressure-density also affects the test dynamic pressure and therewith the aerodynamic loads on the test model. For example, for the case of 50 million Reynolds number and for a test section height of 2.4 m (8 ft) the test dynamic pressure is approximately six times the level in existing tunnels. The corresponding increase in aerodynamic loads on the test model would require increases in the size of the model support system which would increase the uncertainties associated with model-support interference. The target Reynolds number of 120 million would result in a dynamic pressure 2.4 times as great as that at 50 million or about fifteen times the usual load. At such a load the aeroelastic deformation of the model becomes significant, and the resulting aerodynamic forces and moments on the model due to deformation would prevent accurate isolation of Reynolds number effects.

3. Decreased Viscosity Of Test Gas.

The third approach to obtaining large Reynolds numbers, the approach chosen for the NTF, is through the use of a cold test gas. By decreasing the temperature from 49°C (120°F) to -172°C (-280°F), a fivefold increase in Reynolds number is achieved. This increase is obtained largely as a result of the reduction with temperature of the viscous term, μ_∞, in the denominator of the Reynolds number equation, thus increasing the magnitude of the Reynolds number. Reductions in temperature do not cause a change in dynamic pressure. Consequently, by using temperature as a test variable, the Reynolds number can be varied while maintaining a constant aerodynamic load on the test model (keeps a constant model shape). By this means, the effects of Reynolds number, dynamic pressure (aeroelastic deformation), and Mach number can be isolated and studied separately. Moreover, since power required to drive the tunnel diminishes with temperature, testing at high Reynolds number using the cold gas approach can be achieved with drive power levels about equal to those for existing drive systems.

B. ALTERNATIVE LOCATIONS FOR THE NATIONAL TRANSONIC FACILITY.

The LaRC site was recommended by majority decision of the 1974 National Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board. The panel was comprised of four NASA representatives and four Department of Defense representatives (two for the Air Force, one for the Navy, and one from the Pentagon). In reaching their recommendation, the panel considered two other sites:

- Arnold Engineering Development Center, Tennessee (AEDC)
- NASA Ames Research Center, California (ARC)

The factors in this decision are discussed below.

1. Capital Costs. The NTF would be implementable at each of the three sites in almost identical forms. Each site would use existing drive motors shared with other existing facilities. There are differences in the availability of existing liquid nitrogen storage capacity. Average construction project costs suggest that the differences among sites would produce a cost spread of about 5 percent to 10 percent, with LaRC having the highest cost and ARC the lowest. However, the NTF construction project is heavily dominated by the fabrication of a specialized cryogenic steel pressure shell. There is evidence that the regional cost differential does not exist for the pressure shell. Therefore, capital cost differences among the three locations are insignificant.

2. Operating Cost. The direct cost of operating the NTF is estimated to be about $3.6 million per year. Roughly fourteen percent of this is for personnel cost, 1 percent to 2 percent for electrical power for tunnel drive, and the balance for liquid nitrogen. It is thus apparent that any significant differences between sites would have to show up in the cost of liquid nitrogen. It is anticipated that the present agreement between NASA and DOD which involves averaging the LN_2 costs over many geographical areas and charging each center this average cost will be in effect at the time the NTF is operational. This means that the LN_2 costs will be essentially the same regardless of location. Thus, all operating cost differences among the three locations are insignificant.

3. Operation and Performance Advantages. Although all sites would employ existing drive power shared with other facilities, and would thus have to coordinate schedules with other facilities, the historical and projected utilization rates make it clear that this would pose no significant limitation on operation of the NTF at any of the sites. There are no significant performance differences among the sites. (AEDC has the disadvantage that the NTF would share power with two other major national facilities, while at LaRC and ARC power would be shared with only one other facility. LaRC has the disadvantage that those runs at maximum power for maximum Reynolds number near Mach 1 would be limited to 10 minutes due to utilization of an intermittent drive motor rating. These differences are considered quite insignificant.)

4. Environmental Factors. The NTF poses potential environmental impact issues; however, the panel concluded that environmental impact issues could be satisfactorily resolved at all three sites.

5. Staff and Programs. The panel recommended that the National Transonic Facility be located at the NASA Langley Research Center. The decisive factor in the panel's recommendation was the value it attached to a close facility association with the LaRC research staff. LaRC is one of the world's centers of excellence in transonic research at present, and has provided leadership in many of the important innovations and advances in understanding in this field over the past 30 years. Not the least of these LaRC achievements has been the recent advance in cryogenic wind-tunnel technology which makes the recommended configuration of the NTF a viable and cost-effective option for meeting the national needs in a single facility. As a result of the recent reassignment of roles and missions of the various NASA centers, LaRC has the prime responsibility for long-haul aircraft technology. As a consequence, LaRC has the principal responsibility for the development of aircraft performance at transonic speeds.

In the urgent problem-solving mode that often arises in systems development, the broad resources of a co-located research center can be committed to provide an early and effective solution. LaRC has excellent interfaces with both military and civil users. Both Army and Navy have technical groups at Langley. USAF has a liaison office plus the Tactical Air Command HQ. NASA's Technical Advisory Council and Technical Committee structure provide highly productive communications with the entire aeronautical community. The majority of the panel concluded that the advantages of the LaRC site far outweigh the possible fractional economic advantages of other sites outlined in the preceding paragraphs.

C. ALTERNATIVE MEANS OF GASEOUS NITROGEN DISPOSAL

1. Jet Engine-Induced GN_2 Stack Draft. Jet engines could be employed in place of the fans to blow the cold GN_2 up the stack. The advantage of this is that the hot exhaust of the jets could warm the GN_2 to the point of minimizing the ice and fog problem. There are several disadvantages. The engines would require the use of jet fuel and would themselves generate detrimental emissions: carbon monoxide, carbon dioxide, hydrocarbons, and nitrogen oxides. They would also add considerably to the noise potential of the stack.

2. Alternative Stack Design. Stack size could be increased to permit mixing more air with the GN_2, thereby raising the temperature enough to eliminate ice and fog. The volume of air would have to be at least tripled. Increasing the diameter of the stack would decrease its ability to attenuate noise; however, it would make it more feasible to install a system of baffles in the stack. Such baffles could decrease the noise at the stack opening by a significant amount. The exact valve would depend upon the detailed design of the baffles and the stack diameter.

Another stack modification would involve installing an egg crate grid at the stack opening. If such a grid can be designed to allow proper gas flow, it could provide up to a 13 dBA reduction based on a grid with 1" x 1" openings. Such reduction lessens appreciably with grid opening size and is only about 6 dBA for a 4" x 4" grid.

3. Storage and Energy Recovery. The recovery of the energy represented in the cold GN_2 is an attractive idea; however, it is not economically feasible to do so. To recompress the gas at the rate of release would require 22 compressors with a total power requirement of 160,000 kW. This would far exceed the available electric power and would also require an enormous capital investment. Storage of the cold gas in a large insulated tank for recompression at a slower rate is also not feasible because of the enormous tankage required and the large compressor requirement to reduce back pressure on the wind tunnel.

D. NO ACTION

The No Action alternative is that the NTF will not be built in any location. This alternative will save the approximately 65 million dollars of capital costs and most of the 3.6 million dollars of annual operating costs. The latter cannot be entirely saved because testing of flight configurations will continue in other facilities. No action will also save approximately 45×10^6 kWh of electricity per year that would be required to manufacture the liquid nitrogen. Other resources that would be saved include the steel and other construction materials.

The No Action alternative also means that the environment on and about the LaRC site would remain essentially in its present condition. The potential impacts indentified in Chapter III of this report would not have to be considered. Most important of these are the noise, and air hazard questions assiciated with the release of large quantities of extremely cold gaseous introgen.

The No Action alternative implies as well that flight configurations will continue to be tested and designed with the existing limitations. This means that prototype aircraft will continue to be subject to expensive redesign, amounting to multimillions of dollars, with concomitant delays in becoming operational. The lack of the NTF would jeopardize the continuing superiority of the United States in aeronautics and astronautics and, thereby, national security.

V. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

The following unavoidable adverse impacts will occur during construction of the proposed plant.

- New short-term noise sources will be introduced from construction-related vehicles and equipment and machinery used in demolition or construction.

- Minor amounts of airborne emissions, i.e., fugitive dust, construction vehicle, exhaust, welding vapors, and dust from pouring granular perlite insulation, will be created.

- A few LaRC operations will be disrupted during construction. Personnel will be relocated; utilities will be briefly interrupted while connections are made; and during pile-driving activities, vibration-sensitive research would be affected.

The following unavoidable adverse impacts will result from the operation of the proposed facility.

- Cryogenic testing creates an exhaust gas temperature into the stack of about -157°C (-250°F). Ambient temperatures at ground level may be depressed as much as 24°C (43°F). While this will have little or no direct impact, it could create local fog or snow resulting in hazardous driving conditions. In the winter, snow could accumulate on ground surfaces, exacerbating driving hazards. The NTF will not vent gaseous nitrogen when meteorological conditions are favorable for hazardous amounts of fog or snow production.

- Venting of air and gaseous nitrogen into the facility's stack will produce a typical noise level at the stack opening of 125.5 dBA and noise levels at State Highway 172 will be approximately 95 to 97 dBA. At the closest boundary of the nearby trailer court, typical noise levels will be 73 dBA rising to 80 dBA on relatively rare occasions. This 73 dBA level represents a 8 dBA increase over the existing noise levels of the 16-foot tunnel. These noise levels may startle passing drivers and cause an annoyance to nearby residents.

- Total annual net power consumption will be about 48.9 million kWh including NTF operations and liquid nitrogen production. This electricity would be produced by burning oil or coal or by nuclear fission, depending upon the location of the nitrogen plant and the source of electric power to the NTF.

There are no anticipated inconsistencies with land use plans as a result of the proposed actions.

VI. SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The short-term uses of the environment must be weighed against the long-term benefits resulting from the implementation of the proposed National Transonic Facility. The important demands made on the environment include power consumption of 48.9 million kWh per year, occasional short-term disruption of the nearby climatic conditions, occasionally high noise levels, and an extremely small probability of a damaging structural failure of the wind tunnel shell.

The acceptance of these demands results in major benefits to the national aeronautic program through the improvements in transonic testing. Millions of dollars and many man-years of effort can be saved for aircraft designs now under consideration through accurate Reynolds number testing. The rate of technical advance in transonic testing, which has been hindered by the lack of adequate facilities, will be accelerated, and needed new flight systems will be incorporated earlier.

VII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

This section points out resources committed to this project--whether or not they are in short supply--the employment of which would foreclose alternatives for their use. Commitments identified for the proposed plant are as follows:

- Commitment of monies as capital and operating expenditures, including the costs of labor and materials, forecloses other public uses of these funds. These amount to $52 million in capital costs and about $2 million per annum more for operating costs than for the present testing program.

- The commitment of 48.9 kWh of electricity per annum and the fuel resources used to produce this power involve the consumption of a nonrenewable resource. Additional minor commitments of petroleum products are made for the transport of the liquid nitrogen to the facility. In addition, the energy consumed in the production of steel and other components for the NTF represents another major commitment of irretrievable resources.

VIII. RESPONSES TO COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE CONSTRUCTION AND OPERATIONS OF THE NATIONAL TRANSONIC FACILITY AT THE LANGLEY RESEARCH CENTER

Comments on this Draft Environmental Impact Statement were solicited from the federal, state, and local agenices listed on pages vii and viii of this document. These comments are included in Appendix E. Specific subjects addressed in these comments are discussed in the following paragraphs.

A. NOISE

The Environmental Protection Agency (EPA) and the Department of Transportation expressed concern at noise levels at State Highway 172, which is immediately outside the LaRC property line, and at the trailer court.

The analysis of the gaseous nitrogen vent system noise presented in the Draft Statement did not include any consideration of acoustical treatment and showed that noise levels as high as 95 to 97 db(A) from the untreated vent stack system could be experienced at Armistead Avenue, Virginia State Route 172. Subsequent acoustical design studies have developed a concept of using a bulk acoustic absorber lining in the flow passages downstream of the nitrogen vent control valve, which is the major source of noise in this system. This technique is calculated to reduce the vent system noise levels at the nearest residence to 52.7 dB (A), and leaves the tunnel fan noise as the dominant source for noise levels at the highway and at the trailer park.

Acoustical analyses for the tunnel have defined a dual cavity resonator to be installed on the tunnel walls and nacelle both upstream and downstream of the tunnel drive fan. This treatment is primarily to prevent excessive sound pressure levels within the tunnel test section which would interfere with data from the models. This lining also prevents build up of noise due to reinforcement around the closed tunnel circuit. The most pessimistic analyses indicate that the maximum tunnel noise levels that could exist at the nearest residence would be 71.7 dB(A). These analyses are for maximum power operation of the NTF, and do not consider any attenuation due to the thermal insulation inside the tunnel. The analyses also use reduced attenuation factors for all frequencies below the tunnel ring frequency although there is question as to whether this attenuation reduction would not occur only for frequencies near the ring frequency. Finally, the far field attenuation factor of 6 dB(A) per distance doubling which was used for these calculations does not consider the additional attenuation which would result from ground cover and intervening structures. Examination of noise data for the nearby 16-foot tunnel shows that attenuations of 7 to 9 dB(A) per distance doubling occur for distances equivalent to the 150 m (450 feet) from the NTF to the nearest residence, and at greater distances, attenuations up to 16 dB(A) per distance doubling occur. Allowing for the considerations just mentioned, the maximum noise level at the nearest residence should be approximately 64 dB(A).

The 16-Foot Transonic Dynamics Tunnel currently produces maximum noise levels of 65-66 dB(A) at the nearest residence. The 16-foot tunnel typically operates once per night approximately 1/2 hour at maximum power and 1 1/2 hours at reduced levels. The NTF operation at maximum levels cannot continue for more than approximately ten minutes at a time, and would not occur more often than two times at maximum power or 4 times at lower power levels in any 8 hour shift. As noted earlier in this statement, it is impossible for the NTF and the 16-foot tunnel to operate simultaneously.

With the acoustical treatment, the maximum noise level at Armistead Avenue from nitrogen venting will be approximately 60 dB(A) and from tunnel operation will be approximately 74 dB(A). Both of these levels will be sufficiently low that there will not be a hazard due to startling passing motorists.

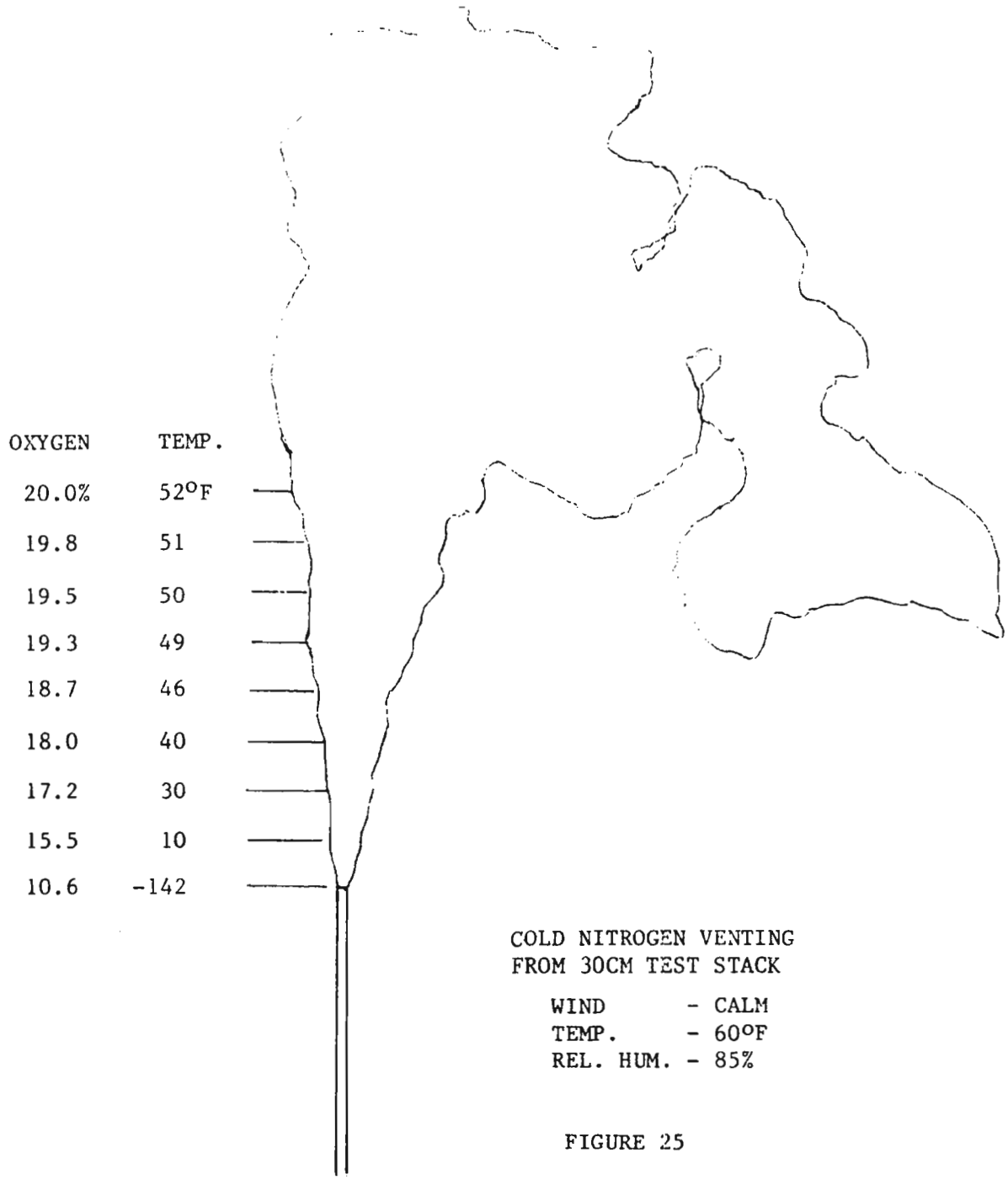
B. COLD NITROGEN GAS VENTING

The EPA, Department of Defense, and Department of the Interior raised questions relative to the effects of venting of cold nitrogen gas into the atmosphere.

The NTF will vent nitrogen gas at temperature ranging between ambient and -157°C (-250°F) at rates between 3 and 544 kg/sec (6 and 1200 lb/sec). All descriptions of environmental effects are based on the maximum conditions of -157°C and 544 kg/sec.

An initial series of runs have been made with the 30 cm (12 in) diameter 12m (40 ft) high test stack discharging cold nitrogen with upward velocities of 9 to 30 m/sec (30 to 100 ft/sec) and wind velocities ranging from 0 to 5 m/sec (0 to 11 mi/hr). Examination of the results of these tests indicate that mixing occurs rapidly in the ascending jet of gas, as predicted by the turbulent jet analytical model, and that the conditions calculated from the PTMAX and PTDIS modeling techniques on page 89 to 92 of this statement are unrealistically pessimistic.

Figure 25 is an illustration of the plume which resulted from the discharge of nitrogen/air mixture at 30 m/sec (100 ft/sec) upward velocity from the test stack under calm wind conditions. The maximum plume height is approximately 26m (85 ft) above the top of the stack. The ambient conditions during this test were 15.5°C (60°F) and 85% relative humidity. Mixing ratios of air to nitrogen in the ascending jet, calculated from the observed jet diameter and momentum of the jet, were used to calculate the average temperature and oxygen concentration shwon at the various levels of the plume. The dew point at the time of this test was 13°C (56°F) and the observed limit of the plume would be close to this temperature.



COLD NITROGEN VENTING
FROM 30CM TEST STACK

WIND - CALM
TEMP. - 60°F
REL. HUM. - 85%

FIGURE 25

Calculations of the performance of the full size vent stack using the turbulent jet model yield mixing ratios at the same fraction of total plume rise that are in agreement, within less than 15% difference with those indicated from the 30 cm (12 min) test stack. Thus, both the analytical model and experimental observations support the conclusion that there will be no hazard associated with the temperature or oxygen content of the cold gas plume at ground level, regardless of where plume touch down occurs. The only effect on wildlife would be to birds which might fly directly into the lower portion of the ascending plume, where the temperature, especially in winter, could be as low as -100°C (-150°F) at the top of the stack and remain at temperatures below -18°C (0°F) throughout the lower third of the ascending plume.

Fog remains as a problem which will have to be controlled by constraints on the operation of the NTF. The discharge of cold nitrogen gas from the vent stack will be accompanied by a visible plume of condensed water vapor under most of the NTF cryogenic operating conditions. This plume would present a hazard only if it persisted long enough to produce a condition of reduced visibility in a critical area such as a highway or the runways and approaches to the LaFB. The amount of mixing with ambient air required to evaporate the condensed water is a function of the ambient relative humidity, and this will be a primary constraint on NTF operations. Tests with the 30 cm diameter vent stack under condition of 85% (Figure 25) and 87% relative humidity showed that sufficient mixing occurred to prevent fog at ground level. Further tests and analyses will be used to determine the maximum relative humidity, probably between 90 and 95%, above which cloud persistance will be a problem and cryogenic operations of the NTF will not be permitted. Each type of cryogenic tunnel run will have an associated nitrogen temperature and venting rate. These conditions of nitrogen venting, together with ambient relative humidity and wind speed, will determine the maximum distance to which the cloud can persist and the minimum distance from the vent stack at which the cloud could touch the ground. The wind direction determines whether a given distance of cloud conditions would constitute a hazard. For instance, if the wind is from the south there are no major roads within 13,000 feet, while if the wind is from the north a hazard due to ground level fog would exist at all distances grater than about 100 feet and an air borne plume extending beyond 3500 feet could interfere with aircraft approaching LAFB runway 7. Therefore, for each condition of cryogenic operation of the NTF, a matrix of allowable relative humidity, wind speed and wind direction will be developed, and operation of the NTF under conditions which could present a hazard due to fog will not be permitted.

Studies are underway to further refine mathematical models which can predict the performance of the cold gas discharge from the full size NTF vent system under the full range of operation and weather conditions. These studies include correlation of experimental results obtained from the 30 cm diameter test stack into the analytical model. Final verification of the analytical models will be obtained during the start-up phases of the NTF, where discharge of nitrogen from the NTF vent stack at reduced rates and under conditions of favorable wind direction and speed will be compared to the analytical predictions.

Operations at higher venting rates or with wind blowing towards critical areas will be made only after the behavior of cloud dispersal is fully defined and it is known that no hazardous condition will result. Winds in this vicinity are from the directions between south southeast and west southwest 36 percent of the time on an annual basis and are the most favorable directions for dispersing the cloud resulting from cold nitrogen venting, since the nearest critical areas would be from 2000 meters to more than 4500 meters downwind. Winds from the directions between west and north occur 25 percent of the time and would blow the cloud towards LAFB runway 7 which lies between 1200 and 2000 meters from the NTF. No NTF cryogenic runs will be made where the wind is from these directions until it is positive that the cloud will disperse before reaching the runway or its approach. Winds from the remaining directions will carry the cloud towards highways, the nearest of which is State Route 172 which passes within about 60 meters of the NTF. Similar precautions will be taken to be sure that conditions are such that the cloud will not touch ground level at one of these highways.

The role of air borne particulates on fog persistance has been questioned, particularly with regard to the refuse burning steam generating facility which is proposed to be constructed at the LaRC. This proposed facility will be equipped with electrostatic precipitators and will result in a net decrease in particulates when it goes into service and the use of the existing oil-fired steam plant is reduced. The current particulate levels have not resulted in persistant fog in any of the runs discharging cold nitrogen from the 30 cm dia test stack.

The possibility of accumulation of snow on the ground as a result of the cold nitrogen venting has been discussed as a possibility. This will be evaluated further by runs of the test stack during subfreezing conditions. All tests so far have been made during warm weather conditions and no precipitation from the cloud has been observed, although the initial temperatures within the cloud are far below freezing. Operation of the NTF during subfreezing weather will be approached cautiously until the possibility of snow accumulations is fully defined.

Several measures have been suggested to minimize the potential for hazards to result from the venting of cold nitrogen gas. These measures are discussed in the following paragraphs.

1. Consider increasing diameter of vent stack to allow the nitrogen to mix with a greater volume of air.

The amount of mixing of the nitrogen with ambient air to avoid fog is a function of relative humidity and nitrogen temperature, and falls into the range of 20/1 to 40/1 ambient air to nitrogen by weight. The stack diameter required, if this degree of mixing were to be accomplished before discharge of this gas, would be excessive. The approach being pursued, therefore, is to ensure that the gas velocity will be sufficiently high to produce effective turbulent mixing with ambient air, and a minimum of ambient air is mixed with the nitrogen before

leaving the stack so that under no conditions could a cloud with a lethal oxygen deficiency reach the ground. Both the analytical modeling and the results from the 30 cm diameter test stack indicates that this turbulent mixing is very effective. An additional design study is being conducted on the possible use of an ejector system where the discharge velocity of the nitrogen could be used to draw in mixing air at the base of the stack. This system could possibly yield higher mixing ratios or higher velocities at the stack exit.

2. Consider increasing stack height to increase time for mixing before gas reaches the ground.

This is under consideration as one of the parameters of the discharge system and the stack height may be increased.

3. Consider possibilities of venting gas away from sensitive receptors.

Locating the vent stack remote from the NTF could reduce somewhat the constraints of weather conditions on NTF cryogenic operations. However, this would require use of a pipe at least 1.5 m (5 feet) in diameter made of a material compatible with cryogenic temperatures to convey the nitrogen gas to this remote point. Even with this diameter, interference with the ability of the NTF to be operated at low internal pressures would result. Further, this pipe would have cross roadways and utility trenches to reach any location which would give significant distance from sensitive receptors and would therefore either have to be elevated or run deeply below grade. It does not appear that reduction in operating constraints in the manner is practical.

4. Consider venting exhaust heat into the cold nitrogen vent stack to warm the emission.

This area is under continuing examination both from the point of view of saving energy by making use of this cold gas and from the advantages of warming the exhaust nitrogen. The major problem in developing a practical system is due to the intermittant, high rate nature of the operation. Any practical methods that can be developed in this area will be applied.

C. AIR AND WATER QUALITY

The Council on the Environment of the Commonwealth of Virginia trasmitted comments on several areas of air and water quality.

1. Air Quality During Construction

a. Fugitive Dust

This project is not expected to produce significant quantities of fugitive dust. No concrete batching, rock crushing, or similar activities will be performed on-site. Hard surfaced roads currently at the site and a 15 foot wide crushed stone road which will be laid to provide access to material and equipment storage area will minimize the amount of traffic required over dirt surfaces. The amount of excavation and back fill required for this project is relatively small. Much of the excavated material will be from below surface ground water levels and will be transported in moist condition to its dumping area. Material storage at the site will consist primarily of semi-product items such as pile casings, electrical cable, steel plates for the tunnel, etc. There will be no on-site storage of bulk items such as sand, portland cement, etc., which are more likely sources of dust. Construction operations will be monitored, and measures such as wetting will be applied as needed to prevent dust nuisance.

b. Smoke from waste burning.

There will be very little combustible wastes from the construction of this facility. The site is previously developed land from which only a small quantity of shrubbery will have to removed. No burning of any sort of debris or wastes will be permitted on the LaRC. The contractor will remove all debris to commercially available disposal sites.

2. Air quality during operation.

This facility will have a requirement for steam for space heating and process use. This steam will be obtained from the existing LaRC steam distribution system. The total steam requirement will be equivalent to the consumption of 110 m^3 (29,000 gallons) per year of #6 fuel oil at the LaRC central steam plant. By the time the NTF in ready, it is expected that the proposed refuse-fired steam generating facility will be in operation at LaRC. This facility will reduce the quantity of #6 fuel oil consumed at LaRC from the present 11,000 m^3 (3×10^6 gallons) to 3,000 m^3 (800,000 gallons) per year, decreasing the emission of sulfur oxides, nitrogen oxides, and particulates and producing an increased emission of carbon monoxide and hydrocarbons. Part of the steam required for the NTF will be available from the refuse-fired facility but, since peak winter heating loads and high rate process steam usage will have to be supplied by supplemental operation of the oil-fired plant, it will be assumed here that all of the steam required for the NTF will be derived from oil. The net effect on combustion pollutants in kg/year are tabulated below.

	Particulates	Sulfur Oxides	Carbon Monoxide	Hydro Carbon	Nitrogen Oxides
NTF Steam Requirements	295	5,155	54	37	1,028
Refuse-Fired Steam Facility	-1,452	-333,015	66,583	31,979	-8,362
	-1,157	-327,860	66,637	32,016	-7,334

3. Water quality.

There are no new sources of water pollution that will result from operation of the NTF. Chromates are maintained at approximately 8 parts per million in the cooling tower system for corrosion control. Blowdown water from the cooling tower is treated to remove chromates by reduction and precipitation before the water is dumped. Floor drains and area catch basins are piped into a storm sewer equipped with an oil skimming basin which will trap any oil or hydraulic fluid spills. There are no large storage tanks for oils or chemicals and there will be no chemical laboratories in this facility. Areas in which drums of chromate, oils or soluents are handled will have spill protection.

No new materials will be introduced into the sanitary landfill which is operated by the Air Force and which currently receives refuse from LaRC, Fort Monroe and the Veterans Administration as well as the refuse from the LAFB. Before the NTF is completed, it is expected that the refuse-fired steam generating facility will be operational and this landfill will be closed, the refuse from the federal agencies and from the City of Hampton being burned in this facility. No wastes from NTF construction or operation will be introduced into the old construction landfill area on the LaRC.

D. General.

Other comments forwarded by the Virginia Council on the environment concerned electrical energy and the major thoroughfare status of Route 172.

It is intended that the NTF runs at high power levels will be performed at night during low demand hours to minimize the effect of the facility's power requirements on the peak demand of the electrical grid from which it operates. This is the same practice which is currently used for operation of the LaRC 16-Foot Transonic Dynamics Tunnel.

Route 172 is recognized as a major thoroughfare in planning constraints on the NTF operations to avoid hazard of fog conditions on highways.

LITERATURE CITED

Associate Deputy Administrator, NASA. 1974. NASA Management Instruction 8800.7C - Guidelines for Conducting Assessments and Preparing Environmental Statements Required by the Environmental Policy Act of 1969. Washington, D. C.

Barnard, T. A. 1975. City of Hampton tidal marsh inventory. Special Report No. 60. Virginia Institute of Marine Science. Gloucester Point Virginia. 64 pp.

Bollinger, G. A. and M. G. Hopper. 1972. The earthquake history of Virginia, 1900-1970. Virginia Polytechnic Institute and State University. Blacksburg, Virginia. 85 pp.

Bolt, Beranek and Newman, Inc. 1975. Preliminary noise analysis of the proposed NASA Langley high Reynolds number transonic research wind tunnel. For NASA.

Braun, E. L. 1950 (facsimile edition 1967). Deciduous forests of eastern North America. Hafner Publishing Company. New York, N. Y. 596 pp.

Byrd, M. A. and D. M. Ware. 1973. Preliminary survey of the flora and selected fauna of Langley Air Force Base. Smithsonian Institution (unpublished). 65 pp.

Coffman, J. L. and C. A. von Hake. 1973. Earthquake history of the United States. U. S. Department of Commerce, National Oceanic and Atmospheric Administration. U. S. Government Printing Office. Washington, D. C. 208 pp.

Commonwealth of Virginia, State Water Control Board. 1970. Water Quality Standards.

Division of Mineral Resources. 1963. Geologic map of Virginia. Department of Conservation and Economic Development, Charlottesville, Virginia, 1 map.

Hampton Planning Commission. 1970. Comprehensive plan, land use. Hampton, Virginia.

Hunt, C. B. 1967. Physiography of the United States. W. H. Freeman and Company. San Francisco. 480 pp.

Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States. American Geographic Society. New York. 38 pp. + 110 plates + map.

Langley Research Center. 1971. Langley Research Center Institutional Environmental Impact Statement. Hampton, Virginia.

Langley Research Center Historical and Archaeological Society. 1974. A short history of historical properties now included in the west area of Langley Research Center, NASA. Hampton, Virginia.

Little, E. L. 1953. A checklist of native and naturalized trees of the United States (including Alaska). Agriculture Handbook No. 41. U. S. Government Printing Office. Washington, D. C. 472 pp.

Meroney, R. N., T. G. Hoot, and J. A. Peterka. October 1973. Wind tunnel tests of negatively bouyant plumes. U. S. Environmental Protection Agency Office of Research and Development.

Michael, Paul L. March 1973. Noise propagation from Langley Research Center facilities. Contract # NAS1-11926.

Minor, R. W. 1950. Field book of seashore life. Van Rees Press, New York City. 888 pp.

Peninsula Chamber of Commerce. 1974. 1974-1975 statistical data for Hampton, Newport News, Poquoson, and York County, Virginia. Hampton, Virginia.

Peninsula Planning District Commission. 1971. Interim metropolitan/ regional water quality management plan. Hampton, Virginia.

_____. January 1974. Projections for the Peninsula study area, 1970-1995. Hampton, Virginia.

Smith, R. I. (ed.) 1964. Keys to marine invertebrates of the Woods Hole Region. Contrib. no. 11, Systemics - ecology program. Marine Biol. Lab., Woods Hole, Massachusetts. 208 pp.

Smithsonian Institution. 1973. An ecological survey of Langley Air Force Base. Office of Environmental Sciences, Ecology Program. Washington, D. C.

State Air Pollution Control Board. 1975 and 1976. Virginia air. Richmond, Virginia. Vols. 5 and 6.

U. S. Department of Commerce. 1970. Bureau of the Census. General characteristics of the population.

U. S. Department of Health, Education, and Welfare. September 27, 1965. Investigation of waste disposal practices at federal installations.

Virginia State Water Control Board, Tidewater Regional Office. 1976. Water quality data for Back River and Brick Kiln Creek for 1975 (unpublished data).

Wise, E. S. 1973. A survey of the plant and animal communities of the salt marshes of the Langley Air Force Base-Langley Research Center, Virginia. A report to the Smithsonian Institution (unpublished). Christopher Newport College. 30 pp.

Woodward-Clyde Consultants. 1976. Geotechnical consulting services for the proposed National Transonic Facility, Langley Research Center, Hampton, Virginia, for Ralph M. Parsons Company for NASA. Los Angeles. 27 pp. + figures, tables, and appendices.

PERSONAL COMMUNICATIONS

Bruce, Robert: Langley Research Center.

Ellis: Sanitation Department, Newport News Department of Public Works.

Farmer, Franklin: Langley Research Center Historical and Archaeological Society.

Jones, J. Claiborne: Virginia Institute of Marine Science.

Langley Mobile Home Village staff.

Miller, Frank: Director of Public Works, City of Hampton.

APPENDIX A

CLIMATOLOGICAL DATA

Table A-1. Wind Velocities and Directions at Langley Air Force as Percentage* of Occurence from 1936 to 1970 (299,395 Observations).

Wind Direction	Wind Velocity (knots) 1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	Direction Total %	Mean Velocity
N	0.5	1.1	2.4	2.5	1.2	0.5	0.1	-	8.3	12.0
NNE	0.4	1.0	2.2	2.1	0.8	0.2	-	-	6.8	11.0
NE	0.5	1.1	2.0	1.3	0.3	0.1	-	-	5.3	9.4
ENE	0.4	1.1	1.7	0.9	0.1	-	-	-	4.2	8.5
E	0.6	1.2	1.6	0.6	0.1	-	-	-	4.2	7.6
ESE	0.7	1.3	1.7	0.6	0.1	-	-	-	4.4	7.3
SE	0.7	1.1	1.2	0.4	0.1	-	-	-	3.4	6.8
SSE	0.6	1.2	1.3	0.6	0.1	-	-	-	3.8	7.4
S	0.8	1.7	2.7	1.4	0.2	-	-	-	6.8	8.3
SSW	0.8	2.2	3.9	2.3	0.4	0.1	-	-	9.8	8.9
SW	0.9	1.8	3.2	2.3	0.5	0.1	-	-	8.8	9.3
WSW	0.6	1.3	2.2	1.9	0.6	0.2	-	-	6.9	10.3
W	0.6	1.0	1.5	1.0	0.4	0.2	-	-	4.6	9.6
WNW	0.4	0.7	0.9	0.7	0.3	0.1	-	-	3.1	9.6
NW	0.5	0.8	1.1	0.9	0.4	0.2	-	-	3.9	9.9
NNW	0.4	0.8	1.6	1.6	0.7	0.3	0.1	-	5.5	11.4
Calm	-	-	-	-	-	-	-	-	9.9	-
Velocity total%	9.7	19.5	31.1	21.0	6.1	2.2	0.4	0.1	100.0	8.5

*Percentages less than 0.1 not shown.
Source: USAF, Air Weather Service.

Table A-2. Wind Velocities at Langley Air Force Base as Percentage of Occurence by Month.

Month	Wind Velocity (knots) <1	1-3	4-6	7-10	11-16	17-21	22-27	28-33	≥34	Mean
Jan	9.8	8.7	17.3	29.1	23.0	8.6	3.0	0.5	0.1	9.2
Feb	8.2	8.0	17.3	29.1	23.4	9.2	4.0	0.7	0.1	9.6
Mar	6.9	6.2	16.1	31.0	25.6	9.5	3.9	0.7	0.1	10.0
Apr	6.9	6.4	16.5	32.6	25.9	8.2	2.8	0.4	0.1	9.7
May	7.7	8.2	19.7	34.4	22.8	5.2	1.7	0.2	-	8.6
Jun	9.3	10.8	22.7	33.9	19.2	3.4	0.6	-	-	7.6
Jul	10.9	12.5	24.2	33.4	16.1	2.5	0.5	-	-	7.1
Aug	13.2	12.6	22.6	31.8	16.2	3.0	0.6	0.2	-	7.0
Sep	11.7	11.0	20.9	30.9	18.6	4.7	1.7	0.4	0.1	7.9
Oct	12.2	10.9	19.1	28.9	20.0	5.9	2.4	0.5	0.1	8.2
Nov	11.1	10.4	18.6	29.9	20.7	6.6	2.3	0.4	-	8.4
Dec	11.1	10.4	19.0	28.4	21.0	6.9	2.7	0.4	0.1	8.6
All	9.9	9.7	19.5	31.1	21.0	6.1	2.2	0.4	0.1	8.5

Source: USAF, Air Weather Service.

Table A-3. Percentage of Wind Velocities Less Than Indicated Values, by Time of Day.

Time of Day (hr.)	% Velocity < 1 knot							
	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Jan	11.7	11.7	11.7	6.3	3.7	5.2	14.1	13.7
Feb	12.0	11.7	11.1	4.9	2.2	2.0	9.5	12.0
Mar	11.6	11.7	8.8	2.3	1.6	2.0	7.3	9.8
Apr	13.1	13.1	8.9	1.9	0.9	0.9	5.9	10.1
May	13.6	15.9	9.8	3.1	1.0	1.2	6.5	10.8
Jun	16.2	18.9	11.5	3.7	2.1	2.2	7.2	12.1
Jul	19.7	21.9	13.5	4.7	2.2	2.2	7.9	15.2
Aug	23.1	24.3	16.6	5.1	2.4	2.6	11.5	19.9
Sep	20.0	21.2	15.1	4.0	1.4	2.2	12.4	17.1
Oct	18.9	19.4	16.5	5.3	2.0	3.4	14.5	17.7
Nov	15.2	15.5	14.9	5.3	1.8	5.2	15.6	15.7
Dec	13.9	14.3	13.3	6.1	3.0	6.4	15.6	16.4

Time of Day (hr.)	% Velocity < 7 knot							
	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Jan	38.7	39.2	38.2	26.1	23.5	33.4	46.6	40.0
Feb	39.6	38.1	35.7	25.8	20.8	25.7	41.5	40.5
Mar	38.1	37.0	31.7	17.3	15.9	18.0	37.4	38.6
Apr	41.6	43.0	31.7	18.1	14.4	17.2	33.3	39.2
May	46.6	46.7	36.3	25.4	19.8	22.7	41.4	46.6
Jun	52.9	55.7	44.0	33.2	28.4	29.0	47.2	52.3
Jul	57.6	60.2	48.7	38.7	33.5	33.7	50.4	57.6
Aug	59.7	60.7	51.9	35.9	31.8	33.5	55.1	57.8
Sep	54.2	55.3	47.2	30.0	25.3	31.0	51.4	54.0
Oct	52.0	51.8	45.3	27.1	24.8	34.9	51.7	50.6
Nov	45.4	46.8	46.4	26.1	22.3	37.1	50.3	46.6
Dec	49.3	44.6	43.8	31.1	27.4	39.0	48.5	45.8

Time of Day (hr.)	% Velocity < 4 knot							
	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Jan	20.2	20.5	20.9	12.7	9.5	13.6	26.6	23.5
Feb	20.9	20.4	19.7	10.4	7.0	8.3	20.5	22.2
Mar	19.9	19.7	15.3	6.5	4.4	5.4	15.3	18.6
Apr	22.4	23.6	15.6	5.8	2.8	3.9	13.4	19.0
May	26.0	27.2	18.6	8.2	4.3	5.2	15.7	22.6
Jun	30.4	33.1	23.0	11.5	7.9	8.3	20.1	26.4
Jul	34.0	37.4	26.8	15.3	9.3	9.5	22.5	32.3
Aug	38.7	39.6	30.1	15.3	9.4	10.4	27.1	35.3
Sep	34.4	35.3	26.9	10.7	6.2	9.7	26.6	31.4
Oct	32.7	32.7	28.0	12.2	7.9	12.9	28.9	29.9
Nov	26.4	27.1	26.4	12.4	7.3	15.5	29.7	27.6
Dec	25.1	25.4	23.9	14.2	10.3	18.1	28.3	27.1

Time of Day (hr.)	% Velocity < 11 knot							
	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Jan	68.7	68.5	66.4	55.0	52.9	63.6	73.8	70.0
Feb	67.7	67.2	65.1	53.3	49.7	57.5	71.5	68.7
Mar	66.4	67.1	62.6	49.0	45.7	51.8	70.3	69.1
Apr	70.9	73.0	63.4	51.8	48.1	51.5	70.6	70.7
May	76.3	78.0	68.4	61.4	59.0	62.0	78.1	77.9
Jun	83.1	84.3	75.9	68.1	67.8	69.1	82.0	83.2
Jul	85.7	88.3	80.1	75.3	72.1	74.0	85.3	86.8
Aug	85.9	86.3	79.5	72.7	71.0	74.1	85.3	80.3
Sep	78.8	79.4	75.6	65.7	64.6	70.0	81.0	80.3
Oct	77.0	74.7	71.9	59.9	61.3	70.3	77.6	76.6
Nov	74.4	74.3	74.2	58.7	56.3	70.5	77.9	73.6
Dec	71.7	72.7	72.3	59.6	56.6	69.6	76.1	72.3

Table A-4. Relative Humidify Frequencies at Langley Air Force Base, 1936-1970.

Overall Percentage of Time Relative Humidity Greater Than Indicated Value	
Value (%)	Frequency (%)
20	99.9
30	98.9
40	94.5
50	86.4
60	72.8
70	56.1
80	37.8
90	16.1

Monthly Mean Relative Humidities And Percentage of Time Relative Humidity Is Greater Than 70 Percent		
Month	Mean	Frequency R.H. > 70%
Jan.	71.2	52.6
Feb.	69.0	48.8
Mar.	67.2	45.4
Apr.	67.0	46.0
May	70.5	53.8
Jun.	73.3	59.7
Jul.	75.4	64.3
Aug.	76.4	67.3
Sep.	75.6	63.6
Oct.	75.3	63.9
Nov.	71.3	53.8
Dec.	71.7	63.3

Source: USAF, Air Weather Service.

Table A-5. Normal and Extreme Temperatures for Langley Air Force Base.

Month	Normal Mean Temperature 1931-1964		Average Daily Limits, 1936-1964				Extreme Temperatures For 1975*			
			Low		High		Low		High	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Jan.	41.5	5.3	32	0	48	8.9	21	-6.1	75	23.9
Feb.	42.0	5.6	34	1.1	50	9.9	26	-3.3	79	26.1
Mar.	48.3	9.1	40	4.4	57	13.9	25	-3.9	81	27.2
Apr.	57.7	14.3	49	9.4	67	19.4	33	0.6	82	27.7
May	67.2	19.6	59	15.0	76	24.4	46	7.8	87	30.5
Jun.	75.4	24.1	67	19.4	83	28.3	57	13.9	93	33.9
Jul.	79.0	26.1	71	21.7	87	30.5	61	16.1	91	32.8
Aug.	77.9	25.5	70	21.1	85	29.4	64	17.8	93	33.9
Sep.	72.7	22.6	65	18.3	79	26.1	54	12.2	87	30.5
Oct.	62.1	16.7	54	12.2	70	21.1	38	3.3	83	28.3
Nov.	51.6	10.9	43	5.0	60	15.6	31	-0.6	77	25.0
Dec.	42.6	5.9	34	1.1	50	10.0	18	-7.8	70	21.1
Annual	59.8	15.5								

*Lowest temperature ever recorded was 5°F (-15°C) in January.
Highest temperature ever recorded was 103°F (39.5°C) in July.

Source: USAF, Air Weather Service.

APPENDIX B

WILDLIFE OF THE LOWER VIRGINIA PENINSULA AND LANGLEY RESEARCH CENTER AND AIR BASE

I. INTRODUCTION

The following lists are based on the 1973 "Preliminary Survey of the Flora and Fauna of Langley Air Force Base" by Byrd and Ware. The following abbreviations are used:

Status	Habitat
A - Abundant	HF - Hardwood Forest
C - Common	MPH - Mixed Pine-Hardwood Forest
U - Uncommon	PF - Pine Forest
R - Rare	AF - Alluvial Forest
WR - Winter Resident	M - Marsh
T - Transient	OW - Open Water
PR - Permanent Resident	S - Successional
SR - Summer Resident	A - Agricultural
	D - Developed Land
	G - General -- may be found in most of the above

A. AMPHIBIANS

1. SPECIES WHICH OCCUR BOTH NORTH AND SOUTH OF HAMPTON ROADS

Species	Common Name	Status	Habitat
Amphiuma means means	Two-toed amphiuma	U	Fresh water streams
Notophthalamus viridescens viridescens	Red-spotted newt	C	Fresh water ponds
Ambystoma opacum	Marbled salamander	U	HF, MPH, PF, AF
Plethodon cinereus cinereus	Red-backed salamander	C	HF, MPF, PF, AF, D
Plethodon glutinosus glutinosus	Slimy salamander	C	HF, MPF, PF, AF, D
Pseudotriton montanus montanus	Eastern mud salamander	U	Fresh water streams
Eurycea longicauda guttolineata	Three-lined salamander	U	Fresh water streams

Species	Common Name	Status	Habitat
Scaphiopus holbrooki	Eastern spadefoot toad	C	HF, MPH, PF, S, A, D
Bufo fowleri	Fowler's toad	C	G (except OW & M)
Bufo terrestris	Southern toad	C	G (except OW & M)
Hyla crucifer	Spring peeper	C	G (except OW & M)
Hyla femoralis	Pinewoods treefrog	C	PF, HF, MPH, AF, S
Hyla versicolor versicolor	Eastern gray treefrog	C	G (except OW &M)
Hyla cinerea	Green treefrog	C	Pond-stream edge
Pseudacris nigrita nigrita	Southern chorus frog	U	Pond-stream edge
Pseudacris triseriata feriarum	Upland chorus frog	C	Pond-stream edge
Pseudacris brimleyi	Brimley's chorus frog	U	Pond-stream edge
2. SPECIES WHICH PROBABLY OCCUR BOTH NORTH AND SOUTH OF HAMPTON ROADS (NORTHERN RECORDS ONLY)			
Ambystoma maculatum	Spotted salamander	U	HF, MPH, PF, AF
Hemidactylium scutatum	Four-toed salamander	U	Fresh water swamps
Pseudotriton ruber ruber	Northern red salamander	U	Fresh water streams
Acris crepitans crepitans	Northern cricket frog	C	Fresh water streams, ponds
3. SPECIES WHICH PROBABLY OCCUR BOTH NORTH AND SOUTH OF HAMPTON ROADS (SOUTHERN RECORDS ONLY)			
Siren lacertina	Greater siren	U	Fresh water streams

Species	Common Name	Status	Habitat
4. SPECIES WHICH OCCUR IN THE LOWER PENINSULA: DISTRIBUTION APPARENTLY LIMITED TO THE AREA NORTH OF HAMPTON ROADS			
Eurycea bislineata bislineata	Northern two-lined salamander	C	Fresh water streams
Bufo americanus	American toad	C	G (except OW & M)
Acris crepitans crepitans	Northern cricket frog	C	Pond-stream edge
B. REPTILES			
1. SPECIES OF REPTILES OF THE LOWER PENINSULA AREA OF VIRGINIA			
Lepidochelys kempi	Atlantic ridley	R	Mouth of Hampton Roads
Chelydra serpentina	Snapping turtle	C	Fresh water streams and ponds
Sternothaerus odoratus	Stinkpot	C	Fresh and brackish streams, swamps
Kinosternon subrubrum subrubrum	Mud turtle	C	Fresh and brackish streams, swamps
Clemmys guttata	Spotted turtle	U	Fresh water ponds and streams
Terrapene carolina carolina	Box turtle	C	HF, MPH, PF, AF, S, A, D
Chrysemys picta picta	Painted turtle	C	Fresh water ponds, streams, rivers
Pseudemys scripta scripta	Yellow-bellied turtle	C	Fresh water ponds, streams, rivers
Pseudemys rubriventris	Red-bellied turtle	U	Fresh water ponds, streams, rivers
Malaclemys terrapin terrapin	Northern diamondback terrapin	C	Salt water and marshes
Sceloporus undulatus hyacinthinus	Eastern fence lizard	C	HF, MPH, PF, AF, S, A, D

Species	Common Name	Status	Habitat
Ophisaurus ventralis	Glass snake lizard	C	A, MPH, pond edge
Cnemidophorus sexlineatus	Six-lined racerunner	C	A, S, D, PF
Eumeces fasciatus	Five-lined skink	C	HF, MPH, PF, S, D
Eumeces laticeps	Broad-headed skink	C	HF, MPH, PF, S, D
Lygosoma laterale	Ground skink	C	HF, MPH, PF, S, D
Eumeces inexpectatus	Southeastern five-lined skink	C	AF, HF
Carphophis amoenus amoenus	Worm snake	C	HF, MPH, PF, D
Abastor erythrogrammus	Rainbow snake	U	Lake and stream fossorial
Diadophis punctatus	Eastern ringneck snake	C	HF, MPH, PF, AF, S, A, D
Heterodon platyrhinos platyrhinos	Eastern hognose snake	C	PW, S, A
Opheodrys aestivus	Rough green snake	C	G (except OW & M)
Natrix taxispilota	Brown water snake	U	Fresh water ponds, marsh
Natrix sipedon sipedon	Northern water snake	C	Fresh water ponds, marsh
Storeria dekayi dekayi	Dekay's snake	C	D, S, MPH
Storeria occipitomaculata	Red-bellied snake	U	HF, MPH, PF
Thamnophis sirtalis sirtalis	Eastern garter snake	C	MPH, AF, M, A, D
Thamnophis sauritus sauritus	Eastern ribbon snake	C	Fresh water body edges
Haldea striatula	Rough earth snake	U	G (except OW, M)
Haldea valeriae	Smooth earth snake	U	G (except OW, M)
Coluber constrictor constrictor	Northern black racer	C	HF, MPH, PF, AF, S, A, D

Species	Common Name	Status	Habitat
Elaphe guttata guttata	Corn snake	R	G (except OW, M)
Elaphe obsoleta obsoleta	Black rat snake	C	G (except OW, M)
Lampropeltis getulus getulus	Eastern kingsnake	C	G (except OW, M)
Lampropeltis doliata temporalis	Scarlet kingsnake	U	Fossorial, S, A, HW
Lampropeltis calligaster rhombomaculata	Mole snake	R	S, A, HW, Fossorial
Cemophora coccinea copei	Scarlet snake	U	S, A, HW, Fossorial
Agkistrodon contortrix controtrix	Southern copperhead	C	HF, AF, MPH, D, A, S, PF
Agkistrodon piscivorus piscivorus	Eastern cottonmouth	U	Fresh water ponds and swamps
Crotalus horridus atricaudatus	Canebrake rattlesnake	R	AF, Canebrakes
2. SPECIES WHICH PROBABLY OCCUR BOTH NORTH AND SOUTH OF HAMPTON ROADS (SOUTHERN RECORDS ONLY)			
Pseudemys floridana	Cooter	R	Fresh water ponds, streams, rivers, swamps
Natrix erythrogaster erythrogaster	Red-bellied water snake	R	Fresh water ponds and streams

C. BIRDS

All species listed below have been recorded from areas immediately adjacent to Langley Research Center and Air Force Base. In addition, those species indicated were observed in the given habitat of LaRC/LAFB in 1973.

Species	Common Name	LaRC/LAFB Observations MPH	PF	MH-RC	Status
Gavia immer	Common loon				WR
Gavia stellata	Red-throated loon				WR
Podiceps grisegena	Red-necked grebe				T
Podiceps auritus	Horned grebe				WR
Podilymbus podiceps	Pied-billed grebe				PR
Phalacrocorax auritus	Doubled-crested cormorant				T
Ardea herodias	Great blue heron				PR
Florida caerulea	Little blue heron				T
Bubulcus ibis	Cattle egret				T
Casmerodius albus	Common egret				SR
Leucophoxy thula	Snowy egret				SR
Hydranassa tricolor	Louisiana Heron				SR
Nycticorax nycticorax	Black-crowned night heron				WR
Nyctanassa violacea	Yellow-crowned night heron				SR
Ixobrychus exilis	Least bittern				SR
Botaurus lentiginosus	American bittern				T
Plegadis falcinellus	Glossy Ibis				T

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Olor columbianus	Whistling Swan				WR
Branta canadensis	Canada goose				WR
Branta bernicla	Brant				WR
Chen hyperborea	Snow goose				WR
Dendrocygna bicolor	Fulvous tree duck				WR
Anas platyrhynchos	Mallard				WR
Anas rubripes	Black duck				WR
Anas strepera	Gadwall				WR
Anas acuta	Pintail				WR
Anas carolinensis	Green-winged teal				WR
Anas discors	Blue-winged teal				T
Mareca americana	American widgeon				WR
Spatula clypeata	Shoveler				WR
Aix sponsa	Wood duck				SR
Aythya americana	Redhead				WR
Aythya collaris	Ring-necked duck				WR
Aythya valisineria	Canvasback				WR
Aythya marila	Greater scaup				WR

Species	Common Name	LaRC/LAFB Observations MPH	PF	MH-RC	Status
Aythya affinis	Lesser scaup				WR
Bucephala clangula	Common goldeneye				WR
Bucephala albeola	Bufflehead				WR
Clangula hyemalis	Oldsquaw				WR
Somateria mollissima	Common eider				WR
Somateria spectabilis	King eider				WR
Melanitta deglandi	White-winged scoter				WR
Melanitta perspicillata	Surf scoter				WR
Oidemia nigra	Common scoter				WR
Oxyura jamaicensis	Ruddy duck				WR
Mergus serrator	Red-breasted merganser				WR
Cathartes aura	Turkey vulture				PR
Coragyps atratus	Black vulture				PR
Accipiter striatus	Sharp-shinned hawk				T
Accipiter cooperi	Cooper's hawk				T
Buteo jamaicensis	Red-tailed hawk				PR
Buteo lineatus	Red-shouldered hawk				PR
Buteo platypterus	Broad-winged hawk				T
Circus cyaneus	Marsh hawk				WR
Falco columbarius	Pigeon hawk				WR

Species	Common Name	LaRC/LAFB Observations MPH	PF	MH-RC	Status
Falco sparverius	Sparrow hawk				WR
Colinus virginianus	Bobwhite	X		X	PR
Rallus elegans	King rail				T
Rallus longirostris	Clapper rail				PR
Rallus limicola	Virginia rail				T
Porzana carolina	Sora				T
Coturnicops noveboracensis	Yellow rail				T
Latterallus jamaicensis	Black rail				T
Gallinula chloropus	Common gallinule				T
Fulica americana	American coot				WR
Haematopus palliatus	American oystercatcher				T
Charadrius semipalmatus	Semipalmated plover				T
Charadrius melodus	Piping plover				T
Charadrius wilsonia	Wilson's plover				T
Charadrius vociferus	Killdeer				PR
Squatarola squatarola	Black-bellied plover				T
Arenaria interpres	Ruddy turnstone				T
Philohela minor	American woodcock	X			WR
Capella gallinago	Common snipe	X			WR
Numenius phaeopus	Whimbrel				T

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Actitis macularia	Spotted sandpiper				T
Tringa solitaria	Solitary sandpiper				T
Catoptrophorus semipalmatus	Willet				T
Totanus melanoleucus	Greater yellowlegs				T
Totanus flavipes	Lesser yellowlegs				T
Calidris canutus	Knot				T
Erolia maritima	Purple sandpiper				WR
Erolia melanotos	Pectoral sandpiper				T
Erolia fuscicollis	White-rumped sandpiper				T
Erolia minutilla	Least sandpiper				T
Erolia alpina	Dunlin				T
Limnodromus griseus	Short-billed dowitcher				T
Micropalama himantopus	Stilt sandpiper				T
Ereunetes pusillus	Semipalmated sandpiper				T
Ereunetes mauri	Western sandpiper				T
Crocethia alba	Sanderling				T
Larus marinus	Great black-backed gull				WR

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Larus argentatus	Herring gull				WR
Larus delawarensis	Ring-billed gull				WR
Larus atricilla	Laughing gull				T
Larus philadelphia	Bonaparte's gull				T
Rissa tridactyla	Black-legged kittiwake				T
Sterna forsteri	Forster's tern				T
Sterna hirundo	Common tern				T
Sterna albifrons	Least tern				SR
Thalasseus maximus	Royal tern				T
Hydroprogne caspia	Caspian tern				T
Chlidonias niger	Black tern				T
Zenaidura macroura	Mourning dove	X		X	PR
Coccyzus americanus	Yellow-billed cuckoo				SR
Coccyzus erythropthalmus	Black-billed cuckoo				T
Tyto alba	Barn owl				PR
Otus asio	Screech owl				PR
Bubo virginianus	Great horned owl				PR
Strix varia	Barred owl				PR

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Asio flammeus	Short-eared owl				WR
Caprimulgus vociferus	Whip-poor-will				T
Chordeiles minor	Common nighthawk				SR
Chaetura pelagica	Chimney swift				SR
Archilochus colubris	Ruby-Throated hummingbird			X	SR
Megaceryle alcyon	Belted kingfisher				PR
Colaptes auratus	Flicker	X	X		PR
Dryocopus pileatus picinus	Pileated woodpecker				PR
Centurus carolinus	Red-bellied woodpecker	X	X		PR
Melanerpes erythrocephalus	Red-headed woodpecker				PR
Sphyrapicus varius	Yellow-bellied sapsucker				WR
Dendrocopos villosus	Hairy woodpecker				PR
Dendrocopus pubescens	Downy woodpecker	X	X	X	PR
Tyrannus tyrannus	Eastern kingbird				SR
Myiarchus crinitus	Great crested flycatcher				SR
Sayornis phoebe	Eastern phoebe				SR
Empidonax virescens	Acadian flycatcher				SR
Contopus virens	Eastern wood pewee				SR
Eremophila alpestris	Horned lark				WR
Iridoprocne bicolor	Tree swallow				T

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Stelgidopteryx ruficollis	Rough-winged swallow				SR
Hirundo rustica	Barn swallow				SR
Progne subis	Purple martin				SR
Cyanocitta cristata	Blue jay	X	X	X	PR
Corvus brachyrhynchos	Common crow			X	PR
Corvus ossifragus	Fish crow			X	SR
Parus carolinensis	Carolina chickadee	X	X	X	PR
Parus bicolor	Tufted titmouse	X	X	X	PR
Sitta carolinensis	White-breasted nuthatch	X		X	PR
Sitta canadensis	Red-breasted nuthatch				WR
Sitta pusilla	Brown-headed nuthatch		X		PR
Certhia familiaris	Brown creeper		X		WR
Troglodytes aedon	House wren	X		X	SR
Troglodytes troglodytes	Winter wren				WR
Thryothorus ludovicianus	Carolina wren	X	X	X	PR
Telmatodytes palustris	Long-billed marsh wren				SR
Cistothorus platensis	Short-billed marsh wren				T
Mimus polyglottos	Mockingbird	X		X	PR

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Dumetella carolinensis	Catbird	X		X	SR
Toxostoma rufum	Brown thrasher	X	X	X	SR
Turdus migratorius	Robin	X		X	SR
Hylocichla mustelina	Wood thrush				SR
Hylocichla guttata	Hermit thrush	X			WR
Hylocichla ustulata	Swainson's thrush				T
Hylocichla minima	Gray-checked thrush				T
Hylocichla fuscescens	Veery	X		X	T
Sialia sialis	Eastern bluebird				PR
Polioptila caerulea	Blue-gray gnatchatcher			X	SR
Regulus satrapa	Golden-crowned kinglet	X	X		WR
Regulus calendula	Ruby-crowned kinglet	X	X	X	WR
Anthus spinoletta	Water pipit				WR
Bombycilla cedrorum	Cedar waxwing	X		X	WR
Lanius ludovicianus	Loggerhead shrike				WR
Sturnus vulgaris	Starling				PR
Vireo griseus	White-eyed vireo			X	SR
Vireo flavifrons	Yellow-throated vireo				SR
Vireo solitarius	Solitary vireo				T
Vireo olivaceus	Red-eyed vireo				SR

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Vireo gilvus	Warbling vireo				T
Mniotilta varia	Black and white warbler	X		X	SR
Vermivora peregrina	Tennessee warbler				T
Parula americana	Parula warbler		X		SR
Dendroica petechia	Yellow warbler				SR
Dendroica magnolia	Magnolia warbler				T
Dendroica tigrina	Cape May warbler				T
Dendroica caerulescens	Black-throated blue warbler				T
Dendroica coronata	Myrtle warbler	X	X	X	WR
Dendroica virens	Black-throated green warbler				T
Dendroica dominica	Yellow-throated warbler		X		SR
Dendroica pensylvanica	Chestnut-sided warbler				T
Dendroica striata	Blackpoll warbler				T
Dendroica pinus	Pine warbler		X		PR
Dendroica discolor	Prairie warbler				SR
Dendroica palmarum	Palm warbler		X		T
Seiurus aurocapillus	Ovenbird				SR
Seiurus noveboracensis	Northern waterthrush				T
Seiurus noveboracensis	Louisiana waterthrush	X			T

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Geothlypis trichas	Yellowthroat	X	X	X	SR
Icteria virens	Yellow-breasted chat				SR
Wilsonia citrina	Hooded warbler				SR
Wilsonia pusilla	Wilson's warbler				T
Wilsonia candensis	Canada warbler				T
Setophaga ruticilla	American redstart	X			T
Passer domesticus	House sparrow				PR
Dolichonyz oryzivorus	Bobolink				T
Sturnella magna	Eastern meadowlark				PR
Agelaius phoeniceus	Red-winged blackbird			X	PR
Icterus spurius	Orchard oriole				SR
Icterus gallbula	Baltimore oriole				T
Euphagus carolinus	Rusty blackbird	X			WR
Cassidix mexicanus	Boat-tailed grackle				SR
Quiscalus quiscula	Common grackle	X	X	X	PR
Molothrus ater	Brown-headed cowbird	X	X		PR
Piranga olivacea	Scarlet tanager				T
Piranga rubra	Summer tanager				SR
Richmondena cardinalis	Cardinal	X	X	X	PR
Pheucticus ludovicianus	Rose-breasted grosbeak				T

Species	Common Name	LaRC/LAFB Observations MHP	PF	MH-RC	Status
Guiraca caerulea	Blue grosbeak				SR
Passerina cyanea	Indigo bunting				SR
Hesperiphona verpertina	Evening grosbeak				WR
Carpodacus purpureus	Purple finch				WR
Spinus pinus	Pine siskin				WR
Spinus tristis	American goldfinch	X	X	X	PR
Pipilo erythrophthalmus	Rufous-sided towhee	X	X	X	PR
Passerculus sandwichensis	Savannah sparrow	X			WR
Ammospiza caudacuta	Sharp-tailed sparrow				PR
Ammospiza martima	Seaside sparrow				SR
Pooecetes gramineus	Vesper sparrow				T
Junco hyemalis	Slate-colored junco				WR
Spizella arborea	Tree sparrow				WR
Spizella passerina	Chipping sparrow				SR
Spizella pusilla	Field sparrow	X		X	PR
Zonotrichia leucophrys	White-crowned sparrow				WR
Zonotrichia albicollis	White-throated sparrow	X	X	X	WR
Passerella iliaca	Fox sparrow				WR
Melospiza georgiana	Swamp sparrow	X		X	WR
Melospiza melodia	Song sparrow	X	X	X	PR
Plectrophenax nivalis	Snow bunting				WR

D. MAMMALS

1. SPECIES WHICH OCCUR BOTH NORTH AND SOUTH OF HAMPTON ROADS

Species	Common Name	Status	Habitat
Didelphis marsupialis virginiana	Opossum	C	G
Sorex longirostris longirostris	Southeastern shrew	U	S, A
Cryptotis parva parva	Least shrew	C	M, S, A
Blarina brevicanda carolinensis	Short-tailed shrew	A	HF, MPH, PF, AF, S
Scalopus aquaticus aquaticus	Eastern Mole	A	D, A, PF
Condylura cristata cristata	Star-nosed mole	U	AF, M
Myotis lucifugus lucifigus	Little brown bat	A	HF, MPH, AF, PF, D, OW (Feeding)
Myotis keenii septentrionalis	Keen's bat	C	HF, MPH, AF, PF, OW (Feeding)
Lasionycteris noctivigans	Silver-haired bat	C	HF, AF, OW (Feeding)
Pipistrellus subflavus subflavus	Eastern pipistrelle	C	HF, MPH, AF, PF, D, OW (Feeding)
Eptesicus fuscus fuscus	Big brown bat	U	HF, MPH, AF, PFD, OW (Feeding)
Lasiurus borealis borealis	Red bat	A	HF, MPH, AF, PF, D, OW (Feeding)
Procyon lotor lotor	Raccoon	A	G
Mustela frenata noveboracensis	Long-tailed weasel	U	HF, AF, MPH, A, S
Mustela vison mink	Mink	U	AF, M, OW
Lutra canadensis lataxina	River otter	U	AF, M, OW
Vulpes fulva fulva	Red fox	U	HF, MPH, PF, S, A
Urocyon cinereoargenteus cinereoargenteus	Gray fox	C	HF, MPH, PF, S, A

Species	Common Name	Status	Habitat
Phoca vitulina concolor	Harbor seal	R (vagrant)	OW
Sciurus carolinensis carolinensis	Gray squirrel	A	HF, MPH, AF, D
Glaucomys volans volans	Southern flying squirrel	C	PF, MPH, HF, AF, D
Reithrodontomys humulis virginianus	Harvest mouse	C	S, A, M
Peromyscus leucopus leucopus	White-footed mouse	A	HF, MPH, AF, S, M, A
Oryzomys palustris palustris	Rice rat	A	M, S, A
Microtus pennsylvanicus pennsylvanicus	Meadow vole	C	A, S, AF (Bogs)
Microtus pinetorum scalopsoides	Pine vole	U (local)	A, S, PW
Ondatra zibethicus macrodon	Muskrat	A	M, OW
Rattus norvegicus	Norway rat	A	D, M, S, A
Mus musculus brevirostris	House mouse	A	D, M, S, A
Sylvilagus floridanus	Eastern cottontail	A	G
Odocoileus virginianus virginianus	White-tailed deer	C	G

APPENDIX C

NOISE ANALYSIS METHODOLOGY

The following discussion is based on a report entitled Noise Analysis of the National Transonic Facility at NASA Langley Research Center (April, 1976) by Dr. Barry R. Wyerman, an acoustical engineering consultant.

1. Fan Noise.

The analysis of noise to be generated by the NTF fan was based on a study done for NASA entitled Preliminary Noise Analysis of the Proposed NASA Langley High Reynolds Number Transonic Research Wind Tunnel by Bolt, Beranek and Newman Inc. (BBN) and a subsequent memo prepared by the Senior Acoustical Engineer at NASA Langley entitled NTF Fan Noise which evaluated and commented on the BBN report. These reports came to different conclusions on the noise levels that the tunnel might be expected to generate, so they were re-analyzed for this environmental impact statement along with additional information not previously available in order to estimate the fan noise output.

The method for estimating fan noise used by BBN is one common in the field. It is based on data for a large family of fans--including both centrifugal and axial fans. The equation used for estimating octave band sound power Lw(f) of a fan is

$$Lw(f) = Kw(f) + 10 \log_{10} CFM + 20 \log_{10} \Delta P \qquad (1)$$

where Kw(f) is an empirically determined specific sound power level characteristic of a family of fan types. The sound power at operating conditions is dependent on the volume flow (cfm) and pressure drop (ΔP).

The method used in the NTF Fan Noise memo for estimating sound power of the NTF fan is based on scaling to the tunnel conditions aircraft fan noise data taken at near standard atmospheric conditions. The equation for determining acoustic power P_a of the fan is

$$P_a = Kmc^2 \left(\frac{\Delta T}{T}\right)^2 \qquad (2)$$

where "K" is a specialized constant for each noise source, "m" is the mass flow rate in Kg/sec, "c" is the stagnation speed of sound in m/sec, and "T" is the stagnation temperature in ^{o}K. This model and estimation method is thought to be more representative of the NTF fan than the model used by BBN. Furthermore, the fan operation parameters were considered at the low temperature, high pressure conditions of the tunnel. The temperature ratio $\frac{(\Delta T)}{T}$ in equation 2 is proportional to $\frac{(\Delta P)}{P}$, which becomes an important point in estimating fan noise.

In the NTF Fan Noise memo it was stated that the differences between the two fan noise estimates are due to three factors.

1. Differences in input data account for about 2 dB of the difference.

2. Safety factors have been introduced by BBN to correct for inflow conditions. It is obvious that the inflow to the NTF fan will be distorted by turning vanes, etc. However, it is questionable whether inflow to the fans considered by the empirical method can be assumed to be clean. This assumption then does not seem reasonable, and the 3 dB added for inflow is unjustified.

3. BBN did not scale fan noise results at atmospheric pressure to the high pressure in the tunnel. In equation 1, the noise generated is proportional to ΔP. In equation 2, the noise is proportional to $\frac{(\Delta P)}{P}$. For the 8 atmospheres of pressure in the tunnel, this results in a difference of 9 dB.

In short, the noise-estimating method presented in the NTF Fan Noise memo is a more accurate model of the NTF fan. This should be preferred in comparison to the method for evaluating noise generated from HVAC fan units.

Based on that memo's data, the contribution of each noise source of the fan for propagation in the upstream and downstream directions are listed in Table C-1. The data have been presented in harmonics of the blade-passing frequency of 145 Hz for operation of the fan at m = 1.0. For operation at m = 1.2, 4 dB should be added to each level.

Table C-1. Estimated Sound Power Level in dB (10^{-12} Watts) for Fan Noise.

	Frequency (Hz)					
NTF Fan Noise Memo	145	290	580	1160	2320	4640
Total Upstream Power	150	145	145	145	144	142
Total Downstream Power	156	151	151	151	150	149
Total Fan Power	157	152	152	152	151	150
	Frequency (Hz)					
BBN Report	125	250	500	1000	2000	4000
Total Fan Power	167	160	157	155	145	131

2. Gaseous Nitrogen Vent System Noise.

The range of sound pressure levels to be generated by the GN_2 vent system was estimated for various operating conditions. This system noise has a number of components. The valve noise is basically a function of turbulent mixing noise and shock noise. These levels have been calculated, and the total valve noise sound power summarized in Table C-2. These levels were then used to develop an estimate for the total noise level to be generated at the top of the stack (relatively conservative absorption coefficient of 0.3 was used for the stack). The typical noise level at the stack opening would be 133.5 dBA with a maximum level of nearly 140 dBA. This information is summarized in Table C-3.

It can be shown that the main valve will generate the highest noise levels. However, for an observer at ground level in the vicinity of the stack, the major source of noise will come from the stack opening and not from the enclosure for the valve. This is because the high transmission loss of the pipe and of the enclosure for the valve will eliminate noise transmitted directly from the valve.

Table C-2. Valve Noise Sound Power in dB (10^{-12} Watts).*

	Frequency (Hz)					
Noise Component	112	225	450	900	1800	3600
1. Correction for turbulent mixing noise	-7	-4	-6	-9	-13	-17
2. Turbulent mixing noise (Line 1 + 143)	136	139	137	134	130	126
3. Correction for shock noise	-10	-7	-9	-16	-25	-37
4. Shock noise (Line 3 + 160)	150	153	151	144	135	123
5. Total sound power for valve noise	150	153	151	144	136	128

*For maximum operating conditions, 6 dB should be added to each level.

To verify this, the transmission loss of the pipe walls and enclosure walls was estimated assuming a 1.27 cm (0.5 in) wall thickness for the 122 cm (48 in) diameter pipe. The transmission loss of the pipe is then given in Table C-4.

Also, assuming an enclosure for the valve made of a 10.2 cm (4 in) thick brick wall, the transmission loss can be estimated and added to that of the pipe. This transmission loss is given in Table C-5.

Table C-3. Sound Power and Sound Pressure Levels Generated by the GN_2 Main Valve in dB.

Noise Component	Frequency (Hz) 125	250	500	1000	2000	4000
1. Sound power of valve (re 10^{-12} Watts)	150	153	151	144	136	128
2. Attenuation of stack for a = 0.3	-9	-9	-9	-9	-9	-9
3. Sound power at stack opening (Line 1 & Line 2)	141	144	142	135	127	119
4. Correction for sound pressure level	-12	-12	-12	-12	-12	-12
5. Sound pressure level at opening (Line 3 & Line 4)	129	132	130	123	115	107
6. Safety factor	3	3	3	3	3	3
7. Sound pressure level at opening (Line 5 & Line 6)	132	135	133	126	118	110
8. A weighting correction	-16	-9	-3	0	1	1
9. Line 7 & Line 8	116	126	130	126	119	111

Total Sound Pressure = 133.5 dBA

For maximum operative conditions, this level will rise to nearly 140 dBA at the stack opening.

Table C-4. Transmission Loss of 1.27 cm Thick, 122 cm Diameter Steel Pipe.

Frequency (Hz)								
133	266	537	800	1064	1331	1600	2000	4000
TL (dbA)								
25	26	27	27	26	29	56	58	59

Table C-5. Transmission Loss Through a 10.2 cm Thick Brick Wall.

Frequency (Hz)	63	125	250	500	1000	2000	4000
TL (dBA)	37	37	37	37	43	53	63

The combined transmission loss of the pipe and walled enclosure will limit the noise radiated directly from the valve housing. Thus, the major noise source, even at ground level, will appear to originate at the opening of the vent stack.

It is also a reasonable assumption that the transmission loss through the vent stack walls will be greater than the transmission loss provided by the interior space of the stack between inlet and outlet. Again, the source of noise will appear to emanate from the stack opening rather than from the base of the stack.

In order to predict the impact of this noise source, an adjustment to the predicted noise level of 133.5 dBA must initially be made to account for the fact that the noise emitted from the stack opening is highly directional and the noise transmitted radially is not equivalent to that of a non-directional source. This adjustment is summarized in Table C-6.

Table C-6. Correction for Directionality of a Vertical Stack Over 3 m x 3 m in Size (in dBA).

Frequency (Hz)	125	250	500	1000	2000	4000
Angle from Perpendicular*						
90°	-3	-3	-9	-9	-14	-14
135°	-4	-4	-11	-11	-18	-18

*Directly Above Stack Opening = 0°

3. Other Sources of Noise.

The method of calculating the sound power level for the exhaust fans is shown in Table C-7, and noise factors for high speed flow through the elbow connecting the vent valve to the exhaust stack are given in Table C-8.

4. Noise Abatement by Absorbent Stack Wall.

A measure of the noise reduction for various absorption coefficients is given in Table C-9. For total absorption ($\alpha = 1$), the noise reduction is limited by the attenuation over distance to 20 dB. Note however that the GN_2 vent system noise analysis was conducted using $\alpha = 0.3$.

Table C-7. Sound Power Level in dB (10^{-12} Watts) for Exhaust Fans

	Frequency (Hz)						
Noise Component	63	125	250	500	1000	2000	4000
1. Lw(f)	51	48	49	47	44	45	43
2. (10 Log CFM + 120 Log P)	65	65	65	65	65	65	65
3. Line 1 + Line 2	116	113	114	112	109	110	108
4. Correction factor for 4 fans	6	6	6	6	6	6	6
5. Total for 4 fans (Line 3 + Line 4)	122	119	120	118	115	116	114

Table C-8. Noise Generated by Flow Through 122 cm Diameter Elbow in dB.

	Frequency (Hz)					
Velocity (m/min)	125	250	500	1000	2000	4000
0.61	56	57	58	58	56	55
2.52	81	80	80	79	72	64

Table C-9. Noise Reduction of the Vent Stack for Various Absorption Coefficients, in dBA.

Absorption Coefficient (α)	0.1	0.3	0.5	0.7	0.9	1.0
Noise Reduction (dBA)	3.5	9	12	15	18	20

APPENDIX D

AIR QUALITY ANALYSIS METHODOLOGY

D-1. COLD PLUME MODEL FOR CRYOGENIC WIND TUNNEL EFFLUENT.

The following description is based on a report dated May 4, 1976 by Earl C. Kindle and Herman Wobus, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va.

A. Cold Plume Model in a Quiescent Atmosphere.

The calm jet program is written to simulate the progress of effluent from a stack under calm wind conditions in consideration of the volume, velocity, temperature (density), and concentration of constituents as it mixes with, settles, and spreads beneath the environment atmosphere.

Some of the physics represented in the program is rather well understood, and some can be treated by introducing several approximations. The problem is divided into two stages: the area of vertical jet core, and the surrounding ambient atmosphere into which the outflow from the jet is introduced (See Figure D-1).

The first stage, or inner volume, is based upon a vertical jet with Gaussian profile of vertical velocity and constituent concentrations, which is considered to reach a steady state shortly after the initial turn-on.

The development of this core plume yields the initial conditions and inner boundary conditions for the second stage, which consists of simulating the motion and mixing within an annular cylindrical volume surrounding the core. While the core is considered to be in steady state, the computations in the surrounding area are time-dependent. Thereafter, various printouts of the computed state can be made for any specified time.

B. The Inner Core.

The basis of the inner core computations is as follows:

Assume two-dimensional Gaussian Profiles for

(1) $W = W_A e^{-\frac{r^2}{2\sigma^2}}$

(2) $C = C_A e^{-\frac{r^2}{2\sigma^2}}$

(3) $\nabla^2 W = \frac{W_A}{\sigma^2}\left[\frac{r^2}{\sigma^2} - 2\right]$

$W = \frac{dz}{dt}$

$U = \frac{dr}{dt}$

$C =$ concentration of effluent

$U_A = 0$

$U_R = -\frac{1}{2\pi R}\frac{\partial}{\partial z}(\text{Vol.up})_{0 \rightarrow R}$

$(\text{Vol.up})_{0 \rightarrow R} = 2\pi \int_0^R wr\,dr = 2\pi\sigma^2\left[1 - e^{-\frac{R^2}{2\sigma^2}}\right]$

Subscript A means at Axis; at height subscript o means at emergence from stack.

Working upward from W_0, C_0, σ_0 (at emergence from stack):

Along the axis

$$(4)\quad \frac{dW}{dt} = \underbrace{g\,\frac{\theta-\theta^*}{\theta^*}}_{\text{Buoyancy}} + \underbrace{K_j(\nabla^2 W)_A}_{\text{Drag}}$$

$$(5)\quad \frac{\partial W_A}{\partial Z} = \frac{1}{W_A}\left(\frac{dW_A}{dt}\right)$$

K_j = diffusion coefficient for jet core

θ = potential temperature

θ^* = ambient potential temperature

θ_S = potential temperature at stack exit

$$(6)\quad \frac{\partial C_A}{\partial Z} = \frac{1}{W_A}\frac{dC_A}{dt} = \frac{1}{W_A}K(\nabla^2 C)_{r=0}$$

The above equations are relatively firm, subject to proper representation of K_j and σ. The growth of sigma with height has been developed from conservation of volume (or concentrations) in the assumed steady state mode; i.e., as a layer of air of thickness δZ rises from one height, Z_1 to another, Z_2, a cylindrical volume containing a given quantity of effluent, or a given fraction of the total within the layer, would expand in radius so that $r^2\,\delta Z$ remains constant (assuming incompressibility for this purpose). By deformation alone, then:

$$(7)\quad \delta Z\,\frac{dr^2}{dt} = -r^2\,\frac{d}{dt}\,\delta Z$$

$$(8)\quad \frac{d}{dt}\,\delta Z = \frac{\partial W}{\partial Z}\,\delta Z$$

Hence

$$(9)\quad \frac{dr^2}{dt} = -r^2\,\frac{\partial W}{\partial Z}$$

for r is the radius containing the fraction of effluent within 1σ unit of the axis.

$$(10)\quad \frac{d\sigma^2}{dt} = -\sigma^2\,\frac{\partial W}{\partial Z}$$

Without diffusion $\quad \frac{dC}{dt} = 0;\ \frac{d\sigma^2}{dt} = \frac{2\sigma^2}{\sigma Z}\,\frac{dZ}{dt}$

(11) $$\frac{\partial \sigma^2}{\partial Z} = -\frac{\sigma^2}{W}\frac{\partial W}{\partial Z}$$

or

(12) $$\sigma_Z^2 = \sigma_1^2 \frac{W_1}{W_2}$$

This would give σ at the upper level by deformation alone. If to this we add $2K_j \Delta t$, the growth of σ^2 by diffusion alone, using $\Delta t = (Z_2 - Z_1)W$, we get

(13) $$\sigma_Z^2 = \sigma_1^2 \frac{W_1}{W_2} + \frac{Z_2 - Z_1}{\frac{1}{2}(W_2 + W_1)} 2K_j$$

This is not a precise treatment of the growth of σ^2 at large radii where W is small compared to W at the axis, since it leads to infinite σ at the height where W becomes 0 however, within the radius of the first stage, it is sufficiently valid for this study.

From the quantities thus derived, initial values of W, U and C are placed in the working arrays for the second stage, adding to the field of U and W a spherical indraft centered at the base of the stack, and equal in volume per second to one-half the output of the stack. As this diminishes by reciprocal to the square of the distance from the stack, it is rather negligible except very close in.

In practice, from a level at which W, C, σ and t have been computed, the values at the next level upward are computed by extrapolating a first guess for W, C and σ at the next level. Using the average of the upper and lower values as applicable for the time of rise from level to level, each quantity can be more accurately derived. With a few iterations, this converges on a solution.

This method permits convenient use of a diffusion constant varyingly described as a function of height (or of W_A or σ, or Froude number, or the like if appropriate formulation can be determined).

There is room to tune the jet model for agreement with experimental data through the fit of W and σ as introduced at the stack, keeping the product $W_A \sigma^2$ = output momentum and $C_A \sigma^2$ = output quantity of constituents, and by choosing as required to agree with observation empirically or by deriving its equivalent from acceptable theory.

C. Estimation of Diffusion Coefficient (K) in Region of the Inner Core.

Equation 13 in the foregoing and equation 2.3a from (1) Hoot, Merone and Peterka are equivalent expressions for mass conservation in a Gaussian distribution model; i.e.,

(14) $$\frac{\partial}{\partial z} W_A \sigma^2 = 2K$$ From equation 13

(15) $$\frac{d}{dz}(b^2 U_m) = 2 \alpha b U_m$$ from equation 2.3a in (1)

where b = characteristic length and corresponds to

U_m = velocity at centerline and corresponds to

α = entrainment constant

σ = standard deviation of horizontal distribution

Hence, $K \cong \alpha b U_m$

For "Top-Hat" profiles, α = 0.045 (for a level just above the stack exit) was computed from empirical data described in (1) and based on Equation 2.9 of that publication. For Gaussian profiles, α Gaussian = $1/\sqrt{2}\ \alpha$ Top-Hat. Then for an average exit rate of 30 meters/second, W_A (along the centerline) = 45 m.p.s. just above the stack exit. If $K \cong \alpha b U_m$ and b = 2 meters, K stack exit $\cong$ 3.0 m 2/sec.

The above K would correspond to a stack exit value of α and should decrease as velocity along a centerline decreases. Results from (1) show that use of the stack exit α systematically under-estimates the maximum stack height and computed results would be more representative of observed value computed in (1) and by Turner (2) if the average α over the distance from stack exit to the top of the plume were reduced by 30 percent; i.e.,

$$\bar{\alpha} = 0.7\, \alpha_{\text{stack exit}}$$

In the model, the following approach is used to allow for this. The value of K used just above the exit should be fairly reliable, however, as the vertical velocity goes to zero at the top of the plume, the contribution from entrainment also decreases. Accordingly, in the model, the turbulent mixing coefficient in the plume jet domain is decreased from the near stack-exit value to approach the ambient atmospheric value at the top of the plume.

The final output gives concentrations of N_2, O_2, temperature, and total liquid water content in g/m^3 To minimize check out problems and to ensure some useful information within the required time frame, the conversion to liquid water content and realization of latent heat is done in the final step; i.e., it is assumed that the total heat content (sensible and latent) is transported and diffused in the mass concentration transport and diffusion processes. This, essentially, is saying that the total condensation and evaporation that takes place in transport from the stack exit to field grid point is approximated by the final conversion. With respect to the heat and liquid water content, this should be a good estimate. However, it would not account for the contribution of latent heat to the buoyancy term. In view of the scale of the other parameters, this should constitute a second order effect, but the omission should result in a small overestimate of the surface liquid water content and nitrogen concentrations.

D. Second or Outer Stage

With the vertical radial section represented as a two-dimensional array (See Figure D-1), boundary conditions for the innermost radius are determined in relation to the core jet of stage 1. The bottom of the array is treated as a reflective boundary, as regards concentrations. For vertical motions, W is defined as null, and an imaging term is introduced in the vertical equation of motion in imitation of an imaging device. Horizontal velocity at the ground is derived through the equation of continuity with the assumption of image symmetry for W

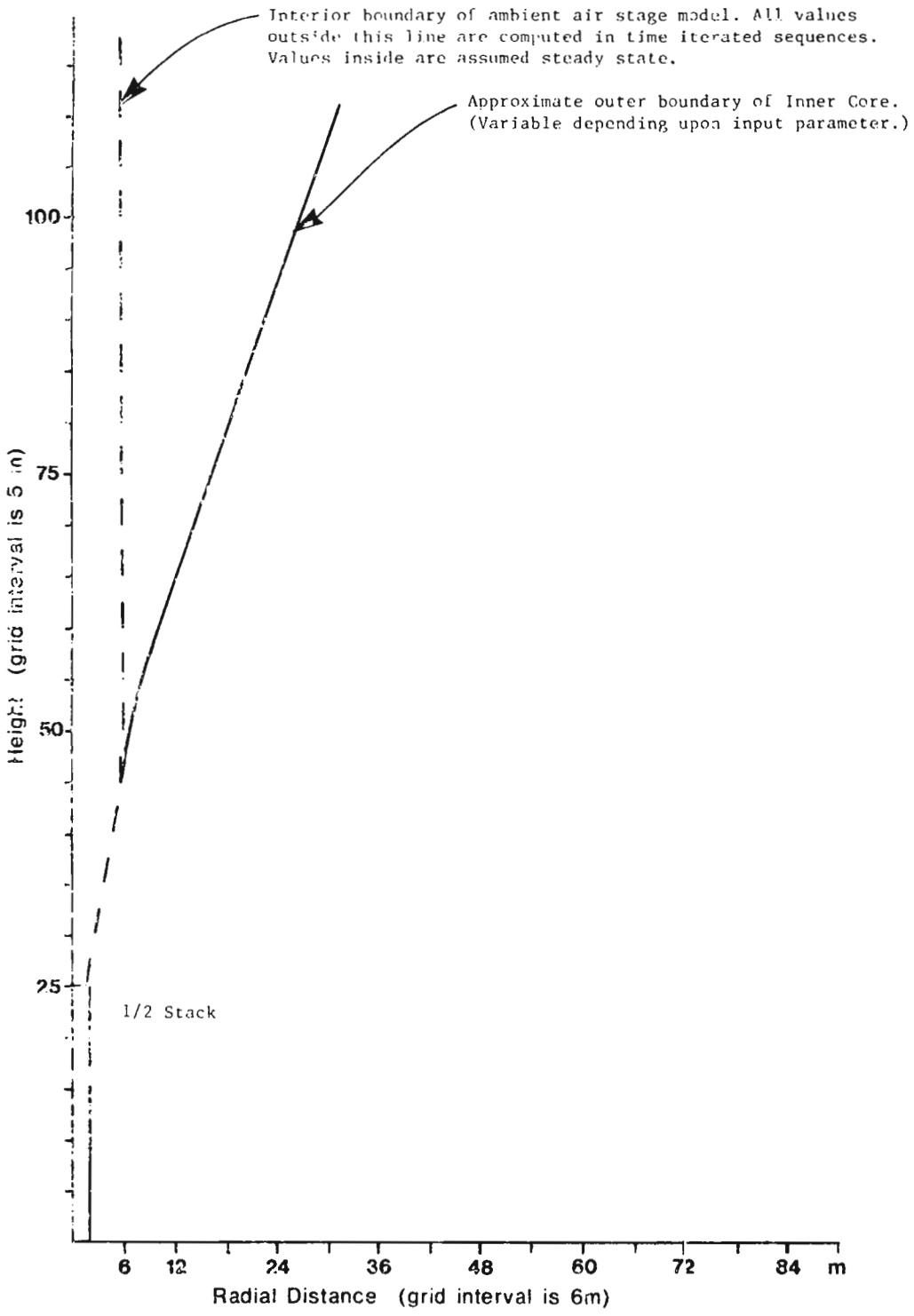
The array is extended above and beyond the area of interest, where rather simple extrapolations of required data permit application of the working equations.

For points within the array the following equations are used:

$$\frac{\partial}{\partial X} = \frac{\partial}{\partial r} \qquad \frac{\partial^2}{\partial X^2} = \frac{\partial^2}{\partial r^2}$$

$$\frac{\partial}{\partial Y} = 0 \qquad \frac{\partial}{\partial Y^2} = \frac{1}{r}\,\frac{\partial}{\partial r}$$

Figure D-1
Boundaries for Plume Regions



$$U = \frac{dr}{dt} \qquad W = \frac{dZ}{dt} \qquad K\# = K \text{ for outer region}$$

For vertical velocity computations, the Bousinesq approximation is used; i.e.,

$$(16)\quad \frac{dW}{dt} = \underbrace{g\left(\frac{\sigma - \sigma^*}{\sigma^*}\right)}_{\text{buoyancy}} + \underbrace{K^* \nabla^2 W}_{\text{mixing}} + I$$

σ = temperature $\qquad \sigma^*$ = ambient temperature

I = Deceleration relative to approach of ground and is approximated by:

$$I = 0 \text{ if } W \geq 0$$
$$I = a\frac{W^2}{Z} \text{ if } W < 0$$

For $W<0$ this is in lieu of a gradient of dynamic pressure as the air approaches a flat boundary. a = 1 yields exponential decay of W as Z approaches zero, a = 1/2 yields linear decay.

$$\frac{\partial}{\partial t} W = \frac{d}{dt} W - U\frac{\partial W}{\partial r} - W\frac{\partial W}{\partial Z}$$

$$U_{n+1} = \frac{1}{R_{n+1}}\left[R_n + \int_N^{N+1} r\frac{\partial W}{\partial Z}\, dr\right]$$

$$\frac{\partial C}{\partial t} = K^* \nabla^2 C - U\frac{\partial C}{\partial r} - W\frac{\partial C}{\partial Z}$$

Where the boundary velocity is outward due to divergence of the air in the upper part of the jet, no change. The concentrations are dominated by the jet model.

Where the boundary velocity is inward, due to the intake at the base of the stack and/or the inhalation of entrainment exceeding the divergence of the jet, adjustment is made to the boundary concentration, crudely simulating a combination of a Lagrangian technique and some smoothing. Since the horizontal flow is inward, the result is based on data within the outer array. U and W are only changed slightly.

REFERENCES

Hoot, T. G., R. N. Meroney, J. A. Peterka, "Wind Tunnel Tests of Negatively Buoyant Plumes," EPA-650/3-74-003, Ecological Report Series.

Turner, J. S., "Plumes with Negative or Reversing Buoyancy," Journal of Fluid Mechanics, 26, pp. 779-792 (1966).

Bodurtha, F. T., "The Behavior of Dense Stack Gases," J. Air Pollution Control Assoc., 11, pp. 431-437 (1961).

Briggs, G. A., "A Simple Model for Bent Over Plume Rise," Ph.D. Dissertation, Pennsylvania State University (1970).

Haltiner, G. J. and F. L. Martin, Dynamical and Physical Meteorology, McGraw-Hill Publishing Co., New York.

Murray, F. W., "Numerical Models of a Tropical Cumulus Cloud with Bilateral and Axial Symmetry," Memorandum RM-5870-ESSA, Rand Corporation, Prepared by Department of Commerce (November 1968).

D-3. METHOD OF CALCULATING ENTHALPY AND WATER CONTENT OF PLUME, WITH EXAMPLE CALCULATION.

A. Stack Conditions

Given:

Temperature of $GN_2 = 116\,^{\circ}K$
Ambient pressure, $P = 1.0$ at m.
Ambinet air in stack, $Ma + H_2O = 4.54 \times 10^5$ g/SEC.
Enthalpy of GN_2 referenced O at $0\,^{\circ}C$
(from ASHRAE Handbook), $H_n = -144 \frac{\text{Joules}}{g}$

Assumed Conditions:

Ambient Temperature, $T = 83\,^{\circ}F$ $(28.3\,^{\circ}C)$
Relative Humidity, $RH = 100\%$
Nitrogen Discharge Rate, $M_n = 5.44 \times 10^5$ g/SEC.
Enthalpy of mixing GN_2 with Air = 0
Read from ASHRAE Handbook:

Enthalpy of moist air per weight of dry air at conditions above referenced, with $Ha = 0$ at $0\,^{\circ}F$ and $H_{H_2O} = 0$ at $32\,^{\circ}F$,
$Ha + H_2O = 4.704 \frac{BTU}{Lb} = 109.4 \frac{\text{Joles}}{g}$
Ambient humidity ratio $\left(\frac{Kg\,H_2O}{Kg\,\text{dry air}}\right)$, $AH_a = 0.0246 \pm .001 \frac{Kg}{Kg}$
Volume $Va = 14.2\ ft^3/Lb$

Calculate:

Ambient air into stack,

$$Ma = \frac{4.54 \times 10^5}{1 + AH_a} = \frac{4.54 \times 10^5}{1 + 0.0246} = 4.43 \times 10^5 \text{ g/SEC.}$$

Enthalpy of exhaust gas,

$$He = \frac{Mn\,Hn + Ma\,Ha + H_2O}{Mn + Ma} = \frac{(5.44 \times 10^5)(-144) + (4.43 \times 10^5)(10.94)}{5.44 \times 10^5 + 4.43 \times 10^5}$$

$$= -30.26 \frac{\text{Joules}}{g} \left(-13 \frac{BTU}{Lb}\right)$$

Stack Discharge Humidity Ratio,

$$AHe = \frac{Mn\,AHn + Ma\,AHa}{Mn + Ma} = \frac{Ma\,AHa}{Mn + Ma} = \frac{(4.43 \times 10^5)(0.0246)}{987.1}$$

$$= 0.0110 \frac{Kg}{Kg}$$

B. Ambient Conditions

Assume as a first order approximation that the weight per cubic of meter of exhaust displaces an equal weight per cubic meter of dry ambient air, and that there is a aiabatic mixing and no fall out of water.

Calculate:

Mass of dry ambient air before mixing

$$M_{am} = \frac{1}{V_a} = \frac{1}{14.2} = 0.0704 \frac{Lb}{Ft.^3} = 1128 \, g/m^3$$

Given:

Concentration of exhaust (from diffusion modeling) $M_e = 300 \, g/m^3$

Mass of ambient air mixed with GN_2, $M_a \cong M_{am} - M_e \cong 828 \, g/m^3$

Enthalpy of resulting mixture of ambinet air and exhaust,

$$H = \frac{M_a H_a + H_2O + M_e H_e}{M_a + M_e} = 7.226 \frac{Joules}{g} = 31.1 \frac{BTU}{Lb.}$$

Absolute humidity of resulting mixture,

$$AH = \frac{M_a AH_a + M_e AH_e}{M_a + M_e} = \frac{(8.28)(0.0246)+(300)(0.0110)}{1128} = .021$$

Read From Psychrometric Chart:

Temperature of Mixture, 67°F

Saturation Absolute Humidity, $AH_{SAT} = \frac{\text{Lbs } H_2O \text{ at Saturation for Mixture}}{\text{Lb dry air}} = .014$

Volume, $V = \frac{\text{Cubic feet}}{\text{Lb dry air}} = 13.6$

Calculate:

$$H_2O = \frac{\text{Lb } H_2O}{\text{Lb dry air}} = \frac{\text{weight condensed water}}{\text{weight of air}} = .021 - .014 = .007$$

Concentration of water (fog or snow),

$$C_{H_2O} = \frac{\text{lb. condensed water}}{\text{Ft.}^3} = \frac{H_2O}{V} = \frac{.007}{13.6} = 5.15 \times 10^{-4} \frac{\text{lb}}{\text{ft.}^3}$$

$$= 8.25 \text{ g/m}^3$$

D-4. METHOD OF CALCULATION OF OPACITY AS A FUNCTION OF WATER DROPLET DENSITY

Our opacity calculations assume that NTF induced fog and snow will have the same particle size distribution as natural fog. Natural fog consists of water droplets 5 to 50 μ in diameter. The theory of light scattering indicates that the fraction $(I/I_\cdot)$ of light transmitted through such fog droplets is

$$\frac{I}{I_\cdot} = e^{-\frac{WL}{KP}}$$

W is the mass concentration of droplets (in g/m^3)

L is the visual path length (in meters)

p is particle density (in g/cm^3); $p = 1.0$ for water)

K is a function of particle size ($K = 1.5 \frac{CM^3}{M^2}$ for 5 micron particles, $K = 16 \frac{CM^3}{M^2}$ for 50 micron particles)

D-5. APPLICATION OF FORMULAS DEVELOPED IN WIND TUNNEL MODELING TO NITROGEN DISCHARGE

The following equations have been found to hold true for cold gas discharges through a stack in a wind tunnel in research by Meroney et al. (1973) at Colorado State University:

1. $H = 1.32\ D_o \left(\frac{U_o}{V}\right)^{\frac{1}{3}} (SG)^{\frac{1}{3}}\ Fr^{\frac{2}{3}}$ = maximum plume rise height above stack (ft)

2. $Fr = \left(\frac{U_o}{g D \frac{P_o - P_a}{P_o}}\right)^{\frac{1}{2}}$ = vertical densimetric Froude Number

3. $X = \frac{3.1\,Q}{V D_o^2} \left(\frac{2H - Hs}{D_o}\right)^{-1.95}$ = maximum ground level concentration at point where plume touches down

4. $\overline{X} = D_o\ Fr \left(\frac{V}{U_o}\right)$ = Distance downwind where plume height is maximum (ft).

5. $Xd = \overline{X} + 0.56 \frac{Fr/n\ D_o}{(U_o/V)^{1/2}} \left(\frac{H}{D_o}\right) \left[\left(2 + \frac{Hs}{H}\right)^3 - 1\right]^{\frac{1}{2}}$ = Downwind distance to point of plume touch-down (ft).

6. $Frh = \frac{V}{\left(g\ D_o\ \frac{P_o - P_a}{P_a}\right)^{\frac{1}{2}}}$ = Horizontal Densimetric Froude Number

Where:

U_o = stack exit velocity (= 100 ft/sec for wind tunnel stack)
V = wind velocity (ft/sec)
SG = specific gravity of discharge compared to air = $\frac{P_o}{P_a}$
P_o = Density of discharge gas (for 544 kg/sec GN2 mixed with 454 kg/sec air. Table D-1 shows the values in pounds per cubic foot).
P_a = Density of ambient air ($Lb/ft.^3$)
g = acceleration of gravity $32\ ft/sec^2$
D = Diameter of stack, assuming it to be round. Because the currently designed nitrogen discharge stack is to be 13.5 ft square, it is necessary to calculate the diameter of a circle with the same cross sectional area as the square.

$$\frac{\pi}{4} D^2 = 13.5^2$$

$$D = 15.23\ ft.$$

Q = mass emission rate of source = 2200 $^{Lb}/_{SEC}$ for 5.44×10^5 g/sec GN_2 mixed with 4.54×10^5 g/sec AIR

H_S = height of stack (= 80 Ft.)

Consider the case where U_0 = 100 ft/sec and SG = 1.5, using the equations above and the rest of the parameters as shown above. Then using equations 1 through 6, one gets the results summarized in Table D-2.

It would be interesting to substitute into the equations the density values for each absolute humidity and temperature to get separate results for each ambient air condition shown in Table D-1.

Without such a substitution, it is possible to conclude that the resulting concentrations are much less than those for Gaussian modeling for an effective plume height of 24.4 meters (80 ft.).

(Meroney, R.N.; Hoot, T.G.; and Peterka, J.A. "Wind Tunnel Tests of Negatively Buoyent Plumes," Office of Research and Development, U.S. Environmental Protection Agency (October 1973)

Table D-1 - Density of exhaust and ambient air (taken from enthalpy calculations) assuming emission rate of 544 kg/sec and air rate of 454 kg/sec).

T	Ambient Temperature (°F) =	83	83	32	32
RH	Ambient Relative Humidity (%) =	100	70	100	70
P_o	Discharge Gas Density (lb/ft^3) =	0.0960	0.100	0.116	0.117
P_a	Ambient Gas Density (lb/ft^3) =	0.0704	0.0710	0.0803	0.0804
SG	Discharge Gas Specific Gravity =	1.35	1.41	1.45	1.45
T_s	Exhaust Temperature (°F) =	-46	-62	-117	-119
T_s	Exhaust Temperature (° C) =	-43	-52	-83	-84

Table D-2 - Results of Calculations Using Wind Tunnel Equations assuming a GN_2 air mixture emission rate of 998 kg/sec (2200 lb/sec), an exit velocity of 30.5 m/sec (100 ft/sec), and a specific gravity of 1.5.

V		H		$\overline{X}$	X_d		$\underline{X}$	
Wind Velocity		Height of Plume			Downwind distance to plume touchdown		Concentration at Plume Touchdown	
mph	m/sec	ft	m	(ft)	ft	km	$\frac{Lb}{ft^3}$	$\frac{g}{M^3}$
1	0.45	370	113	13.7	4380	1.34	0.00272	43.6
2	0.89	294	90	27.4	6450	1.97	0.00203	32.5
3	1.34	257	78	41.1	8143	2.49	0.0017	27.2
4	1.79	233	71	54.8	9596	2.94	0.0015	24.0
5	2.23	217	66	68.5	10931	3.35	0.0014	21.8
6	2.68	204	62	82.2	12158	3.73	0.00125	20.0
7	3.13	194	59	95.9	13319	4.09	0.00116	18.6

Table D-3. WIND TUNNEL DISCHARGE: ANALYSIS OF CONCENTRATION AS A FUNCTION OF STABILITY AND WIND SPEED (1971 version, D. B. Turner).

Emission rate (g/sec): 992,000 Ambient air temp.: 301°K
Physical stack height: 24.38 m Volume flow: 0.00 m^3/sec
Stack gas temp.: 301°K

Stability	Wind Speed (m/sec)	Max. Concentration (g/m^3)	Distance to Max. Concentration (km)	Plume Height (m)
1	.5	421	.127	24.4
1	.8	263	.127	24.4
1	1.0	210	.127	24.4
1	1.5	140	.127	24.4
1	2.0	105	.127	24.4
1	2.5	84	.127	24.4
1	3.0	70	.127	24.4
2	.5	436	.170	24.4
2	.8	272	.170	24.4
2	1.0	218	.170	24.4
2	1.5	145	.170	24.4
2	2.0	109	.170	24.4
2	2.5	87	.170	24.4
2	3.0	72	.170	24.4
2	4.0	55	.170	24.4
2	5.0	44	.170	24.4
3	2.0	116	.250	24.4
3	2.5	93	.250	24.4
3	3.0	77	.250	24.4
3	4.0	58	.250	24.4
3	5.0	46	.250	24.4
3	7.0	33	.250	24.4
3	10.0	23	.250	24.4
3	12.0	19	.250	24.4
3	15.0	15	.250	24.4
4	.5	400	.447	24.4
4	.8	250	.447	24.4
4	1.0	199	.447	24.4
4	1.5	133	.447	24.4
4	2.0	100	.447	24.4
4	2.5	80	.447	24.4
4	3.0	66	.447	24.4
4	4.0	50	.447	24.4
4	5.0	40	.447	24.4
4	7.0	29	.447	24.4
4	10.0	20	.447	24.4
4	12.0	17	.447	24.4
4	15.0	13	.447	24.4
4	20.0	10	.447	24.4
5	2.0	87	.694	24.4
5	2.5	69	.694	24.4
5	3.0	58	.694	24.4
5	4.0	44	.694	24.4
5	5.0	35	.694	24.4
6	2.0	75	1.221	24.4
6	2.5	60	1.221	24.4
6	3.0	50	1.221	24.4
6	4.0	37	1.221	24.4
6	5.0	30	1.221	24.4

APPENDIX E

COMMENTS RECEIVED ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

October 7, 1976

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Mr. Crow:

As requested by your letter of September 2, 1976, to the Chairman of the Council on Environmental Quality, we have reviewed the draft environmental impact statement, National Transonic Facility (Amendment 1), Langley Research Center, Hampton, Virginia.

We have one comment to offer. On page 84, the statement notes that the venting of gaseous nitrogen will cause high noise levels on SR 172 adjacent to the new facility and that this may create safety hazards by startling users of the road. Since the vented gas may sound like an explosive release of pressure (e.g., the rupture of a boiler), we recommend that suitable warning signs be positioned along SR 172 to alert motorists to this hazard. The signs might note, for example, that when amber lights are flashing they should be prepared for loud unexpected noise as part of tunnel operations.

We appreciate the opportunity to review this statement.

Sincerely,

Martin Convisser, Director
Office of Environmental Affairs
Office of the Assistant Secretary for
Environment, Safety, and Consumer Affairs

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

October 26, 1976

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Re: Amendment 1 to the Langley Research Center Institutional Statement

Dear Mr. Crow:

We have reviewed the amendment to the above referenced Environmental Impact Statement and have classified it as LO-2 in EPA's reference category. We have enclosed a copy of the Definition of Codes for the General Nature of EPA Comments to provide a more detailed description of this rating. Also, in accordance with our responsibilities under Section 309 of the Clean Air Act to inform the public of EPA's views on the potential environmental impacts of Federally assisted actions, this rating will be published in the Federal Register.

While we have no specific objections to the project as described, EPA is somewhat concerned with the noise impacts resulting from the nitrogen vent system and the tunnel drive fan, as well as with the discharge of large quantities of cold gaseous nitrogen into the atmosphere. These concerns are outlined in more detail in the following paragraphs.

Since the noise levels will increase significantly due to the National Transonic Facility operation, and since the operating hours will be from midnight to 8 a.m., EPA would like the final EIS to include a description of the design changes mentioned on page 85 that will lower the noise levels to acceptable levels.

We acknowledge that other independent community sources produce high noise levels, but EPA questions whether these activities occur from midnight to 8 a.m. Furthermore, we note that while operational times are typically 10 minutes or less at a stretch, it has not been indicated whether the operation will occur only once per night or several times per night.

If it occurs several times throughout the night, it could be more disturbing to the residents of the trailer court than if it were a constant noise or if it only occurred once during the night.

Therefore, the final EIS should include an operating schedule denoting the approximate number of times per night that the transonic facility will be operated.

With respect to the potential meterological impacts, EPA notes that the NTF will not discharge gaseous nitrogen from the vent stack when meteorological conditions are such that hazards could result. However, EPA believes that further measures should be looked into which would focus on reducing the potential for these impacts to occur. These measures are enumerated below:

1. Further consideration should be given to increasing the diameter of the stack which would allow the gaseous nitrogen to mix with a greater volume of air. This could also be a means of reducing noise impacts through the installation of baffles,

2. The possibility of increasing the stack height might also be considered. This would increase the time that the gas would mix with the atmosphere before reaching the ground.

3. The possibility of venting the gas away from sensitive receptors before releasing it into the atmosphere might be looked into.

4. Finally, venting the exhaust heat generated through the operation of the motors or from other facilities at the research center into the stack might act to warm the gaseous nitrogen emissions and mitigate thermal impacts.

As a final point, EPA would like to review the results of the pilot study for nitrogen discharge that will be performed under conditions simulating those at the NTF.

We hope that this review will assist you in the preparation of the final Environmental Impact Statement. If you have any questions, or if we can be of further assistance, you may wish to contact Mr. Sam Little or Mr. William Hoffman of my staff at 215-597-7093. We would appreciate the receipt of one copy of the final Environmental Statement at such time as it is filed with the Council on Environmental Quality.

Sincerely yours,

Nicholas M. Ruha
Chief
EIS and Wetlands Review Section

Enclosure

DEFINITION OF CODES FOR THE GENERAL NATURE OF EPA COMMENTS

ENVIRONMENTAL IMPACT OF THE ACTION

LO--Lack of Objection

EPA has no objections to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER--Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.

EU--Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

ADEQUACY OF THE IMPACT STATEMENT

Category 1--Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as reasonable alternatives available to the project or action.

Category 2--Insufficient Information

EPA believes that the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3--Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonable available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 76/913

NOV 4 1976

Dear Mr. Crow:

Thank you for your letter of September 2, 1976, transmitting copies of the National Aeronautics and Space Administration's draft environmental statement for Langley Research Center (Transonic Facility), York and James Counties, Virginia.

We have reviewed the subject project and have the following comment.

We recommend that the final statement fully address the potential impact of emissions from the gaseous nitrogen vent system on wildlife at the site.

We hope that this comment will be useful to you.

Sincerely yours,

Stanley K. Bowers

Deputy Assistant Secretary of the Interior

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

4 NOV 1976

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20006

Dear Mr. Crow:

This is in response to your request of September 2, 1976, for the Department of Defense's review of NASA's amendment to the final environmental impact statement for the National Transonic Facility (NTF) at Langley Research Center, Hampton, Virginia. Our Office of Defense Research and Engineering and the Department of the Air Force reviewed the proposal. We support the establishment of the facility. We do, however, believe that additional discussion is necessary on fog and snow generation which may result from the operation of NTF, its interaction with other emissions from the base and NTF, and the steam generating plant which is planned for the area. Our concern is the possible impact on local flying operations. Specific Air Force comments on these issues are enclosed.

Thank you for the opportunity to review this proposal. If you have further questions, please contact Mr. H. R. Smith or myself on 695-0221.

Sincerely,

George Marienthal

George Marienthal
Deputy Assistant Secretary of Defense
(Environment and Safety)

Enclosure

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE ASSISTANT SECRETARY

14 OCT 1976

MEMORANDUM FOR DEPUTY ASSISTANT SECRETARY (ENVIRONMENT AND SAFETY) OFFICE OF ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS)

SUBJECT: NASA Environmental Impact Statement Amendment on Langley Research Center of the National Transonic Facility (NTF)

In response to your memorandum dated September 16, 1976, subject Environmental Impact Statement Amendment has been reviewed both by the Air Staff and HQ Tactical Air Command, Langley AFB.

Recommend you forward the following comments to the National Aeronautics and Space Administration:

a. Reference paragraph 2.B., page 86: Additional information and discussion on fog/snow generation relative to impact on Air Force flight operations should be included. The possibility of reduced visibility due to induced fog and snow in the approach area to runway 7 has not been adequately addressed. Some estimate of the density and frequency of occurrence should be included.

b. A new 255 ton per day refuse fired steam generating plant is planned for the NASA complex. Emissions from this incinerator will contain condensation nuclei. Discussions on the possible interaction of the emissions from the incinerator and the NTF should be included. Such interaction could further increase the potential for fog/snow generation with their potential for impact on local flying operations.

Signed

BILLY E. WELCH, Ph.D
Special Assistant for
Environmental Quality

COMMONWEALTH of VIRGINIA

GERALD P. McCARTHY
CHAIRMAN AND
ADMINISTRATOR

Council on the Environment

903 NINTH STREET OFFICE
RICHMOND 23219
804 786 4500

November 10, 1976

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Subject: National Transonic Facility, Langley
Research Center, Hampton, Virginia

Dear Mr. Crow:

The Council on the Environment has completed its review of the subject Draft Environmental Impact Statement. The following State agencies participated in that review:

Department of Industrial Development
State Water Control Board
Department of Health
Air Pollution Control Board
Soil and Water Conservation Commission
State Corporation Commission
Department of Highways and Transportation
Virginia Energy Office

Based on our review of the project and the comments that we have received, we have the following suggestions for your consideration.

The Statement should be expanded to include measures taken to:

a. Reduce fugitive dust from transportation of dirt, sand, stone, gravel, etc., both into and out of the construction site, including the wetting down, when practicable, of the loads during loading and

unloading operations, the frequent wash down of truck bodies, and the use of attached hinged covers or tarpaulins to cover loads while in transit.

b. Prevent transport of fugitive dust from the construction site, work areas, material storage areas, and haul roads by use of water dampening, oil, calcium chloride, liquid latex,,or other known effective techniques.

c. Dispose of land clearing, demolition, and construction wastes, by means other than burning at the construction site, if at all feasible.

d. Obtain the necessary permits for the construction and operation of temporary installations required, e.g., concrete or asphalt batching plants, stone crushers, etc.

e. Insure that all material handling and storage equipment employed at the construction site is equipped with adequate pollution control devices such as hoods, fans, scrubbers, filters, etc.

It is noted that the subject of space and/or process heating for this facility is not addressed. If there is to be any, either from a new installation or from additional loads on existing installations, additional fuel requirements and methods of combustion must be provided to determine the increased emissions and environmental effects of any additional particulates, CO, SO_2, NO_2 and hydrocarbons emitted from the additional fuel burned.

The potential sources of water pollution associated with this facility are chromate for corrosion inhibition in the cooling system, chemicals from laboratory drains, and oil from machinery drains and hydraulic system leaks. Proper measures should be employed to mitigate associated impacts.

There are two landfills on the property that represent a potential threat to groundwater. The disposal of wastes in these landfills should be carefully supervised to avoid groundwater contamination.

Storage sites for chromium, used solvents, and oil should have adequate spill prevention facilities. Large storage tanks should be diked, and containment and cleanup devices should be available for smaller tanks.

The Department of Highways and Transportation has pointed out that Route 172, which serves the facility, is a major thoroughfare. The 1985 Peninsula Area Major Thoroughfare Plan recommends that Route 172 be improved to a four-lane divided facility.

The Virginia Energy Office has commented that continuing attention should be given to minimizing the impact of the facility's peak demand upon the normal peak demand of the electrical grid in which it operates.

Thankyou for the opportunity to comment on this document.

Sincerely yours,

Gerald P. McCarthy

GPM:jts

cc: The Honorable Earl J. Shiflet, Secretary of Commerce and Resources
Mr. J. L. Hamrick, State Water Control Board
Mr. Lewis R. Lawson, Jr., Virginia Energy Office
Mr. R. L. Hundley, Department of Highways and Transportation
Mr. James Ruehrmund, Air Pollution Control Board

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

OFFICE OF THE SECRETARY

WASHINGTON, D.C. 20201

NOV

Mr. Duward L. Crow
Associate Deputy Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Mr. Crow:

We acknowledge the receipt of the draft environmental impact statement concerning the National Transonic Facility, Langely Research Center, Hampton, Virginia (Amendment 1 to the EIS, 1971).

Although we will not be submitting comments, we appreciate the opportunity to review the document. We would like to continue to receive all future environmental impact statements that your agency prepares.

Sincerely,

Charles Custard
Director
Office of Environmental Affairs