DOE/EIS - 0138
Volume I

FINAL
ENVIRONMENTAL IMPACT STATEMENT

SUPERCONDUCTING SUPER COLLIDER

Volume I

December 1988

U.S. Department of Energy

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DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20545
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U.S. Department of Energy
Washington D.C. 20585

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COVER SHEET

LEAD AGENCY

U.S. Department of Energy (DOE)

COOPERATING AGENCY

Bureau of Land Management, U.S. Department of the Interior (Arizona only)

TITLE

Final Environmental Impact Statement (FEIS), Superconducting Super Collider. (The site alternatives for the SSC are located Colorado, Illino ,
site alternative located in Texas has been selected as the preferred site).

CONTACT

Additional copies or information concerning this EIS can be obtained from the SSC Site Task Force (STF), ER-65/GTN, Office of Energy Research, U.S. Department of Energy, Washington, D.C. 20545. Telephone (301) 353-6570.

ABSTRACT

The proposed action for this EIS is to select the site for construction and operation of the Superconducting Super Collider (SSC) project, which would be the largest scientific instrument ever to be built. The SSC would be a laboratory facility designed to investigate the basic structure of matter. It would be a proton accelerator capable of accelerating two beams of protons to an energy of 20 trillion electron volts.

The EIS assesses and compares the environmental impacts of the proposed construction and operation of the SSC at each of seven site alternatives. The no-action alternative (continued use of existing accel
U.S. and existing and new accelerators in other countries) is also evaluated. In addition, four technical alternatives and several programmatic alternatives are discussed.

The main feature of the proposed SSC would be a 53-mile-long oval tunnel, which would contain circulating beams of protons within two rings of superconducting magnets. The SSC would have laboratory facilities housed in a campus area, as well as various access and service areas.

This EIS provides as much information as possible at this stage of the project development regarding the potential environmental impacts of the proposed construction and operation of an SSC at each of the site

alternatives. However, the DOE recognizes that further review under the National Environmental Policy Act (NEPA) is required prior to construction and operation of the proposed SSC project at the selected site based on more detailed design and to identify specific mitigation measures which can be incorporated into final design. Accordingly, following selection of a site for the proposed SSC, the DOE will prepare a Supplemental EIS to address in more detail the impacts of constructing and operating the proposed SSC at the selected site and alternatives for mitigating those impacts.

To measure the effects of constructing the SSC at any of the seven alternative sites, the DOE determined which aspects of the human environment would be significantly affected. The EIS describes the baseline conditions at each of the seven site alternatives, the trends underway resulting in changes, the potential environmental impacts expected if the SSC were sited, possible mitigations of adverse impacts, and resulting residual adverse impacts.

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SUPERCONDUCTING SUPER COLLIDER

FINAL ENVIRONMENTAL IMPACT STATEMENT

FOREWORD

OVERVIEW

This Environmental Impact Statement (EIS) analyzes the environmental impacts of the proposed SSC project, which would be the largest scientific instrument ever constructed. The SSC would be used to gain a better understanding of the fundamental structure of matter.

The EIS considers the impacts projected to occur if the SSC were to be sited at one of seven alternative locations. These impacts are measured against the impacts expected to occur if the SSC were not built; this is called the no-action alternative. The site alternative located in Texas has been selected as the preferred site. The final decision on the location of the facility will be announced in the Record of Decision (ROD) scheduled to be issued in January 1989. Prior to construction and operation of the proposed SSC project, the DOE will prepare a supplement to this EIS to address in more detail the environmental impacts at the selected site, and the alternatives for mitigating those impacts.

BACKGROUND

Research and development for the SSC project have been conducted as a national scientific effort under the guidance of the Central Design Group (CDG), an organizational entity of Universities Research Association, Inc. The Reference Design Study, completed in March 1984, established the basis for design of the SSC. The CDG completed the Conceptual Design Report (CDR) in 1986, which led to the conclusion that the SSC was technically feasible and that cost and schedule estimates were acceptable. In January 1987, the President proposed construction of the SSC to the Congress. Construction of the proposed SSC is anticipated to cost $4.4 billion (fiscal year 1988 dollars) and would be completed during the mid-1990's.

The major feature of the proposed SSC would be a racetrack-shaped tunnel about 53 mi in circumference. Two beams of protons (subatomic particles) would be accelerated in opposite directions to energies 20 times higher than is now possible at any other accelerator in the world. They would then be made to collide at an energy level of 40 trillion electron volts (TeV). The tunnel would be constructed with its centerline at least 35 ft underground. Service areas would be located approximately every 5 mi, and access shafts would be located midway between each service area.

The proposed SSC would be expected to remain in operation for 25 to 30 years after construction. After completion of its useful life, the SSC would be decommissioned. Underground facilities would be sealed and above-ground facilities removed where appropriate. Additional review, in accordance with the National Environmental Policy Act (NEPA), would be completed prior to a decision on decommissioning.

ALTERNATIVE SITES CONSIDERED

On April 1, 1987, the DOE issued an Invitation for Site Proposals (ISP) for the proposed SSC. In response, 43 proposals were received and reviewed by the DOE; of these, 36 were further evaluated by the National Academy of Sciences and the National Academy of Engineering (NAS/NAE). Based upon criteria listed in the ISP, design details of the proposals, and specific characteristics of the sites, the NAS/NAE recommended to the DOE a best qualified list (BQL) of sites to be considered further. These sites were presented to the DOE on December 24, 1987. One of the recommended BQL sites was subsequently withdrawn by the proposing organization. Following a review and validation of the NAS/NAE recommendation, the BQL was accepted by the DOE and announced on January 19, 1988. The proposals for these seven sites, as provided in response to the ISP (modified in some cases by certain design considerations), form the seven site alternatives considered in this EIS.

SELECTION OF THE PREFERRED SITE

Following announcement of the BQL in January 1988, the DOE began a detailed evaluation of the BQL proposals. Site visits were conducted to each BQL site between April and July 1988. Following all site visits, the DOE reviewed all site data, including those assembled for the EIS, public and agency comments on the Draft EIS, and the life-cycle cost analyses prepared for each site. The results of the DOE evaluations of technical criteria and cost considerations were published in "SSC Site Evaluations - A Report by the SSC Site Task Force" (DOE/ER-0392, November 1988). The selection of the preferred site, the Texas site alternative, was announced by the DOE on November 10, 1988.

PREVIOUS PUBLIC PARTICIPATION

The public was first notified of the DOE's intent to prepare an EIS on the proposed SSC project through the Advance Notice of Intent (52 FR 16304, May 4, 1987). The Advance Notice requested comments on the scope of the EIS to be prepared and on the content of the EIS. Nine letters were received in response to the Advance Notice; six were requests for copies of the document and three were comments on the EIS content. The Advance Notice was followed by the Notice of Intent (53 FR 1821, January 22, 1988) which again asked for public comments on the scope and content of the EIS. In addition, scoping meetings were held in the vicinity of each of the BQL sites. The DOE received approximately 2,100 letters which provided comments on the scope of the EIS. Comments given at each of the scoping meetings were documented through written transcripts of the meetings. The DOE has considered these written and oral comments in the preparation of this EIS.

The DOE issued the Draft EIS (DEIS) in August, 1988, followed by the publication of the Notice of Availability (53 FR 34148) by the Environmental Protection Agency (EPA) on September 2, 1988. The Notice of Availability requested comments on the Draft EIS. In addition, public hearings were held in the vicinity of each of the BQL sites.

Responses to comments received until October 17, 1988 (45 days after the publication of the Notice of Availability) are provided in Volume IIB. Comments received after October 17 were reviewed in detail, but no individual responses were developed. It was determined that none of the late comments addressed new issues not covered by previous comments, nor would they result in a change to the conclusions reached in the EIS. The DOE received written and oral statements from approximately 5,700 commenters including letters, petitions, and testimony from public hearings on the Draft EIS. The DOE has considered these written and oral comments in the preparation of this Final EIS.

HOW TO USE THIS DOCUMENT

This Final EIS includes:

Volume I - Revision of the Draft EIS

Volume II - Comment/Response Document - Index and Summary
- Volume IIA.1 - Letters
- Volume IIA.2 - Transcripts
- Volume IIB - Responses

Volume III - Methodology for Site Selection
- Chapters 1 and 2 - Revision of the Draft EIS
- Chapter 3 - SSC Site Evaluations

Volume IV - DEIS Appendices 1-6, 9, 10, 12-16
- Errata and Revisions for Appendices 1, 4, 6, 9, 10, 12-16 (to the DEIS)
- Appendix 5 Errata (to the DEIS)
- Appendix 7 - Revision
- Appendix 8 - Revision
- Appendix 11 - Revision

Commenters should refer to Volume II - Index and Summary to locate their comment response number. Comment responses are in Volume IIB.

For the convenience of interested persons and organizations, copies of the EIS have been provided to libraries and reading rooms throughout the country. The DOE reading rooms and selected libraries in the seven states where the site alternatives are located are:

DOE Reading Rooms

U.S. Department of Energy Library, Room GA-138, U.S. DOE, Forrestal Building, 1000 Independence Avenue, SW, Washington, D.C. 20585

Public Reading Room, Chicago Operations Office, 9800 South Cass Avenue, Argonne, IL 60439

Public Reading Room, Oak Ridge Operations Office, Federal Building, P.O. Box E, Oak Ridge, TN 37831

Public Libraries

Arizona

Noble Science and Engineering Library, Arizona State University, Tempe, AZ 85287-1506

Phoenix Public Library, 12 E. McDowell Road, Phoenix, AZ 85004

Colorado

Fort Morgan Public Library, 414 Main Street, Fort Morgan, CO 80701

East Morgan County Library, 500 Clayton Street, Brush, CO 80723

Illinois

Illinois SSC Project Office, c/o Illinois State Water Survey, 101 North Island Avenue, Batavia, IL 60510

Aurora Public Library, 1 East Benton Street, Aurora, IL 60506

St. Charles Public Library, 1 South 6th Avenue, St. Charles, IL 60174

Kaneville Township Library, c/o Kaneville Civic Center, P.O. Box 5, Main Street and Harter Road, Kaneville, IL 60144

West Chicago Public Library, 332 East Washington Street, West Chicago, IL 60185

Michigan

Ingham County Library System, Library Service Center, 407 North Cedar Street, Mason, MI 48854

Jackson District Library System, 244 West Michigan Avenue, Jackson, MI 49201

North Carolina

Richard H. Thorton Library, Spring and Main Street, Oxford, NC 27565

Durham County Library, 300 N. Roxboro Street, Durham, NC 27701

Roxboro Library, 307 South Main Street, Roxboro, NC 27573

Tennessee

Linebaugh Public Library, 110 West College, Murfreesboro, TN 37130

Tennessee Department of Economic and Community Development Library, 320 6th Avenue North, 8th Floor, Rachel Jackson Building, Nashville, TN 37219-5308

Texas

Sims Library, 515 West Main Street, Waxahachie, TX 75665

Ennis Public Library, 501 West Ennis Avenue, Ennis, TX 75119

REQUESTS FOR COPIES

The DOE will furnish a copy of the EIS or any appendix upon request. Requests for an appendix should specify the title of the volume requested (see Table of Contents of this volume for a list of the appendices). Telephone requests for copies of the EIS will be accepted at (301) 353-6570. Please submit requests to Dr. Wilmot Hess at the following address:

Dr. Wilmot Hess, Chairman
SSC Site Task Force
ER-65/GTN
Office of Energy Research
U.S. Department of Energy
Washington, D.C. 20545

Requests should be marked either "Attn: SSC EIS Request" or "Attn: SSC EIS Appendices Request".

FINAL ENVIRONMENTAL IMPACT STATEMENT

The text of Volume I, Volume II, Volume III, and Volume IV Appendices 7, 8, and 11 have been printed in their entirety. All other appendices in the Draft EIS should be retained as part of this final document.

This Final EIS contains revisions and additions to the text of the Draft EIS, based upon agency and public comments received. Comments on the Draft EIS are printed in Volume II of this Final EIS. Additionally, Volume II presents the DOE's responses to the comments received. This Final EIS identifies the DOE's preferred site. The DOE's final decision, and the rationale for its choice, will be documented in the ROD.

The ROD will be issued at least 30 days after publication of this Final EIS The ROD is scheduled for completion in January 1989.

CHAPTER 1

SUMMARY

CHAPTER 1 SUMMARY

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CHAPTER 1 SUMMARY

1.1 OVERVIEW

The Department of Energy (DOE) has proposed the Superconducting Super Collider (SSC), a state-of-the-art laboratory facility in the United States for the study of high energy physics. The proposed SSC would be the largest scientific instrument ever built.

This Environmental Impact Statement (EIS) analyzes the potential effects to the human environment of the construction and operations of the proposed SSC at any one of seven site alternatives and analyzes other alternatives to the proposed action. A preliminary evaluation of future expansion areas and of SSC decommissioning are included in the document. Prior to construction and operation of the SSC, the DOE wi supplement to this EIS to address in more detail the environmental impacts and mitigations at the selected site. This chapter summarizes the information contained in this EIS.

The basic purpose of the SSC is to gain a better understanding of the fundamental structure of matter.

This machine would be capable of accelerating two beams of subatomic particles (protons) to an energy of 20 TeV (trillion electron volts). The two beams would then be made to collide, and the results of these collisions (at 40 TeV) would be studied by scientists. The SSC could create particle collisions at energies 20 times higher than can be achieved at existing accelerators. This means that the SSC could probe the properties of matter at distances 20 times smaller than can now be done using existing and planned particle accelerators. The SSC would provide the United States with the capability of maintaining its world leadership in the field of high energy physics.

The SSC is expected to result in other benefits as well. Besides providing scientific data, the SSC could be a source of spin-off technology having applications in other fields. Within the past ten years, the technology developed for high energy physics has made new products possible, including equipment used for medical diagnostics and therapy, improved computer components, and new superconducting magnet materials.

Projecting to the future, discoveries resulting from the SSC may lead to benefits that are currently impossible to envision. Looking back in time, one sees that research in subatomic physics over the last 80 years was essential to the development of technology comprising a significant portion of our current gross national product, including portions of such important industries as communications, consumer electronics, and computers. On a broader scale, the wonder and excitement resulting from discoveries due to the SSC may provide inspiration for young people to enter careers in science and engineering. This atmosphere would contribute to maintaining America's economic competitiveness in an increasingly technological world.

1.2 PROPOSED ACTION AND ALTERNATIVES

The proposed action is the SSC project. The main feature of the SSC would be a 53-mi-circumference oval accelerator tunnel located at least 30 ft underground. The SSC would also have laboratory facilities housed in a campus area and various tunnel access and accelerator service structures located on the surface.

Four different types of alternatives to the proposed action have been considered in this EIS.

- Site alternatives - seven locations have been analyzed in the EIS. These are:
  - Arizona - approximately 30 mi southwest of Phoenix in Maricopa County.
  - Colorado - approximately 65 mi northeast of Denver in Adams, Morgan, and Washington Counties.
  - Illinois - approximately 40 mi west of Chicago in Kane, DuPage, and Kendall Counties.
  - Michigan - approximately 35 mi northwest of Ann Arbor in Ingham and Jackson Counties.
  - North Carolina - approximately 15 mi north of Durham in Person, Granville, and Durham Counties.
  - Tennessee - approximately 30 mi southeast of Nashville in Bedford, Marshall, Rutherford, and Williamson Counties.
  - Texas - approximately 25 mi south of Dallas and 35 mi southeast of Fort Worth.in Ellis County.
- Technical alternatives - the EIS addresses the possibility of using different technology, equipment, or building configuration for the SSC.
- Programmatic alternatives - the EIS discusses the possibilities of using other accelerators, international collaboration, and delaying the project.
- No-action alternative - the EIS examines the option not to construct the SSC, not affecting current environmental conditions and trends at the seven site alternatives.

1.3 AFFECTED ENVIRONMENT

To measure the effects of the SSC at any of the seven site alternatives, the DOE determined which aspects of the human environment would be significantly affected. The EIS describes the baseline conditions at each of the sites and trends for changes projected to occur whether or not the SSC is built at each of the sites.

1.4 ENVIRONMENTAL CONSEQUENCES

The EIS identifies and analyzes the potential environmental impacts expected to occur from the siting of the SSC at the seven site alternatives. The future use areas within the proposed land to be acquired are evaluated based on preliminary information concerning their potential development. After completion of its useful life, the SSC would be decommissioned. A Supplemental EIS, in accordance with the National Environmental Policy Act (NEPA), will be completed following site selection, prior to construction and operation of the SSC based on more detailed design and to identify specific mitigation measures which can be incorporated into the final design. The Supplemental EIS will address in more detail the environmental impacts at the selected site and the alternatives for mitigating those impacts. Prior to a decision to develop the future use areas, or to decommission the SSC, further NEPA review would be completed. This EIS contains an assessment of construction, operations, and decommissioning activities.

Residual impacts identified in the EIS are those projected to occur if the proposed action, together with proposed mitigation measures, were implemented at any of the sites. In some cases, it might be possible to further mitigate these residual impacts through modifications to the final site design. These final site design and resulting mitigation measures will be identified and analyzed in the Supplemental EIS.

If the SSC were built, certain environmental impacts would occur regardless of which site were chosen for the SSC. Construction of the facility would consume appreciable quantities of building material, primarily cement. Except for portions of the Arizona and Illinois sites that are already public land, land used for the SSC would pass from private or state ownership to the Federal Government. Operation of the SSC would require a continual supply of natural and depletable resources, including electric power and water.

The SSC would also have beneficial impacts at any of the site alternatives. Many job opportunities would be created, during both construction and operations; local businesses would also benefit. The SSC is expected to have a beneficial impact on community, socioeconomic, and educational services. These benefits have been previously experienced at Fermilab, a national accelerator facility in Illinois where there has been an influx of highly trained scientists, as well as at the Stanford Linear Accelerator Center (SLAC) in California, Brookhaven National Laboratory in New York, and other high energy physics research facilities.

Over the long term, the state in which the SSC is constructed would gain economically from the presence of the SSC. However, at some locations a short-term economic stress would occur initially, during early construction, as lands are removed from the local tax base and the communities accommodate additional infrastructure impacts such as increased vehicular traffic, increased attendance at local schools, or increased wastewater treatment needs.

Table 1-1 summarizes and compares major environmental impacts from the SSC at each of the seven site alternatives.

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Table 1-1

UNMITIGABLE ENVIRONMENTAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT THE SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Water Resources							
Water supply	Groundwater supply: may initiate local overdraft	Groundwater supply: purchase of groundwater now going to other uses	Groundwater supply: incremental increase to regional overdraft	Groundwater supply: incremental increase to local overdraft	Surface water supply: 23% of Lake Butner excess capacity	Surface water supply: use of moderate fraction of excess capacity	Surface water supply: use of small fraction of excess capacity
Ecological Resources							
Wetlands[1]	None	4 acres	199 acres	190 acres	41 acres	38 acres	3 acres
Socioeconomics							
Number of jobs							
Total[2], peak yr Construction	9,477	10,361	10,495	9,621	9,615	9,417	9,651
% increase[3]	0.68	0.72	0.26	0.42	0.93	1.31	0.44
Total[2], first yr Operations	6,180	6,381	7,030	6,322	6,399	6,886	6,513
% increase[3]	0.35	0.37	0.17	0.27	0.55	0.85	0.26
Total Number of Relocations	6	23	219	221	180	128	175

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Table 1-1 (Cont)

UNMITIGABLE ENVIRONMENTAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT THE SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Infrastructure							
Roads							
Miles of new road[4]	60	94	8	10	39	13	31
Electric Power							
Miles of new powerline to SSC substations	41	99	2	6	4	32	5

1. The maximum acreage of wetlands that would be impacted during construction of the surface facilities for the proposed action. Wetlands occurring within Area C, the J sites, and K3 and K4 are not considered because they are proposed future expansion areas and may not be developed (see Section 3.7.3).

2. An approximate total based on the sum of peak year direct SSC employment and peak year indirect jobs which would be created due to the presence of the SSC.

3. The region of influence to which the number of jobs is compared is defined in Chapter 5

4. For Arizona: Based on the alternate road plan developed by the DOE for Arizona, as discussed in Chapter 3, Section 3.4.1. The road plan proposed by the State of Arizona (101 mi of new road) included construction of the Estrella Freeway from Goodyear to I-8.

1.5 FEDERAL PERMITS, LICENSES, AND OTHER ENTITLEMENTS

The DOE has examined specific Federal permits, licenses, and other entitlements that may be needed to construct and operate the SSC at each of the seven proposed sites. These would vary based on resource needs at the different sites.

Regardless of where it is sited, the SSC would produce very small amounts of radionuclides, a small fraction of which would be released to the environment. In addition, very small releases of other types of hazardous emissions would occur. Under the National Emission Standards for Hazardous Air Pollutants [40 CFR 61], the DOE would be required to obtain Environmental Protection Agency (EPA) approval to construct and operate the SSC.

1.6 PUBLIC PARTICIPATION

The public was invited to provide comments and attend public meetings as part of the scoping process on the Draft EIS (DEIS). The public was asked to review the DEIS and provide comments during a 45-day public comment period. The Final EIS (FEIS) incorporates changes made in response to comments received through letters and transcripts from the meetings. The comments and responses are also included in the FEIS.

1.7 CHANGES IN THE FINAL EIS FROM THE DRAFT EIS

There were changes made in the EIS (compared to the draft document) which resulted from public, state proposer, and agency comments noting errors or omissions in the draft and providing information which clarified, expanded, or supplemented information used as the basis of DOE's independent assessment of environmental impacts. Wetlands assessments were refined using data from DOE field surveys completed after publication of the DEIS. Air quality assessments were also revised based on EPA comments. Throughout the analysis, increased emphasis has been placed on mitigation alternatives and alternatives of the proposed action. Issues to be addressed in the Supplemental EIS have been added or further defined. The paragraphs below identify changes in the EIS. These are not ordered in any priority since none changed the conclusions of the EIS.

1.7.1 Relocations

The number of relocations reported in the FEIS has changed from the DEIS. These changes resulted from DOE site visits and supplemental information provided at the proposing states based on additional surveys and evaluations conducted after the date information was provided for the DEIS (essentially March 15, 1988, submittals from proposing organizations). See this Volume I, Chapter 3, Section 3.1, and Volume IV, Appendix 4 which provide analyses.

1.7.2 Flexibility of Design and Site Alternatives

A discussion of the flexibility of the conceptual design and the site adapted conceptual design (site flexibility) is provided in Chapter 3, Section 3.6.1. This section provides a discussion of the use of design and site flexibilities as mitigations. The DOE believes that the most efficient and cost effective mitigation of many potential impacts will be avoidance. This information is provided to enhance the discussion of mitigation possibilities (Chapter 3, Section 3.6.1), costs (Chapter 3, Section 3.6.2), and impacts (Chapter 3, Section 3.6.6) in response to public comment.

The estimates of acreages permanently and temporarily disturbed were refined based on more detailed engineering analysis of the surface facilities of the SSC (Chapter 3, Table 3-2).

1.7.3 Impacts of Future Expansion

Although the DEIS identified future expansion areas (area C, J areas, K3 and K4) there was no discussion of their potential impacts. Such impacts are anticipated to be similar but smaller in scale than those caused by proposed construction and operations of the SSC. A discussion of potential development of the future use areas and associated impacts has been added to the Final EIS (see Chapter 3, Sections 3.1.5 and 3.7.3).

1.7.4 Secondary Impacts of Ancillary Facilities

The secondary impacts of the ancillary facilities which would likely be developed by the host state were not discussed in the DEIS. These discussions have been added (see Chapter 3, Section 3.7.2 and Chapter 5, Section 5.2.13) to the FEIS to assure consideration of potential cumulative impacts.

1.7.5 Earth Resources Impacts

The discussion of earth resources has been expanded to include supplemental information provided by the State of Tennessee on karst features in the area of the proposed Tennessee site (see Chapter 5, Section 5.1.1 and Volume IV, Appendices 5 and 11).

1.7.6 Water Resource Impacts

The discussion of water resources impacts has been expanded by inclusion of additional information provided by agencies, municipalities, and utilities (see Chapter 5, Section 5.1.2). These enhancements include:

- o Water supply - more detailed information regarding sources and proportions which are furnished by groundwater and surface water; verification of the reliability of water supply/sources.

- o Floodplain assessment - additional information including maps of floodplains is provided, coupled with a more detailed evaluation of the State-proposed adaptations of surface facilities and their potential for providing mitigation.

- o Water quality - indirect impacts of the SSC on water quality have been more thoroughly evaluated, especially with respect to the potential sedimentation of surface waters from temporary storage or permanent disposal of spoils from the tunneling.

- o Wells - the number of wells potentially affected was reestimated based on additional input from site proposers and the reevaluation of design flexibility; the estimates of number of wells that could require relocation or substitution were revised downward.

1.7.7 Air Quality

There were many comments on the air quality analysis presented in the DEIS. The analysis presented in the DEIS overstated the impacts to air quality. Impacts, realistically, would largely be very localized near tunnel egress points and along spoils hauling routes (see Chapter 5, Section 5.1.3). In addition, a major reduction in projected air emissions was achieved by assuming use of chemical dust suppressants. The following changes have been made in the FEIS:

- o Prevention of Significant Deterioration requirements for the SSC have been added to the discussion.

- o Vehicle emissions have been analyzed and presented in the same units as those of stationary sources.

- o Potential total suspended particulates exceedences are more realistically evaluated and additional mitigations identified.

- o The apparent exceedences of carbon monoxide at several sites are largely due to the use of data from metropolitan area stations, lacking site-specific information; it is probable no carbon monoxide exceedences would occur in association with SSC construction and operations at any of the site alternatives. This explanation is added to the discussion.

1.7.8 Noise Analysis

One of the changes made is the presentation of data with reference to residences, hospitals, schools, and other local areas in which people could be annoyed by noise from the service areas and from general construction operations. The use of the term "human receptor" was eliminated. Using aerial photography and estimates of populations in the local areas of the proposed site, noise levels were more carefully evaluated in the FEIS (see Chapter 5, Section 5.1.4).

1.7.9 Ecological Resources

In the areas of wetlands and threatened and endangered species populations, additional data were made available following publication of the DEIS. The DOE conducted site surveys of wetlands at all sites except Arizona, where none were present. These surveys focused on refining acreages associated with proposed surface facilities and evaluation of the quality of the existing wetlands. Surveys of potentially threatened and endangered species in the areas of the proposed sites were conducted by the DOE, by State agencies, and by cooperating Federal agencies (see Chapter 5, Section 5.1.5 and the discussion and references in Volume IV, Appendix 11).

In addition to these additional data, errata to the wetlands acreages were prepared for the FEIS. In Michigan, acreage reported as wetlands in the proposed fee simple areas actually were acreages of wetlands on the surface of the entire proposed ring configuration. This error implied a level of significant impact to wetlands in Michigan which would not occur if the SSC were constructed at the proposed site.

A discussion of the cave ecosystem in the Snail Shell Cave and surrounding underground areas was added in Chapter 4, Section 4.7 in response to supplemental information provided by the State of Tennessee. Potential impacts to this system are discussed in Chapter 5, Section 5.1.5 and Volume IV, Appendix 11.

Finally, a discussion of fire ants and the associated hazards to engineered systems and public health was added to the discussion of the impacts in Texas (see Chapter 5, Sections 5.1.5 and 5.1.6 and Volume IV, Appendices 11 and 12).

1.7.10 Health Impacts

The discussion of Valley Fever in the proposed Arizona site was expanded to include more detail (see Chapter 5, Section 5.1.6 and Volume IV, Appendix 12) in response to public comment on the brevity of the DEIS discussion.

1.7.11 Land Resources

The acreage of prime farmlands and important farmlands disturbed temporarily (during construction) or permanently was recalculated using refined engineering estimates of acreage requirements for surface facilities and construction support areas. These acreages were also verified using Soil Conservation Service evaluations for each of the site alternatives (see Chapter 5, Section 5.1.7 and Volume IV, Appendix 13.2).

1.8 IDENTIFICATION OF THE PREFERRED SITE

The evaluation by the Site Task Force (STF) was conducted in compliance with applicable Government procurement procedures. The STF considered the proposals in accordance with the evaluation criteria set forth in the Invitation for Site Proposals.

After the presentation by the STF to the Secretary of Energy and to the Energy System Acquisition Advisory Board, the Secretary solicited the views of the Board and other appropriate senior DOE staff. The Secretary reviewed the SSC DEIS and a summary of the public comments on the DEIS. The Secretary also heard a presentation by representatives of each state proposing a site on the best qualified list (the seven site alternatives).

Consistent with the requirements of NEPA and regulations implementing that Act, the Secretary, on November 10, selected the preferred site for the SSC. A decision on site selection will be made no sooner than 30 days after publication of the FEIS. The FEIS, as well as the other available information, will form the basis of the DOE's Record of Decision. The preferred location for the SSC is the site proposed by the State of Texas.

1.9 SUMMARY OF COMMENTS AND RESPONSES

Following the close of the public comment process on October 17, 1988, comments were analyzed for their possible effects on the FEIS, and individual responses were prepared. Volume IIA contains copies of all written and oral comments. A total of approximately 5,700 commenters provided about 7,000 comments. Volume IIB contains the DOE's responses to these public comments. Comments received after October 17, 1988, were reviewed in detail but no individual responses were developed. None of the late comments addressed issues not already identified in other comments received or resulted in a change to the EIS. The six categories that received the most comments were: socioeconomics and infrastructure, water resources, ecological resources, policy issues, combined land acquisition and land resources, and radiation and health impacts.

CHAPTER 2

PURPOSE AND NEED FOR ACTION

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2.1 PURPOSE OF THE SSC

The underlying purpose of the proposed action is to understand the basic structure of matter at a new, more fundamental level than is presently possible. The scientific instrument required to accomplish this extension of knowledge is a high energy accelerator that is more powerful, and consequently larger, than any now in existence.

The proposed action is the Superconducting Super Collider (SSC), project. Specifically, the proposed SSC accelerator would be a proton-proton collider, consisting of two rings of superconducting magnets in an underground tunnel, an associated proton injection system, four experimental halls, and necessary support buildings and facilities. In this collider, beams of protons would be accelerated to an energy level of 20 TeV moving in opposite directions in each of the two rings and made to collide at specific points in the experimental halls. Under carefully controlled conditions, scientists would be able to extract and derive new information by studying the results of these collisions.

2.2 NEED FOR THE SSC

2.2.1 Scientific Need

There is a scientific need for an understanding of nature and physical processes. From earliest times, people have sought to understand the physical world. Much of the knowledge gained regarding physical phenomena in recent years has been achieved through the use of high energy accelerators. The ever larger and more powerful particle accelerators developed over the past 50 years have brought into sharper focus fundamental physical processes. For example, within the last 20 years protons and neutrons (which had previously been thought to be fundamental and indivisible particles) have been found to be composed of smaller particles called quarks. The discoveries gained from this research have deepened and broadened human understanding of the physical world. Studies of the smallest particles of matter have also increased our understanding of the origin of the universe. Investigations with these machines have been carried out primarily in the U.S., Canada, Europe, Japan, and the Soviet Union.

The results of these discoveries have had a direct effect on the quality of human life. Accelerator technology has led to the development of whole new industries and practical applications such as equipment for medical diagnosis and treatment, Positron Emission Tomography (PET) scans and magnetic resonance imaging, nuclear medicine, and superconducting magnets.

Projecting to the future, discoveries resulting from the SSC may lead to benefits that are impossible to envision. Looking back in time, one sees that research in subatomic physics over the last 80 years contributed significantly to the development of technology comprising approximately one-third of our current gross national product, including such important industries as communications, consumer electronics, and computers. On a broader scale, the wonder and excitement resulting from discoveries due to the SSC may provide inspiration for young people to enter careers in science and engineering. This could contribute to maintaining America's economic competitiveness in an increasingly technical world. Before the turn of the century, however, energy limits of present accelerators will begin to hinder the further advancement of high energy physics research. In order to continue on this path of physical discovery, a higher energy accelerator is required. The proposed SSC would be the highest energy accelerator designed to date--about 20 times more powerful than any in the world. Through its use, scientists would be able to study a new realm of high energy processes for the first time in an attempt to answer some of the basic questions of the underlying structure of the physical world.

2.2.2 Recommendation for the SSC

In July 1983, the High Energy Physics Advisory Panel (HEPAP), a DOE scientific advisory group, transmitted to the Office of Energy Research of the DOE information from a report (DOE/ER-0169) written by their Subpanel on New Facilities which stated that they had reached a unanimous recommendation for the "immediate initiation of a multi-TeV high-luminosity proton-proton collider project with the goal of physics experiments at this facility at the earliest possible date." This proposed project was designated the Superconducting Super Collider (SSC). In his letter of recommendation, the chairman of HEPAP commented that the SSC "would be the forefront high energy facility of the world and is essential for a strong and creative U.S. high energy physics program into the next century." This recommendation was reiterated by the Physics Survey Committee of the National Research Council in its report, Physics Through the 1990s (National Academy of Sciences and National Research Council or NAS/NRC 1986).

2.2.3 Scientific Experiments

Protons with the energies to be achieved by those in the SSC have existed since the creation of the universe and have been striking the earth constantly in the form of cosmic rays. There are many more protons of 20 TeV (and higher energies) that collide with the molecules of air in the upper atmosphere every second than the number of protons that would collide each second in the SSC. However, even though these high energy particles are plentiful, it is almost impossible to study them because they enter the earth's atmosphere at random times, in random directions, and with random energies. They interact at such high altitudes that only a small fraction of the collision products can be detected on the earth's surface. The proposed SSC would make it possible to control and study these high energy particles for the first time.

The scientific work of the SSC laboratory would be focused on the study of the elementary constituents of matter at energies 20 times higher than are now available. This means that the SSC could probe dimensions and other properties of matter at a level 20 times smaller than can be done using existing accelerators. For this purpose, large, complex instruments to detect the interactions and resultant products would surround the interaction regions where the proton beams are brought into collision. The detectors would be capable of recording the results of a reaction by measuring the charged particles and energy flow resulting from the collisions. Analysis of these data would permit the experimenter to infer the properties of particles smaller than 10^{-19} m or less, or, equivalently, at constituent energies of 2 TeV or more. Projected capabilities for other facilities are now only in the 0.2 to 0.3-TeV range.

The recent progress of particle physics has produced astounding results. The proton and neutron are not structureless nor ultimately fundamental--they are composed of smaller particles. The smaller particles (quarks) as well as leptons (electrons, muons, and neutrinos), seem to be the elementary particles, structureless and indivisible, at least at the present limits of resolution. Perhaps these particles, too, will turn out to be composed of even smaller constituents. Three families of quarks and leptons have been found. The basic forces between these particles have been identified. Moreover, the weak and electromagnetic forces have been united into a single theory which has passed every experimental test so far. The theory correctly predicted the approximate mass of the charmed quark before its discovery and the precise masses of the W and the Z particles, the carriers of the weak force. This description of the strong, electromagnetic, and weak forces is extraordinarily successful, but it is still incomplete.

The energies of interest are constituent energies of 1 TeV or more. With the present technology, these energies can only be studied by use of a high-luminosity, multi-TeV proton collider, such as the proposed SSC. Although the new energy range which would be made available by the SSC is known to be highly promising, the types of particles and the associated forces to be found can only be postulated now. The research potential of the SSC includes, along with many other possibilities:

- Extension of the search for new quarks and leptons by a factor of 40 in mass (energy) from the present 0.05 TeV to 2 TeV.
- Search for new particles, like the W and Z of the weak force, up to masses of 7 TeV, a factor of more than 20 beyond the present 0.3 TeV.
- Exploration of the mass-generating phenomenon at energies up to 1 TeV, more than an order-of-magnitude beyond current capabilities,
- Search for new, even more basic entities of matter, in quarks and leptons, to distances 40 times smaller than the present limits.

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2.2.4 Research at Other Accelerators

Researchers at existing laboratories are exploring the current particle frontier, but the accelerators at these laboratories are unable to achieve the energies and luminosities necessary to address many of the important questions which have arisen in the past decade. In the United States, the Tevatron at Fermilab, the highest energy accelerator in the world, has a maximum energy of 1/20th of the proposed SSC with 1/1000th the luminosity. The Stanford Linear Accelerator (SLAC) in California has an energy equivalent to about 1/100th that of the SSC with 1/1000th the luminosity. Although both of these machines will be the workhorses of U.S. high energy physics during the next decade, it is not technically feasible to improve their performance substantially in terms of either energy or luminosity.

Other high energy accelerators in the U.S., including those at Brookhaven National Laboratory (New York), Cornell University (New York), and the Continuous Electron Beam Accelerator Facility (CEBAF) which is nearing completion in Newport News, Virginia, are designed to operate at energies well below those of the SSC. Although many of the experiments at these facilities are related to and supportive of those anticipated at the SSC, they are not capable of providing beams meeting SSC objectives nor can they be reasonably modified to do so.

Several other very high energy accelerators are under construction outside the U.S.--an electron-positron collider is nearing completion at CERN (Geneva, Switzerland), an electron-proton collider is nearing completion at DESY (Hamburg, West Germany), and a proton-proton collider is being built at Serpukov in the USSR. These machines are each well below the energy and the luminosity of the SSC. They could not be used to meet the objectives of the SSC without major modifications. These modifications would approximate in scope implementation of the SSC design as a stand-alone project.

The strength of the proposed SSC is its expansive reach to high energies and the accompanying high luminosity, which provide the conditions to extend the current understanding of the basic structure of matter. These two basic features would support a variety of experimental initiatives to create a rich and diverse research program and maintain the U.S. world leadership in this field of study. The SSC would also play an important role in higher education. Research conducted at the SSC would be done principally by groups of university scientists and graduate students and serve as a unique training ground for the next scientific generation.

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CHAPTER 3

PROPOSED ACTION AND ALTERNATIVES

CHAPTER 3 PROPOSED ACTION AND ALTERNATIVES

TABLES

FIGURES

CHAPTER 3 PROPOSED ACTION AND ALTERNATIVES

This chapter describes the proposed action, alternatives considered, potential environmental impacts, and mitigation means anticipated to minimize impacts. The description of the proposed SSC facility includes conceptual design details along with specific conceptualization which would be needed to adapt the proposed SSC facility to local conditions at all of the seven site alternatives.

Various technical and procedural alternatives were considered but not analyzed in detail. The no-action alternative, which provides a baseline for measuring environmental effects, is the continuation of current conditions and trends (described in Chapter 4, Affected Environment) that would be expected to occur at any of the seven sites if the SSC were not constructed. The environmental impacts (analyzed in Chapter 5, Environmental Consequences) are summarized and compared. Finally, site-independent and site-specific mitigations (also described in Chapter 5) are identified; these could be used to minimize adverse impacts of the proposed action.

3.1 PROPOSED ACTION

The proposed action is to select a site for construction and operation of the SSC. The proposed SSC would be a 20-TeV particle accelerator, its supporting systems, and facilities which would serve as a U.S. National Laboratory for high energy physics experiments. The five phases of the proposed project are:

- Siting - This phase consists of DOE's Invitation for Site Proposals (ISP) and the resulting proposals, the evaluation process leading to the Best Qualified List (BQL) of seven sites, the identification of a preferred site in the final EIS, and the selection of a site in the Record of Decision (ROD).

- Preconstruction - This phase consists of activities at the selected site to confirm geotechnical conditions; to validate site engineering parameters; and perform assessments or surveys necessary to verify site data for site-specific project design.

- Construction - This phase includes continued design as well as physical establishment of the tunnel, the SSC instrument (including magnets, detectors, support systems), the surface facilities and campus area, and infrastructure connections (roads and utility corridors). A Supplemental EIS will be prepared to analyze in greater detail the environmental impacts and mitigations at the selected site prior to the start of construction.

- Operations - This is the primary and long-term phase that involves use of facilities for physics experiments. The operating life of the SSC is expected to be 25 to 35 years.
- Decommissioning - This phase involves the removal, closure, decontamination, and other activities whose objective is the removal from service of the SSC and its support facilities. Additional NEPA review would be required prior to starting decommissioning action.

3.1.1 Description of the Proposed SSC

3.1.1.1 Project Overview

The proposed SSC project includes the siting, construction and operation of a 20-TeV particle accelerator along with its supporting systems and facilities to serve as a national laboratory for high energy physics experiments.

The principal feature of the proposed SSC is the collider ring, a roughly 53-mi-long oval tunnel. Approximately 10,000 superconducting magnets in the form of two rings, one atop the other, would focus and guide two proton beams around the tunnel. Within the magnets, the two proton beams (one in each magnet ring) would be accelerated in opposite directions to an energy of 20 TeV and made to collide with a combined energy of 40 TeV. Special facilities, intermittently spaced around the collider ring, would provide the cryogenic system that would keep the superconducting magnets cooled to a temperature near absolute zero.

Other prominent features of the proposed SSC are the experimental halls, the injector facilities, and the campus area. The experimental halls would contain the giant detectors that record the particle collision products. The injector facilities would consist of four separate cascading accelerators in which the proton beams are first formed and then accelerated to the required energy for injection into the ring magnets in the collider tunnel. The campus area would include the main laboratory and administration building, the auditorium, warehouses, support facilities, and a number of shop buildings.

Table 3-1 summarizes the land requirements for the proposed SSC facilities including facility dimensions, number of facilities, and acreages. Table 3-2 provides estimates of acreages permanently and temporarily disturbed by SSC construction and operations for each site.

It should be emphasized that the following discussion of the proposed SSC is based on the conceptual design of such a facility. The dimensions and layouts for facilities and areas are based on this conceptual design. These will be reevaluated in the final design, which will be developed after a site is selected, but are expected to be conceptually similar to those described below.

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Table 3-1

SSC LAND REQUIREMENTS FOR FACILITIES DEVELOPMENT

Area	Letter Designation (Figure 3-1)	No. of Locations	Width (ft)	Length (ft)	Area per Location (acres)	Total Area (acres rounded)
Campus	A	1	2,100	7,200	--	350
Injector	B	1	7,200	10,300	--	1,700
Service Area	F	1	500	500	5.7	6[a]
Future Expansion	C	1	7,200	8,800	--	1,450
Collider Arcs[b]						
Upper and Lower[b]	D	2	1,000	83,520	1,895	3,790
Intermediate Access	E	6	200	200	0.9	6[c]
Service Areas	F	6	500	500	5.7	34[c]
Clusters						
Near Cluster	G	1	1,300	68,250	--	2,010
Intermediate Access	E	2	200	200	0.9	2[d]
Service Areas	F	3	500	500	5.7	17[d]
Far Cluster	H	1	1,300	51,870	--	1,540
Intermediate Access	E	2	200	200	0.9	2[e]
Service Areas	F	1	500	500	5.7	6[e]
Far Cluster Bypass	H	1	0-625	42,880	--	440
Buffer Areas and Buried Beam Zone[b]	I	2	0-10,100	38,680	2,268	4,550
Buried Beam Zone Access Areas	J[j]	6[f]	1,320	1,320	40	240[g]
Interaction Points and Experimental Areas	K[j]	6[h]				
Beam Absorbers	L	2[i]				
Total						15,830

a. Acreage included in Area B
b. A stratified fee estate for these areas may be sufficient (see Section B3 of the ISP)
c. Acreage included in Area D
d. Acreage included in Area G
e. Acreage included in Area H
f. Unconditional fee simple title is required for Areas J1 through J4
g. Acreage included in Areas G and I
h. Included within Areas G and H
i. Included within Area G
j. J areas and two K areas are reserved for future expansion

Table 3-2

ACREAGE PERMANENTLY AND TEMPORARILY DISTURBED BY SSC CONSTRUCTION AND OPERATIONS

Site	Facility	Permanently disturbed	Temporarily disturbed	Total
AZ	Roads, Railroads, and Utilities	453	784	1237
	Spoils Disposal and Evaporation Ponds	135	0	135
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	245	307
	Total	933	1222	2155
CO	Roads, Railroads, and Utilities	587	1759	2346
	Spoils Disposal and Evaporation Ponds	395	97	492
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	19	81
	Total	1327	2068	3395
IL	Roads, Railroads, and Utilities	78	159	237
	Spoils Disposal and Evaporation Ponds	0	0	0
	Campus and Injector	87	105	192
	Collider and Experimental Halls	62	3	65
	Total	227	267	494
MI	Roads, Railroads, and Utilities	57	467	524
	Spoils Disposal and Evaporation Ponds	0	0	0
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	18	80
	Total	402	678	1080
NC	Roads, Railroads, and Utilities	447	593	1040
	Spoils Disposal and Evaporation Ponds	315	6	321
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	15	77
	Total	1107	807	1914
TN	Roads, Railroads, and Utilities	108	452	560
	Spoils Disposal and Evaporation Ponds	364	24	388
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	3	65
	Total	817	672	1489
TX	Roads, Railroads, and Utilities	191	414	605
	Spoils Disposal and Evaporation Ponds	461	49	510
	Campus and Injector	283	193	476
	Collider and Experimental Halls	62	34	96
	Total	997	690	1687

1. Assumptions made regarding acreages for future expansion areas C, J, K3, and K4 are included in Section 3.7.3. For the other areas, acreage is calculated only for areas which would be disturbed by the planned facilities.

2. For the AZ, IL, and MI sites, spoils are assumed to be deposited in abandoned mines or quarries. Therefore, no disturbed acreage for spoils disposal is included for these three sites. For the other four sites, the temporarily disturbed areas shown account for temporary access roads to the spoil disposal sites. The permanently disturbed areas shown account for the spoil disposal sites.

3. For the cooling tower wastewater, special treatment plants are required at the IL, MI, NC, and TN sites. At the AZ, CO, and TX sites, evaporation ponds may be used instead. It was assumed that such ponds will be used for these three sites, and acreages of permanently disturbed land have been included for this purpose in the amounts of 135, 255, and 396 acres, respectively.

3.1.1.2 Conventional Facilities

A. Site and Infrastructure

A site-independent layout of the proposed SSC project site is shown in Figure 3-1. Site and infrastructure encompass most conventional project components, with the exception of underground facilities and buildings.

General access to the proposed SSC would be provided by a primary road that ties into the regional highway system. The primary roads within the project boundaries would be the roads connecting the campus area with the far cluster and other access roads servicing the facilities along the collider ring.

Parking spaces would be provided for approximately 1,800 vehicles. The areas around the surface buildings would be landscaped, and sensitive project areas would be protected by fences.

B. Campus Area (A area)

The proposed campus complex is planned to contain 15 buildings situated on approximately 100 acres. The buildings provide work space for approximately 2,500 employees and 500 visiting scientists, and include the central office and laboratory building, six heavy works buildings, three shop buildings, and several support buildings (see Figure 3-2). The campus area would be landscaped to blend into the general setting of the selected site.

C. Injector (B area)

The proposed injector would encompass the surface and subsurface structures that contain the technical systems which generate, accelerate, and inject the protons into the collider ring. These structures are the linear accelerator (Linac), low energy booster (LEB), medium energy booster (MEB), and high energy booster (HEB) (which includes a test beam facility) (see Figure 3-3).

The Linac enclosure would be 494 ft long with inside dimensions of 12 ft by 12 ft. It would be 20 ft below ground, has two 15-ft-diameter exit/vent shafts, and would be connected to the LEB by a 410-ft-long transfer tunnel.

The LEB would be installed in a ring-shaped tunnel with a circumference of 817 ft and inside dimensions of 8 ft by 8 ft. It would be 14 ft below ground and connected to the MEB with a 40-ft-long transfer tunnel. There would be two 15-ft-diameter exit/vent shafts and several surface buildings.

The MEB would be installed in a ring-shaped tunnel with a circumference of 6,233 ft and a 10-ft-diameter circular cross section. It would be 16 ft below ground and have two transfer tunnels connecting it to the HEB. The MEB ring would have six 15-ft-diameter intermediate access shafts and associated surface buildings.

Figure 3-1

SITE-INDEPENDENT PROJECT LAYOUT

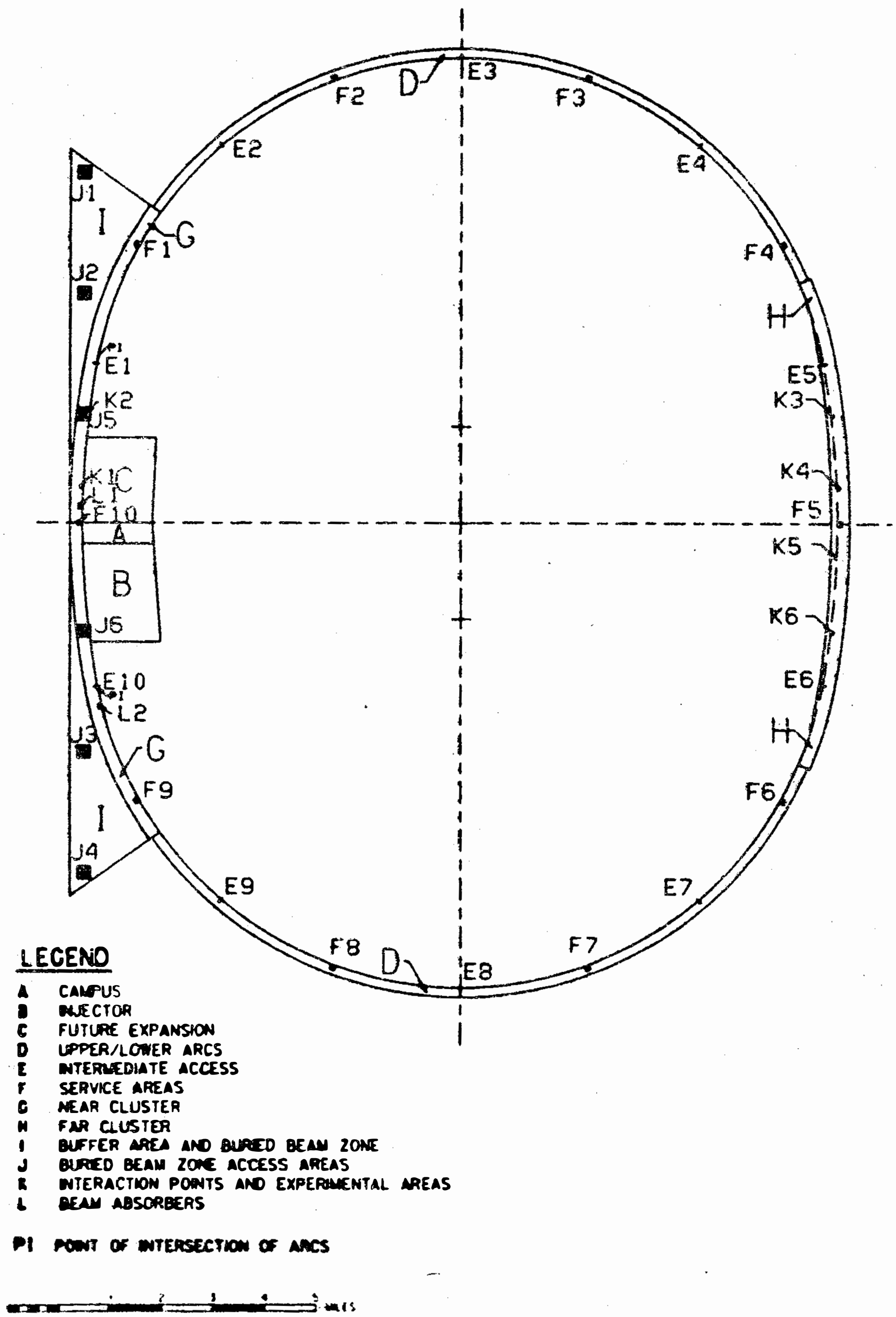
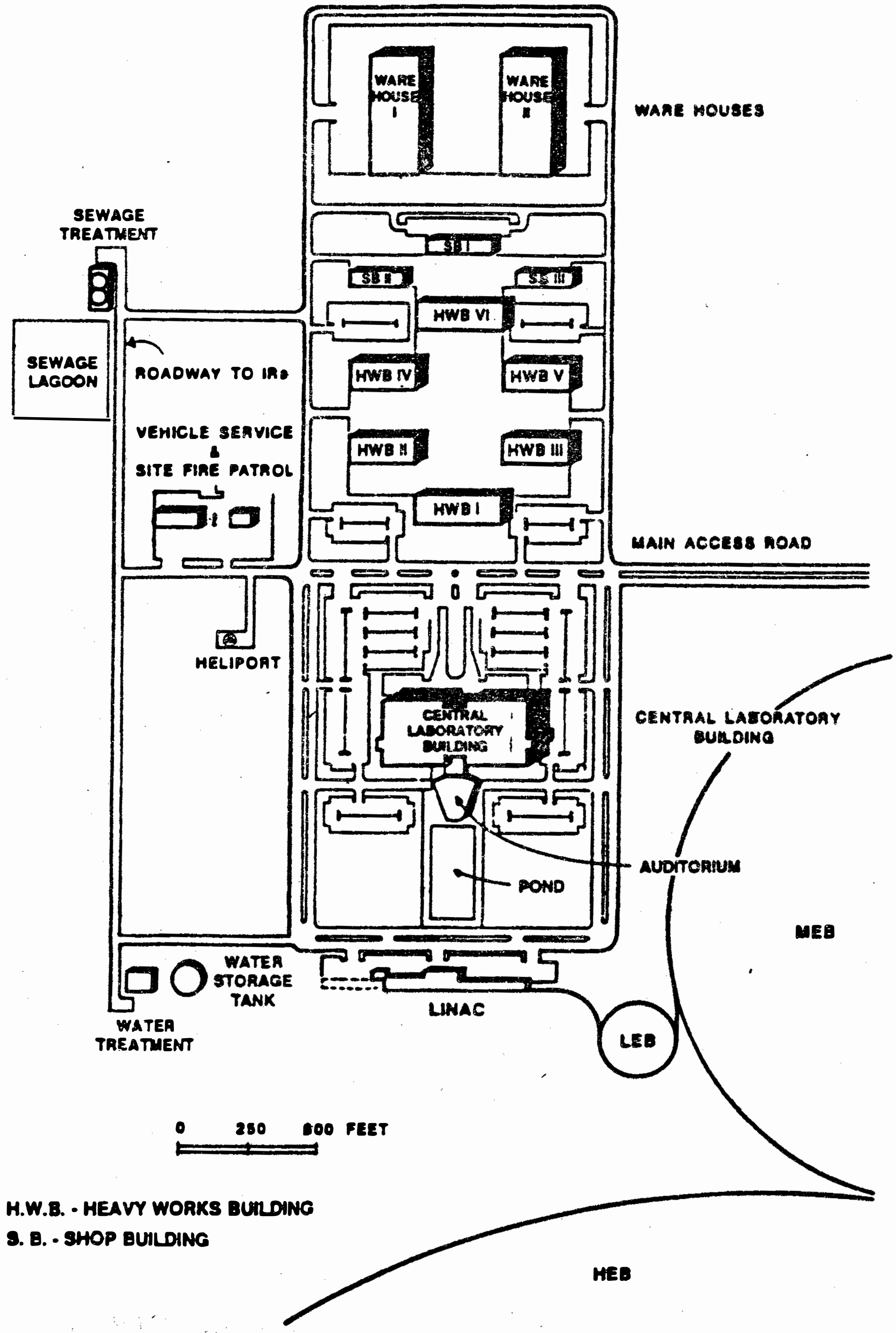


Figure 3-2

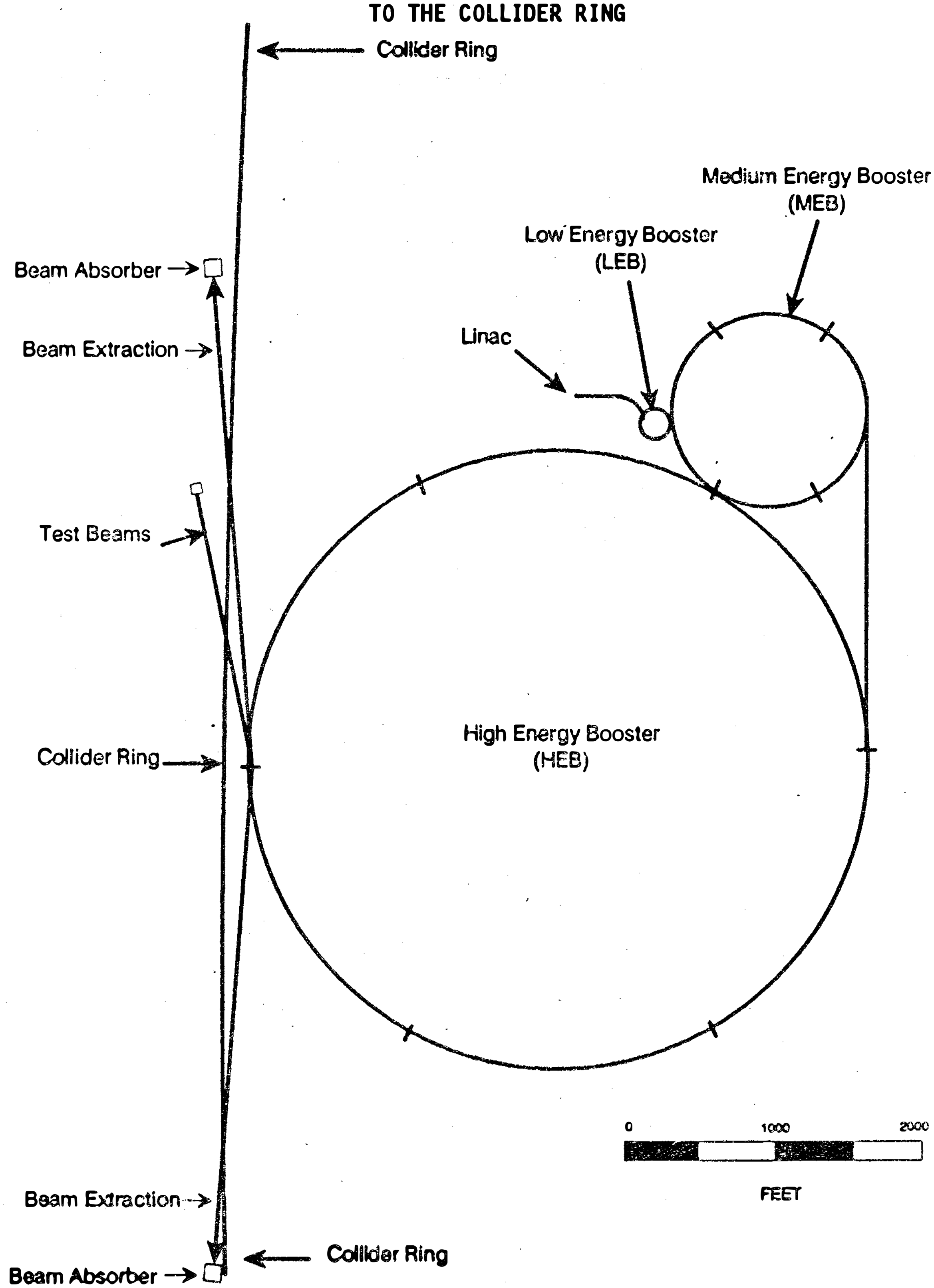
SITE-INDEPENDENT CAMPUS LAYOUT



H.W.B. - HEAVY WORKS BUILDING
S. B. - SHOP BUILDING

Figure 3-3

INJECTOR FACILITY SHOWN ADJACENT
TO THE COLLIDER RING



The HEB would be installed in a ring-shaped tunnel with a circumference of 19,666 ft and a 10-ft-diameter cross section. It would be 18 ft below ground and have two transfer tunnels connecting it to the collider ring. Situated at equal intervals along the HEB ring would be six clusters of underground enclosures and associated surface buildings that would include the following major facilities: intermediate access shafts, service areas (compressor and refrigeration buildings, power supply), inject/eject facilities, beam absorbers, cooling towers, and radio-frequency enclosures.

The test beam facility would connect to the HEB and terminate in a test hall 3,200 ft from the HEB. The beam enclosures would be covered by about 15 ft of soil.

D. Collider Ring (D area)

The proposed collider ring would include the 53-mi-long tunnel housing the main accelerator plus a large number of structures supporting operational functions such as refrigeration, ventilation, personnel and materials access and exit, and beam inject/extract facilities.

The collider ring tunnel would have a cross section as shown in Figure 3-4, with a minimum inside dimension of 10 ft. The tunnel lining, where required by local geology, might consist of shotcrete, reinforced concrete, precast concrete segments for bored tunnels, or precast concrete segments for tunnels constructed by the cut-and-cover method.

The tunnel floor would accommodate the support frames for the superconducting magnets, provide sufficient work space, and allow adequate clearance for magnet transport vehicles.

The depth of the tunnel below the surface would be dependent on local site conditions. There is no predetermined maximum tunnel depth; but it is anticipated that depths in excess of approximately 600 ft would be unfeasible. The minimum depth of cover above the tunnel would be 30 ft with a minimum of 15 ft above the primary shield to the surface.

The near semicircular upper and lower arcs of the collider ring would be made up of four equally long tunnel sectors. The sectors would be separated from each other by intermediate access facilities (E areas); a service area (F areas) would be located at the center of each sector. Each intermediate access facility would include a surface building, a 20-ft-diameter shaft, and a system of tunnels that connect to the collider ring tunnel.

Each service area (see Figure 3-5) would include buildings, a 30-ft-diameter shaft, and a system of tunnels that connect to the collider ring tunnel. Near its connections to the HEB, the collider ring would contain a cluster of facilities that involve proton beam injection, acceleration, and beam absorption.

Figure 3-4

COLLIDER RING TUNNEL SECTION

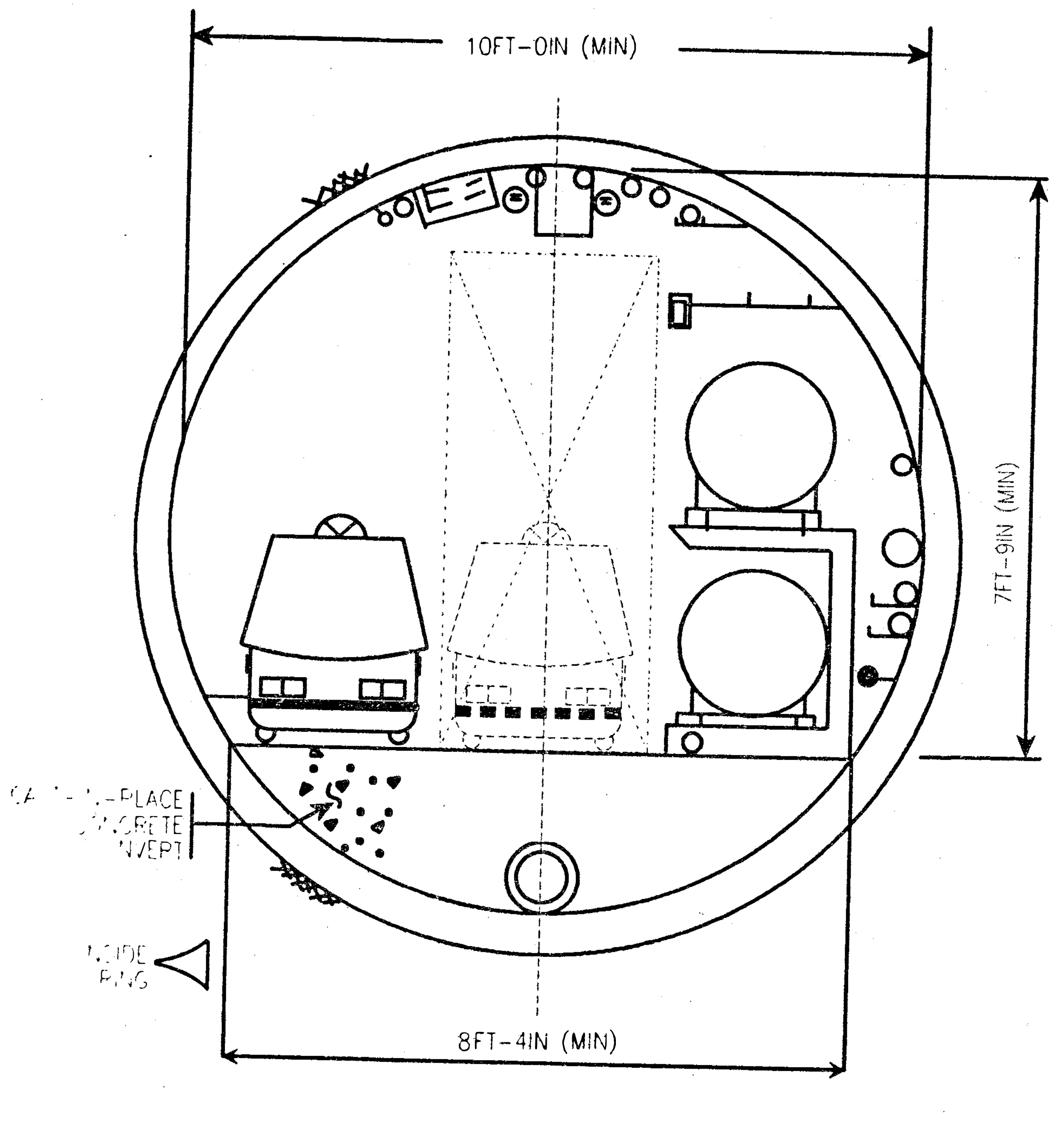
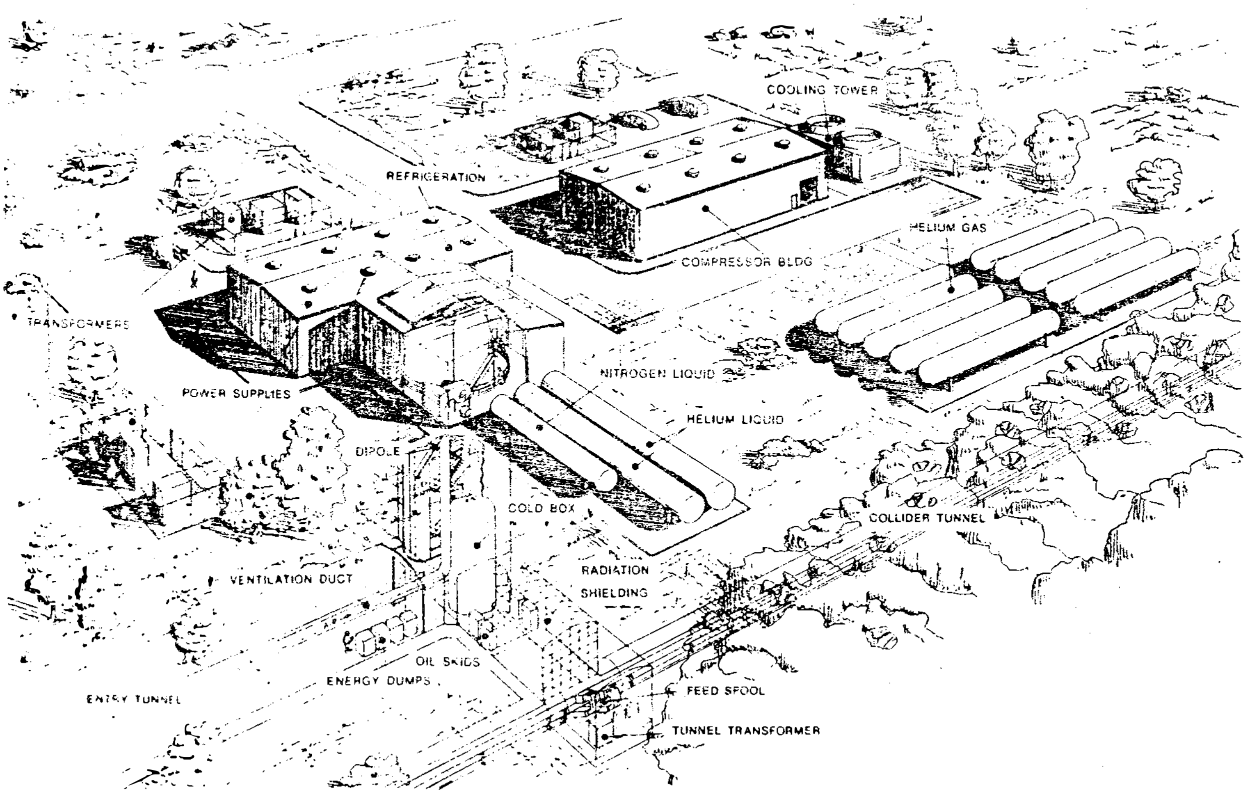


Figure 3-5

SERVICE AREA PERSPECTIVE



E. Experimental Facilities

Two interaction regions (K areas) would be provided within each of the two collider ring segments which would connect the upper and the lower arcs (area D); space for two future interaction regions would be provided in the far cluster. The interaction points would be the locations where the particle collisions take place. To study these collisions, it would be necessary to surround the collision point with a detector capable of registering the matter and energy byproducts of the collision while at the same time allowing the free flow of particles along the beam line.

The SSC detectors are expected to weigh as much as 50,000 tons each. The dimensions of such detectors are not defined at this stage of the project, but a range of sizes and shapes is considered possible. Maximum detector sizes would probably be limited by the maximum feasible cavern sizes that can be constructed in specific geological site locations. The current conceptual design of the underground halls and the surface building is shown in Figure 3-6.

F. Utilities

Each cluster would receive electric power from a separate source. Overhead transmission lines would carry incoming power from the local utility, a substation at each cluster would reduce the voltage, and power would be distributed around the site.

On-site communications, fire alarm, monitoring, and safety alarm systems would be provided; wired connections to the local telephone utilities would establish off-site communication. Emergency generators would serve essential loads in case of power interruption. An emergency telecommunications system would reduce the risk and impact of service disruption.

A water main would be brought to the campus either from a suitable well field or local municipality. Water usage around the ring would be provided from wells near the points of use, a distribution piping system following the ring, or convenient local off-site sources.

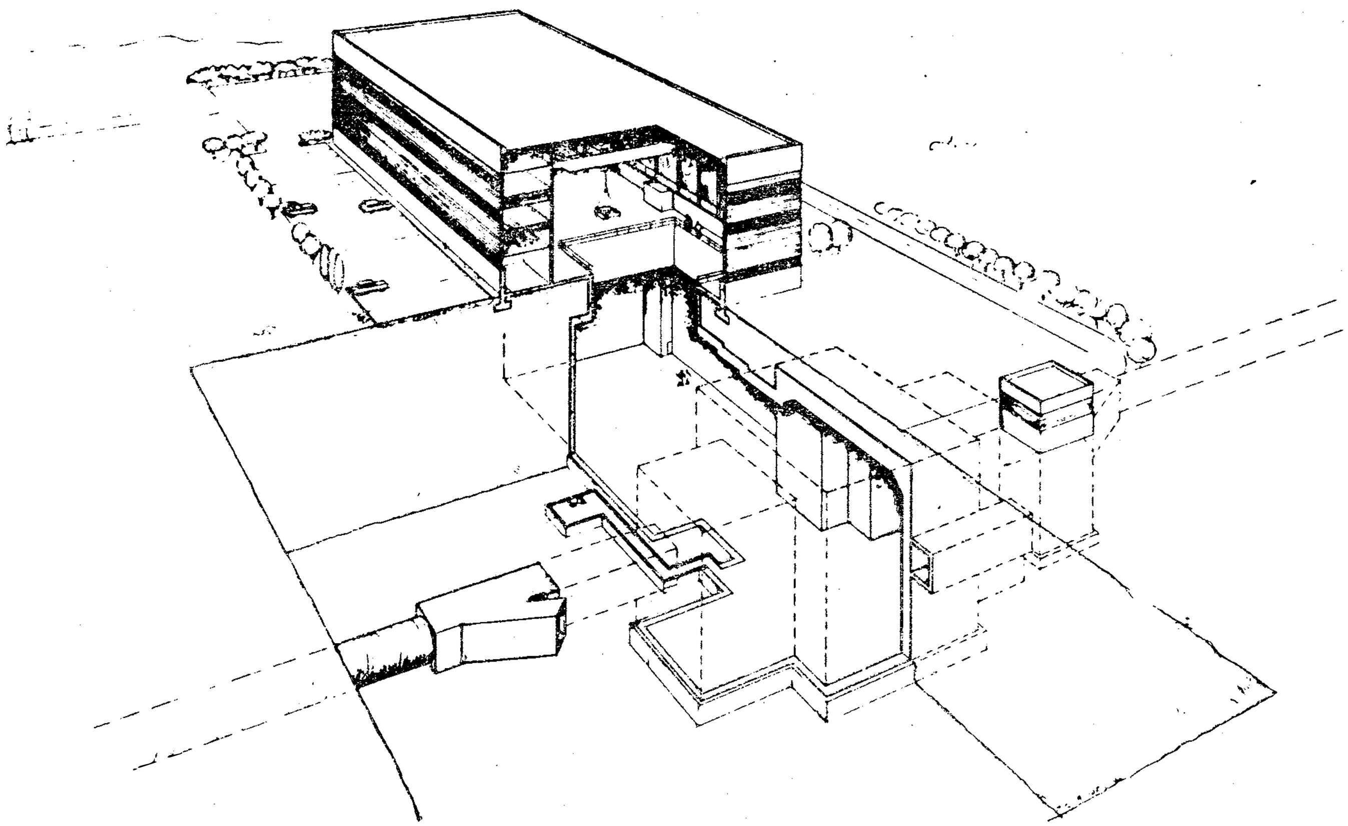
Natural gas is expected to be the heating fuel for the campus and the far cluster. Electrical and/or solar heat could also be used. The collider tunnel would be unheated. Other utilities would include on-site or off-site sewage treatment, wastewater treatment, and fire protection.

3.1.1.3 Technical to Conventional Interface

Technical to conventional interface would occur with electric power and water cooling systems. Power at 13.8 kV would be brought to all radio-frequency locations at the Linac, LEB, MEB, HEB, and collider ring, and terminate in indoor switchgear. Service of 4,160 V would be brought to

Figure 3-6

EXPERIMENTAL FACILITY PERSPECTIVE



Interaction hall looking outward from collider ring center.
Collision hall is in foreground aligned with collider tunnel.
Assembly hall with staging building is beyond.

all pump-compressor buildings for the cryogenic equipment; 480 V would be available on the campus at the injector, collider ring, and experimental areas.

Water would be used to cool the cryogenic and technical equipment. The cooling towers would use industrial water that would cool the cryogenic systems directly. The towers would also remove heat at heat exchangers that, in turn, cool low conductivity water recirculated to and from the technical equipment. Water chilled by mechanical refrigeration would be used to cool electronic equipment in each of the experimental halls.

3.1.1.4 Technical Systems

A series of cryogenic refrigeration systems would provide 5 K, 20 K, and 84 K systems to the HEB and 4.15 K, 20 K, and 84 K to the ring for the purpose of magnet cooling. The injector and collider ring would be served by vacuum pumps located within the conventional facilities.

3.1.2 Site Selection

In February 1987, the DOE formed an SSC Site Task Force (STF) to develop and manage a process leading to the selection of a site for the SSC. The STF developed the ISP and its two amendments for potential sites for the proposed SSC (U.S. Department of Energy, Apr 1, 1987; Amendment 1, Jun 24, 1987; and Amendment 2, Jul 14, 1987). This solicitation invited states and other parties to provide land and propose specific sites for the implementation of the proposed SSC project. Proposers were also encouraged to provide opportunities to offset portions of costs to the Federal Government.

Forty-three proposals were received by DOE by September 2, 1987. The initial evaluation of the proposals consisted of DOE's determination of compliance with the qualification criteria. If a proposal or proposed site did not meet the qualification criteria, it was eliminated from consideration, the proposing organization was informed of the elimination, and the criteria not satisfied were enumerated.

Thirty-six proposals met the qualification criteria and were forwarded to a committee convened by the National Academy of Sciences and the National Academy of Engineering (NAS/NAE).

The NAS/NAE Committee formed seven working groups focusing on the six technical evaluation criteria (Section 1.1 of the ISP) and on cost. These six technical evaluation criteria are:

Geology and tunneling
Regional resources
Environment
Setting
Regional conditions
Utilities

Each group was composed of committee members having specific expertise in the area of focus of that group. The charter of each working group was to identify strengths and weaknesses of each proposal using a scale of good, satisfactory, and questionable. The results of these efforts were used as a basis for committee discussions of those sites meriting inclusion in the recommended BQL to be furnished to DOE.

The recommended BQL included:

Arizona/Maricopa
Colorado
Illinois
Michigan/Stockbridge
New York/Rochester
North Carolina
Tennessee
Texas/Dallas-Fort Worth

The New York/Rochester site proposal was subsequently withdrawn by the proposing organization.

The DOE received eight site alternative recommendations from the NAS/NAE Committee on December 24, 1987. The STF met with the Committee for a discussion of their findings and recommendations. The STF then reviewed the Committee's report during a 2-week period. The STF independently evaluated the Committee's findings and concurred with their findings. On January 19, 1988, the DOE announced the site alternatives. The STF continued its review of proposals following selection of the site alternatives; this included requests for an analysis of additional data and site visits by the STF. The sites were analyzed as the reasonable siting alternatives for the proposed SSC. The Secretary of Energy has identified the site proposed by the State of Texas as the preferred site alternative. See Volume III for a detailed discussion of the site selection process including identification of the preferred alternative. Site selection will be documented in a Record of Decision (ROD) to be issued no sooner than 30 days following publication of the FEIS.

3.1.3 Preconstruction

Several preconstruction activities would take place at the site selected for the proposed SSC prior to actual construction. These activities are described in detail in Appendix 1 and include:

- Geotechnical verification and validation, which would involve drilling in selected areas, including shaft locations and areas designated as locations for interaction halls.
- Assessments and consultation as needed with the U.S. Fish and Wildlife Service (USFWS), State Historic Preservation Officers (SHPO's), and other appropriate Federal and State agencies.
- Establishment of baseline monitoring programs at the site, such as installation of a meteorological station.

- Definition of site-specific engineering parameters using shallow soil borings at building sites and detailed evaluation of specific areas where facilities are to be built.
- Development of preliminary site-specific designs.
- Establishing interfaces with state agencies.
- Preparation of a Supplemental EIS for the selected site.

Agreements may be needed between the DOE or the state and landowners for access prior to the time that the DOE would take title to the land. It is anticipated that the DOE would acquire title to fee simple or stratified fee lands based on the sequence required for construction.

The sequence of land acquisition is:

- Campus area and near cluster
- Far cluster
- Land needed to connect the tunnels between the clusters; land for access shafts, service areas, and infrastructure connections.

The DOE would require that the state whose site is selected meet the following schedule and sequence for delivery of title to the selected site:

Area of the Site (see Figure 3-1)	Execution of Offer Survey, and Preliminary Title Evidence	Transfer Date
Areas A and G	Feb 1, 1990	Mar 1, 1990
Areas B and H	Apr 1, 1990	Jul 1, 1990
Lower arc (a portion of area D)	Jul 1, 1990	Oct 1, 1990
Upper arc (remainder of area D) and areas C, I, and J	Oct 1, 1990	Jan 1, 1991

All intermediate access and service areas (areas E and F) would be acquired along with their respective quarters of the collider ring. This pattern and sequence may require modifications to fit any site-specific needs. The dates in this schedule are predicated on the ROD being issued in January 1989.

In order to accommodate the early stages of site design and pre-construction, the DOE would require use of approximately 100 acres of area A as soon as possible after the ROD is signed. Use of this land and the existing improvements will be required at no cost to the Federal Government.

3.1.4 Construction

After the Supplemental EIS has been completed, construction-related activities would begin in the spring of 1990 and be complete in mid-1996. Construction is anticipated to begin on the campus, the injector, and the cluster areas. Subsequent activities are then anticipated in the upper and lower arcs. This sequence is subject to final site-specific conditions and final design considerations. Major construction activities would include:

- Cut-and-cover excavation for installation of the injector facility (except in Illinois which proposed to use the existing Fermilab tunnel); to allow for a comparative analysis, it has been assumed that injectors at the proposed Michigan and Tennessee sites would be constructed using cut-and-cover rather than tunneling as proposed by the two states (see Appendix 1).
- Vertical tunneling of access shafts for the several tunnel access areas, at approximately 2.5-mi increments around the ring.
- Tunnel boring using tunnel boring machines (except in a short portion of the Arizona site where cut-and-cover excavation would be used) for the 53-mi ring. See Appendix 1.
- Excavation of four interaction halls by cut-and-cover, or underground mining techniques, depending on local conditions.
- Creation of disposal sites for spoils generated from the excavation temporarily stored near the access shaft.
- Services, including power, cryogenics, water, and waste treatment at the several service areas.
- Construction of campus facilities and service area facilities around the ring.
- Startup and testing of magnets, detectors, and other technical systems.
- Construction of access roads, site service roads, railroad sidings, utility substations, and utility corridors.

3.1.5 Operations

Activities during operations would be beam testing and establishment of routine operations including:

- Use of collider rings for high energy physics research or accelerator and development studies (~ 250 day/yr).
- Use of high energy booster accelerator to generate beams for testing of detector components (independent of collider operations).
- Scheduled machine and detector maintenance and repair (~ 115 day/yr).

Operations would begin in 1996 and continue for a period of 25 to 35 years.

3.1.6 Future Expansion

The ISP specified that a future expansion area (Area C) of approximately 1,450 acres be provided in fee simple title. It further specified that six abort/external beam access areas (Areas J) of 40 acres each be similarly provided. The present conceptual design of the SSC has no specific plans for use of these areas at this time. Experience at other accelerator laboratories, e.g., Fermilab, SLAC, and CERN, is that an accelerator, once built, is not a fixed or stagnant entity throughout its useful life. On the contrary, as new discoveries are made using such accelerators, new ideas emerge for modifying and improving these machines for different classes of experiments. On a machine at the forefront of knowledge such as the SSC, it is inevitable that such ideas for enhancement of capabilities will emerge, and some of these may well entail use of land in addition to the requirements for the SSC as it now exists in conceptual design.

At this time, such additions or modifications can only be a matter of speculation. Area C could, for example, be used for a circular electron accelerator and storage ring for electron-proton physics experiments. Alternatively, a linear electron accelerator might be built under the J areas for similar purposes. An external beam and experimental area might be developed under the J areas. These areas could also be used for some facility which simply has not been thought of yet. Further NEPA review would be performed for any proposal for development in the expansion areas.

3.1.7 Decommissioning

When decommissioning of the SSC facility is proposed, additional NEPA review will be performed. DOE has prepared a preliminary decommissioning plan for the SSC and estimated order-of-magnitude costs for implementing such a plan. This plan is summarized and the potential environmental impacts evaluated in Volume IV, Appendix 3. This preliminary evaluation indicates that decommissioning would be technically, economically, and environmentally feasible.

3.2 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

The DOE has considered three types of alternatives in this EIS: site alternatives, technical alternatives, and programmatic alternatives. The methods used to determine the reasonable site alternatives were discussed in Section 3.1.2. No technical or programmatic alternatives were identified for detailed analysis in this EIS, as discussed below. DOE-sponsored working groups have examined alternative instrument design concepts, contrasting efficiencies, resource requirements, and possibilities of meeting the 20-TeV objective (see Chapter 9, Principal References). If these types of technologies were used, the purpose and need for the SSC would not be met (see Chapter 2, Purpose and Need for the Proposed Action).

Alternatives eliminated from detailed study, together with the technical or programmatic reasons for such elimination, are discussed below.

3.2.1 Technical Alternatives

3.2.1.1 Beam Composition Alternatives

The only electrically charged, stable particles that can be accelerated to high energies in a collider environment are protons, electrons, and their antiparticles, antiprotons and positrons. The underlying physics goals at both lepton (electrons and positrons) and hadron (protons and anti protons) colliders is the same: to understand the fundamental structure of matter. However, the approach that is used--the specific types of physics experiments--is quite different at the two different types of machines. The physics program at a lepton machine could not be carried out at a hadron machine, and vice versa. Experimenters at the two types of machines investigate the subnuclear world from two different viewpoints; thus lepton and hadron colliders complement each other, but one cannot be a substitute for the other. The situation is somewhat analogous to the use of radiotelescopes and optical telescopes. In this case, astronomers are trying to study the physics and composition of matter involving vast distances rather than tiny distances. Radiotelescopes and optical telescopes enable astronomers to study different aspects of the same basic phenomena; the instruments are complementary to each other, but one cannot be a substitute for the other.

The step up in energy and luminosity from existing accelerators might be taken in a lepton collider rather than a hadron collider such as the SSC. To reach energies equivalent to the proposed SSC in a lepton collider would require the use of much higher power tubes (klystrons) than are now available. These higher power tubes are now under development but probably will not become operational for several years. To reach luminosities equivalent to the SSC in lepton colliders would require as yet unidentified techniques for reducing beam diameter at the collision point. At the electron-positron linear collider at SLAC, experience indicates that at very high energies, it is difficult using presently known techniques to produce high energy beams as small as one micron in diameter. A lepton collider of luminosities comparable to the SSC would require beam spot size at the interaction point 100 to 1,000 times smaller than one micron.

3.2.1.2 Beam Energy Alternatives

A total beam energy of 40 TeV (combined energy of the two 20-TeV beams) was selected for the proposed SSC because it represents a large step beyond the capability of other experimental devices that will be in operation before the SSC is proposed to be completed. The need for an accelerator at the beam energy of the SSC is acknowledged by physicists throughout the world. Higher beam energies would be fiscally prohibitive; lower beam energies would not satisfy the objective of the 40-TeV collision energies that are expected to result in newly discovered, smaller particles.

3.2.1.3 Beam Luminosity Alternatives

The capabilities of the proposed SSC depend upon both beam energy and beam luminosity (number of colliding particles). A luminosity of 10^{33} cm^{-2} s^{-1} as proposed is believed to optimize the scientific performance of the total experimental device, collider plus detector. A higher luminosity would place an increased burden on the detectors to discriminate among the collision products of scientific interest from other collision products. A decreased luminosity would decrease the frequency of collisions, thus decreasing the chance that interesting collision products would be produced. These results are indifferent to the choice of a proton-proton or proton-antiproton collider; however, a proton-antiproton collider is not practical at a luminosity as high as 10^{33} cm^{-2} s^{-1}.

3.2.2 Magnet Alternatives

In principle, several alternatives exist for producing the magnetic field required for the main accelerator rings of the proposed SSC. The size of the collider ring, the design of the cryogenic or cooling systems, and the number of service areas are all dependent on the strength of the field generated by the magnets. Alternative magnets have been given careful consideration. The magnet design described in Appendix 1 was determined as optimal in both cost and feasibility. Some of the considerations for this conclusion are indicated below.

3.2.2.1 Conventional Magnets

It is possible that an SSC-type accelerator could be built with conventional iron-copper electromagnets rather than superconducting magnets. However, such conventional magnets are limited in the strength of magnetic field producible to about one-third that of superconducting magnets. The circumference of the rings required for the proposed SSC is inversely related to the strength of the magnetic field. A reduction of this field to one-third the value of the present design would mean a ring circumference of three times its present design, or about 160 mi. Conventional magnets also require large amounts of electric power--many times that required for operation and refrigeration of superconducting magnets. The cost of electric power, even with superconducting magnets, is a major component of the estimated operating cost of the SSC. Cost of power for conventional magnets for the SSC would be prohibitively high.

3.2.2.2 Warm Superconducting Magnets

Following the discovery of superconducting substances with transition temperatures above the temperature of liquid nitrogen, there has been speculation that new materials might be developed that would make possible a simpler and less costly magnet for the proposed SSC (SSC would use liquid helium). However, such new materials do not yet exist in a form that could be used for collider magnets, and one cannot predict with confidence when, if ever, they might be developed into useful magnet conductor materials. Thus, the use of these materials is not considered technically feasible for the SSC if the SSC is to be operational in the 1990's.

3.2.2.3 Alternative Superconducting Magnets

In the magnetic field range of 3 to 7 tesla, a number of possible alternatives for magnet design were studied in detail. Serious consideration and considerable research and development were devoted to several possible designs. A Magnet Selection Advisory Panel was appointed by the director of the CDG to provide a recommendation. This Panel and its consultants included international experts in the area of superconducting magnet technology. The following is a summary of the Panel's comments.

Several approaches to the design of the superconducting dipole magnet for the SSC have been pursued for several years. In 1985, consensus among the researchers narrowed the field of candidate designs to two, each representing one of the two main styles of design, "superferric" and "cosine theta." The research on the cosine theta style showed it to be a well understood magnet with reliably predictable costs and production schedules. The reliability of the predictions rested on a large base of data developed in building and operating one large accelerator and developing models and prototypes for several others. Conversely, the work with the superferric style had shown it to be more complex than the cosine theta style and more complex than foreseen in 1983. As a result of the complexities, only models of 1-m length were extensively tested prior to the Panel's recommendation. In the Panel's opinion, this style had not displayed the simplicity and ease of construction and operation it conceptually promised. If the superferric style held out the promise of substantial construction cost savings to outweigh the additional research and development costs required to develop it for production, it would be a strong candidate despite its less mature state of development. This was shown not to be the case. Although its proponents argued that it would be less expensive, the Panel was convinced that the contrary would be true. Use of the superferric style, in the Panel's opinion, was likely to result in higher total costs, exclusive of research and development. Therefore, the Panel recommended adoption of the cosine theta, style D design (Magnet Selection Advisory Panel 1985).

The Panel was unanimous in recommending the magnet design that was then selected by the director of the CDG on the basis that this magnet design had been found by the Panel to be further developed than the others considered and most likely to meet the proposed SSC magnet specifications on schedule.

3.2.3 Technical Alternatives Under Consideration

Feasible alternatives to SSC technical systems are discussed briefly below. These are alternatives for 1) detectors and experimental areas and 2) injector configurations.

- Detectors and experimental areas - Alternatives include: 1) a bypass around the interaction areas such that maintenance can be done on detectors while the beams are used for other purposes, and 2) interaction halls that are "push-pull" facilities where detectors would be assembled in a cavity adjacent to the hall and pushed into the beam line position as needed.

- The energies of the Linac, LEB, MEB, and HEB have many alternatives which vary energies slightly from those in the conceptual design, e.g., an LEB accelerating to 8.3 GeV rather than the 8.0 GeV currently in the conceptual design.

Alternatives within detector/experimental halls and injector construction are still under consideration and decision on those alternatives will not be made until final design. Implementation of any of these alternatives may result in slight adjustments to the placement of facilities, changes in building dimensions, and rearrangement of adjacent facilities. While a number of these alternatives may be implemented, they would not have environmental impacts which are significantly different from those associated with the current conceptual design. They would not result in significantly greater spoils volumes, additional land requirements, or additional surface disturbance. The ISP-specified land requirements would be sufficient to satisfy any of the alternatives being evaluated. Therefore, they are not analyzed in detail in this EIS, but will be included in the Supplemental EIS.

3.2.4 Programmatic Alternatives

3.2.4.1 Use of Other Accelerators

Accelerators at two U.S. laboratories, Fermilab (in Illinois) and the Stanford Linear Accelerator Center (SLAC) (in California), are currently in routine use in high energy physics experiments. As was pointed out in Chapter 2, these machines do not meet the requirements, in terms of either energy or luminosity, to carry out the objectives for which the SSC is being designed. Modifications to these machines to accomplish these objectives are either not feasible on a predictable time scale (SLAC) or would be equivalent in scope to the SSC itself (Fermilab). The European Organization for Nuclear Research (CERN), Geneva, Switzerland, has proposed that the tunnel for its soon-to-be-completed electron-positron collider (LEP) be used for an 8-TeV large hadron collider (LHC) at some early future time. Although this energy (total of 16 TeV) would be lower than the SSC, it would still represent a considerable step beyond energies presently available. The USSR has under construction at Serpukhov a 0.4-TeV on 3-TeV proton-proton collider with a luminosity of 10^{32} to be completed in the 1990's (and has government approval to increase the energy to 3-TeV on 3-TeV). In principle, U.S. physicists could go to those laboratories to do their research. This would, however, defeat one of the most important purposes of the SSC, namely, that it "would be the forefront high energy facility of the world and is essential for a strong and creative high energy physics program into the next century" (see Chapter 2).

In reality, there are no alternatives that would fulfill all of the objectives of the SSC. Some have suggested U.S. participation in the construction of the Large Hadron Collider (LHC) facility at CERN (Switzerland). LHC would have substantially less physics capability than the SSC (its energy would be 40 percent that of the SSC); would have less experimental capacity (two experiments running half-time compared to four full-time at the SSC); involves substantial technical risks in development of 10 T magnets operating at 1.8° K (both beyond the state-of-the-art technology, unlike the SSC); would have to operate in a luminosity regime where detector performance is questionable; has no detailed designs or supportable cost estimates; and has not been approved by the CERN council nor the 14-member countries which fund CERN.

Although the cost of LHC is not well defined at this time and U.S. participation in LHC has not been discussed, it is clear that a substantial U.S. commitment (probably in excess of $1 billion) would be required to get access to a relatively small amount of physics research.

Others have suggested waiting for a new technology accelerator such as an electron-positron linear collider. Studies by a HEPAP Subpanel and the JASON group (HEPAP, 1983) have both concluded that it would be at least a decade before such a machine would be feasible. Such a facility has not been proposed by the scientific community. There are no reliable

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cost estimates for such a facility at this early date when the design is unknown. While there is hope that the cost of such a collider might be less than that of the SSC, it might also be substantially more.

3.2.4.2 International Collaboration

In the ISP, the DOE specified that "The site proposed must be entirely located in the United States of America...." It also stated that "International cooperation on the SSC will increase the scientific and technological resources available to the project. The DOE will seek cost sharing for the SSC from interested countries." The DOE has been actively pursuing the possibilities for international collaboration and cost sharing for the SSC. Although considerable interest in such possibilities has been expressed by other nations, they are unwilling to make a firm commitment until the U.S. itself makes a firm commitment for construction of the SSC.

3.2.4.3 Delay of Project

The DOE has considered the possibility of delaying final design and construction of the SSC until alternative technical procedures become feasible for use. However, no advantage would be gained.

The possibility of using warm superconducting magnets was discussed in Section 3.2.2.2. In fact, even if it were possible to build warm superconducting magnets at this time, they would not appreciably reduce the scope or cost of the SSC. The size of the SSC ring is determined by the maximum allowable magnetic field of the magnets. The higher the field, the smaller the diameter of the ring. The design field of the magnets is determined not so much by the maximum current-carrying capacity of the superconducting cable as it is by the engineering problem of constraining the materials in the magnets under the tremendous forces of the high magnetic field. At this time, it would pose a severe engineering problem to design a magnet which would operate at a field substantially higher than the present SSC magnet design. Furthermore, for the SSC to work at all, the vacuum chambers inside which the beams circulate require a vacuum of 10^{-12} torr--close to that in outer space. At the temperature of liquid helium, 4 K, such a vacuum can be reasonably easily maintained. At higher temperatures, maintaining such a vacuum around the 53-mi ring would be complex and even more expensive. Therefore, delaying the SSC until warm superconducting magnets become practical, even assuming that these became available in the near future, is unattractive both in terms of no reduction of scope as well as in terms of increased engineering problems.

As was noted in Section 3.2.4.1, the electron-positron linear collider at Stanford, the SLAC, is in itself not capable of being modified to bring it to SSC specifications. It has also been pointed out in Section 3.2.1 that the physics programs at a lepton collider complement, but do not substitute for, those at a hadron collider. One of the purposes of the SLAC was to test the concept of high energy electron-positron colliders, in particular, to ascertain the difficulty of achieving high energy, high-intensity spot sizes (more accurately, very low emittance) at the interaction point of the beams. As was mentioned in Section 3.2.1, both this and higher powered klystrons are required to achieve high energy and high luminosity in an electron-positron linear collider. It is possible that both of these problems would be solved within the next few years, although it is by no means certain. It is also possible that such a machine would be somewhat less complex than the SSC, although this too is by no means certain. The SSC, although only in a conceptual stage, relies on technology that exists and has been shown to work at Fermilab.

The SSC can be engineered and built and be available for physics research by the end of the 1990's. This cannot be guaranteed for other types of accelerators at this time. If the SSC is delayed, one possibility would be that CERN would proceed with its plans for a proton-proton collider in the LEP tunnel. There would undoubtedly be an opportunity for U.S. collaboration and participation in this. But it would not be a U.S. machine. U.S. physicists might also collaborate in experiments at the Serpukhov machine in the USSR. However, since these very large accelerators are so complex, the time from conception to availability is 10 years or more (the HEPAP recommendation quoted above was made in 1983, and the SSC schedule calls for completion in 1996). If the SSC were delayed to wait for more advanced technology, the U.S. would be well out of the forefront of the high energy physics field by the turn of the century.

3.3 NO-ACTION ALTERNATIVE

Implementation of the no-action alternative (a decision not to site, construct, and operate the SSC) would jeopardize the future of the U.S. high energy physics program, a vital component of the U.S. basic research effort, which provides the underpinning for our nation's technological strength. The no-action alternative would strip the U.S. of its world leadership position in high energy physics that has been held since the inception of high energy physics research. Without the SSC, there would be a serious exodus of American scientific talent and experience to Europe. Although productive research would continue at Fermilab, SLAC, and BNL, these facilities cannot do the research that is planned for the SSC and are not likely to remain on the research forefront as new facilities come into operation elsewhere in the world.

The impacts of implementing the no-action alternative at any of the site alternatives represent a continuation of the current conditions and trends (see Chapter 4). The no-action scenarios at each of the site alternatives are described below.

- o Arizona site - Continued multiple use of public lands, including grazing, recreation, and Wilderness Study Areas; peripheral development from the Phoenix metropolitan area; increased use as wilderness if portions of the area are so designated by Congress.

- Colorado - Continued dryland and limited irrigated cropland production; continued oil extraction; slow growth of Fort Morgan and Brush; continued limited road access to the area with few new access roads.

- Illinois - Continued light industrial and suburban development at current rapid rate; declining large tract agriculture, especially in the western portion of the site and more pressure toward suburbanization there; continued use of Fermilab for high energy research and development.

- Michigan - Continued use of light industrial and suburban areas mixed with wetlands recreation and agricultural production; some encroachment on wetlands with continued moderate suburbanization; continued oil extraction.

- North Carolina - Continued timber production, light agricultural and rural development; some developmental pressure from the Durham and Research Triangle Park area; minimal new area access by road development.

- Tennessee - Continued use of Tennessee walking horse farms, minimal agriculture, and forested tracts among rural communities; family farms and truck vegetable/fruit farms; research by hydrogeologists, biologists, and others in karst ecosystems.

- Texas - Continued moderate growth of light industrial, service, and suburban development with more rapid growth toward the north because of easy access to the Dallas-Fort Worth area; continued agricultural use of land, especially in the south portion.

3.4 SITE ALTERNATIVES

The seven site alternatives represent the reasonable site alternatives for construction and operations of the proposed SSC. Table 3-3 presents the state-proposed adaptations of the conceptual design presented in the ISP. Technical systems adaptations, with the exception of those noted in the table, were incorporated into the impact analysis. Estimated acreage requirements for proposed transportation and infrastructure facilities which are directly required for the SSC are summarized in Table 3-4.

The ISP specifies that acquisition of land will be the responsibility of the state selected. The specific land acquisition plans proposed by the states are summarized in Table 3-5 by acreages and in Table 3-6 by parcels. Table 3-6 also presents the numbers of relocations anticipated by the land acquisition plans.

Table 3-3

STATE-PROPOSED SITE-SPECIFIC ADAPTATIONS TO THE SSC CONCEPTUAL DESIGN AS SPECIFIED IN THE ISP

SSC Component	AZ	CO	IL	MI	NC	TN	TX
TECHNICAL SYSTEMS	No Change	No Change	Use Fermilab as SSC injector	Place MEB and HEB approximately 20 ft below collider ring[f]	No Change	Place injector deep underground[f]	No Change
Conventional Facilities:							
Near Cluster	Congressional Withdrawal	No Change	K2 is switched with inner utility region. Changed uses proposed in areas A, B, and C	Areas A, B, and C are reconfigured, and area C is reduced in size	No Change	Injector is deep underground	No Change
Far Cluster	Congressional Withdrawal and Right-of-Way	No Change	No Change	Change 45 acres from fee simple to stratified fee estate	No Change	No Change	No Change
Service Areas	Right-of-Way Permit	No Change	Move (max. 500 ft) and/or rotate (max 45°) areas F3, F5, F6, F7, and F9	Move (max. 500 ft) areas F2, F3, and F4	No Change	Move F9 to incline the shaft. Change the shape of F2	No Change
Access/Vent Shafts	Right-of-Way	No Change	Move (max. 360 ft) and/or rotate (max 45°) areas E3, E7, E8, E9	No Change	No Change	Move E7 to incline the shaft	No Change
Buried Beam Zone Access Areas	Right-of-Way	No Change	Move (max. 1,900 ft) areas J1, J2, J3, and J5. Move (700 ft) and rotate (45°) area J4.	Move (max. 1,600 ft) and rotate (max. 30°) areas J1, J2, J3, and J4.	No Change	Change the shape of areas J1, J2, and J4	No Change

Table 3-3 (Cont)

STATE-PROPOSED SITE-SPECIFIC ADAPTATIONS TO THE SSC CONCEPTUAL DESIGN AS SPECIFIED IN THE ISP

SSC Component	AZ	CO	IL	MI	NC	TN	TX
Roads:							
4-lane access provided	No	No	Yes	Yes	Yes	Yes	Yes
Miles of new road	60[e]	94	8	10	39	13	31
Miles of road upgrading	20	91	20	99	10	12	23
Railroad:							
Miles of new siding	6	20	1	1	None	None	None
Electric Power:							
Trans-Ring Tie Line	Yes[a]	Yes[b]	No	No	No	No	Yes[a]
Miles of new powerline to SSC substations	41	99	2	6	4	32	5
Miles of new powerline to water supply pumping station	11	0	0	0	12	0	0
Natural Gas:							
Miles of new pipe to near cluster	9	4	2	7	6	12	7
Miles of new pipe to far cluster	17	17	2	3	15	3	5

Table 3-3 (Cont)

STATE-PROPOSED SITE-SPECIFIC ADAPTATIONS TO THE SSC CONCEPTUAL DESIGN AS SPECIFIED IN THE ISP

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SSC Component	AZ	CO	IL	MI	NC	TN	TX
Water Supply:							
Miles to campus, and source	11 existing wells	85 Morgan County Quality Water District existing wells (may need to purchase surface water-rights for recharge - South Platte or Colorado River (CBT)	On-site, existing well field (groundwater source); expand Fermilab well field	3 municipal (groundwater source); Stockbridge well field	5 from Lake Butner	2 municipal Rutherford Co. (F9, F10, F1, F2); surface water	9 municipal pipeline to Tarrant Co.; surface water
Miles to far cluster, and source	53 from campus through tunnel[c]	53 from campus[c]	5 new wells	On-site, new wells	9 from Mayo Reservoir	3 municipal Marshall Co; surface water	7 new wells and municipal well fields
Supply to Service Areas	Included above	Included above	At 3 locations municipal (2 mi)*; for all other locations new wells	New wells	New wells	7 mi, municipal F3, F9 Bedford Co.; surface water; F7, F8 College Grove wells	New wells
Sewage from campus area	Treatment plant on site	Treatment plant on site	Existing municipal plants	1 mi to new municipal system	6 mi to existing municipal system	6 mi to existing municipal system	Treatment plant on site
Waste Disposition:							
Spoils disposal[d]	At Sacaton mine, approximately 70 mi from the SSC	8 sites on 140 acres, maximum distance about 11 mi	4 quarries, maximum distance about 10 mi	8 quarries maximum distance about 20 mi	17 sites on 315 acres, all within about 4 mi of the site	34 sites on 364 acres, all within about one mile of the site	50% to Midlothian area 5 mi NW of area E2; 50% on about 65 acres at various locations, all within about 2 mi of the site

* Aurora - F1 area (industrial); Oswego - F2 area (industrial); St Charles - F9 area (industrial)
a Line would be constructed but is not required in ISP; therefore not analyzed in EIS
b Needed to satisfy ISP requirements, and analyzed in the EIS
c Must provide water to each service
d State proposed option analyzed for EIS; other options available but not analyzed. (Refer to Appendix 10 for details.)
e Based on the alternative road plan developed by the DOE for Arizona, as discussed in Section 3.4.1. The road plan proposed by the State of Arizona included construction of the Estrella Freeway from Goodyear to I-8.
f State proposed adaptations were not used in this EIS to allow for comparative analysis between sites. See Appendix 1.

Table 3-4

ESTIMATED ACREAGE REQUIREMENTS FOR PROPOSED TRANSPORTATION, INFRASTRUCTURE FACILITIES*

State	Total	Roads	Railroads	Electric Transmission	Water	Sewage	Natural Gas	Telecommunications	Spoils Disposal
Arizona	1,418	891	55[a]	465[a] (easement)	7[a] (wells)	f	0	0	Sacaton Mine
Colorado	4,395	2.115	250[a]	1,530[a] (easement)	360[a] (easement)	f	0	0	140 acres 8 sites
Illinois	27	16	5[a]	0	6[b]	b	b	b	4 sites
Michigan	185	120[a]	5[a]	0	10[a,d]	50[a,d]	0	0	8 sites
North Carolina	525 to 935	42	0	72[c] or 482 (easements)	c	c	c	96 (easements)	315 acres 17 sites
Tennessee	638	250	0	24[b] (easement)	b	b	b	0	364 acres 35 sites
Texas	285	65	0	70[a] (easement)	55[a] (easement)	f	30[a] (easement)	0	65 acres 10 sites[e]

* Based on proposal information. Firm requirements have not been established.
a Estimate; facility proposed but no area given
b Miscellaneous utilities
c All utilities except communications; 72 acres or 482 acres depending upon which electric utility company provides power
d Treatment plant
e Estimate; several alternatives proposed
f Included in campus acreage

Table 3-5

SUMMARY OF SITE-SPECIFIC LAND ACQUISITION PLANS - ACREAGES[a]

	ISP Area Required		Arizona		Colorado		Illinois[g]		Michigan		North Carolina[h]		Tennessee		Texas	
	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total
PROPOSED ACREAGES																
Total Acreage	15,830	100.0	15,830	100.0	15,830	100.0	18,648	100.0	16,025	100.0	15,897	100.0	15,900	100.0	16,748	100.0
Fee Simple	7,690	48.6	15,830	100.0	7,690	48.6	10,508	56.3	7,885	49.2	7,950	50.0	7,750	48.7	8,650	51.6
Strat. Fee	8,140	51.4	0	0	8,140[e]	51.4	8,140	43.7	8,140	50.8	7,947	50.0	8,150	51.3	8,098	48.4
LAND OWNERSHIP																
Federal Land, Total			9,748[l]	61.6	0	0	6,800	36.5	0	0	0	0	0	0	310	1.9
Fee Simple			9,748[i]				6,800								104[j]	
Strat. Fee			0				0								206[k]	
State Land, Total			1,007	6.3	780	4.9	b		285	1.8	1,389	8.7	0	0	200	1.2
Fee Simple			1,007		240				0		1,132				168	
Strat. Fee			0		540[e]				285		257				32	
Local Govt. Land, Total			0	0	0	0	b		77	0.5	71	0.4	c		57	0.3
Fee Simple									0		1				21	
Strat. Fee									77		70				36	
Private Land, Total			5,075	32.1	15,050	95.1	11,848	63.5	15,663	97.7	14,437	90.8	15,900	100.0	15,823	34.5
Fee Simple			5,075		7,450		3,708		7,885		6,817		7,750		8,167	
Strat. Fee			0		7,600[e]		8,140		7,778		7,620		8,150		7,656	
Other Land, Total			0	0	0	0	0		0	0	0	0	0	0	358[d]	2.1
Fee Simple															189	
Strat. Fee															169	
ADDITIONAL AVAILABLE LAND																
Potentially Available Acreage			267		2,600		f		f		f		f		f	

a Areas A-L only, based on proposal data, see paragraph 4.4
b Areas not provided; included in private property
c One school site
d State and county road right-of-way
e The State of Colorado has proposed to acquire 62,680 acres but will furnish only that reported to DOE
f Amount of acreage undetermined
g Number of affected parcels and ownerships may vary by as much as 20% and numbers of relocations by 50
h Number of parcels and ownerships may vary by as much as 10% and number of relocations by 70%
i Right-of-way and/or withdrawal
j Transfer from Corps of Engineers
k Permit from Corps of Engineers
l Assuming Congressional withdrawal of the total portion of the required fee simple lands

Table 3-6

SUMMARY OF SITE-SPECIFIC LAND ACQUISITION PLANS - PARCELS**

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
PROPOSED PARCEL ACQUISITION							
Total Number of Parcels Affected	224	157	3,305	801	826	898	614
Fee Simple	224	157	437	333	*	434	318
Strat. Fee	0	0	2,868	468	*	464	296
Affected Parcels, by Ownership			*	*	*	*	*
Federal	82	0					
State	5	4					
Local	0	0					
Private	137	153					
Total Number of Ownerships	139	67	2,750	687	780	807	420
Fee Simple	139	67	*	286	*	*	240
Strat. Fee	0	0	*	401	*	*	180
Total Number of Relocations	6	23	219	221	180	128	175

* Not furnished by the State proposal
** Areas A-L only, based on proposal data, see Section 4.4

Site adaptations are discussed in the Engineering Description (see Appendix 1) and in Land Acquisition (see Appendix 4) and are evaluated in the detailed impact assessments (see Chapter 5). These sites are analyzed with respect to current conditions and baseline trends described in Chapter 4.

3.4.1 Arizona Site

The proposed site is located approximately 30 mi southwest of Phoenix, Arizona, in the southern portion of Maricopa County (see Figures 3-7 and 3-8). The proposal located 11.9 mi (22 percent) of the collider ring in cut-and-cover tunnel and the remainder in a tunnel boring machine (TBM) tunnel. The proposal limited the maximum depth of the cut-and-cover tunnel to 80 ft below the existing ground surface. In some areas the proposed cut-and-cover tunnel was actually greater than 80 ft, and for these areas this was changed to a TBM tunnel. The proposed cut-and-cover tunnel, which crossed the Gila Bend-Maricopa Road, the Southern Pacific Railroad tracks, and the Butterfield Stage Route, was also changed to a TBM tunnel. This resulted in 6.0 mi (11 percent) of the collider ring in a cut-and-cover tunnel and the remaining 47 mi (89 percent) in a TBM tunnel, which was used for purposes of the DEIS. The tunnel would be constructed in unsaturated materials including fanglomerates, granite, and interbedded volcanic and sedimentary rocks. The tunnel would be entirely above the water table.

The Maricopa region of the Sonoran desert is arid and vegetated by two principal plant associations, the Lower Colorado and Arizona Upland desert scrub. This site is the least developed of the seven BQL sites; more than 60 percent is public land administered by the Department of Interior, Bureau of Land Management (BLM).

There are no changes proposed to the technical systems from those presented in the ISP.

The site-specific adaptation of the SSC to this site would include development of significant infrastructure and transportation support. Tables 3-3 and 3-4 summarize these adaptations. For example, 101 mi of new road and 20 mi of road upgrades are proposed by Arizona. An alternative road plan for Arizona was developed by the EIS preparers to mitigate impacts that would result from the plan proposed by Arizona, and because of the anticipated unavailability of the Estrella Freeway, as discussed in Appendix 14. The alternative plan includes 60 mi of new roads and 20 mi of road upgrades. Six mi of new railroad siding are proposed by Arizona. The proposed source for all on-site project water requirements is groundwater from an existing but unused well field immediately to the southeast of the site. A new wastewater treatment plant is proposed on site.

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 2.45 million yd^3.

Figure 3-7

REGION OF THE PROPOSED ARIZONA SITE

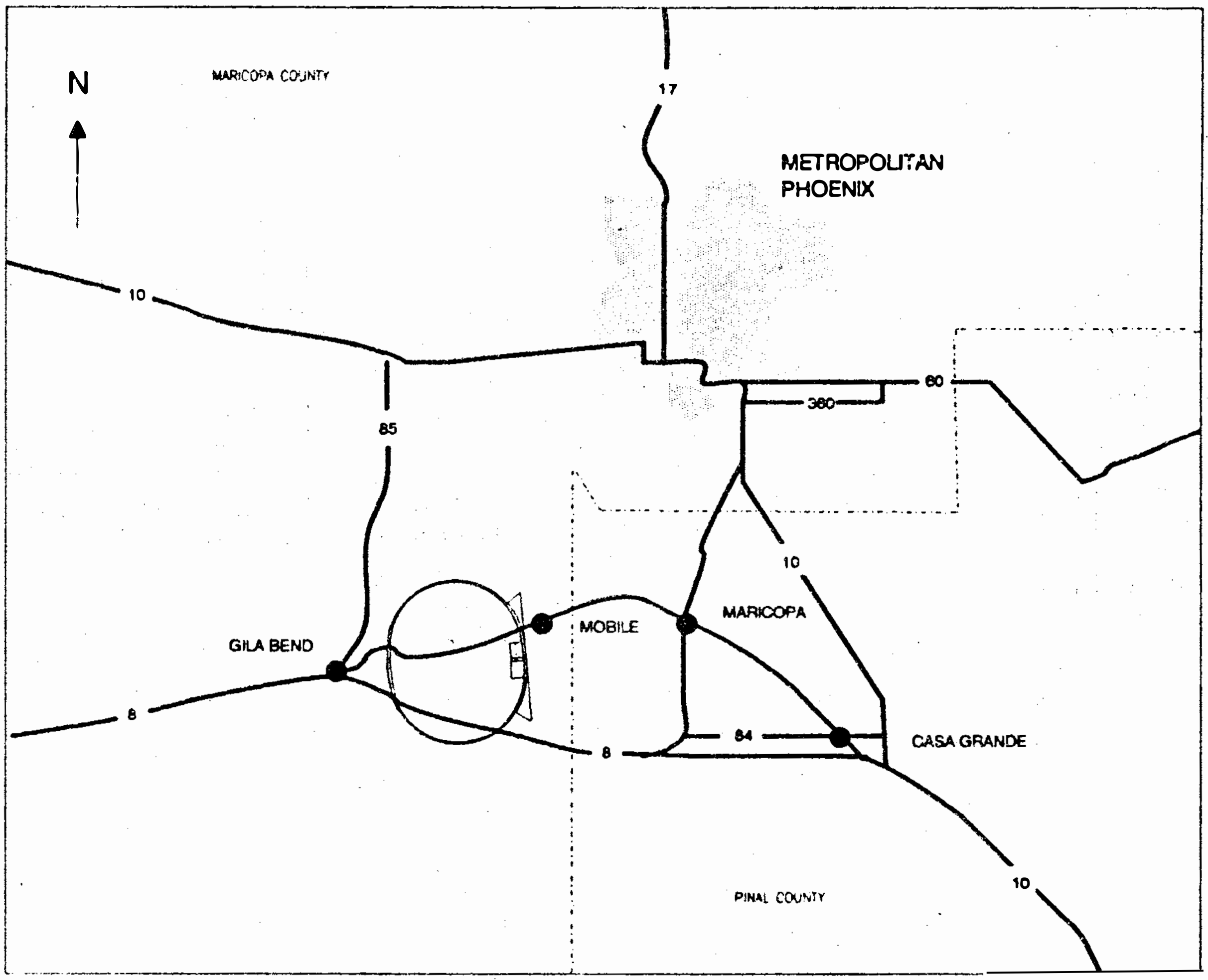
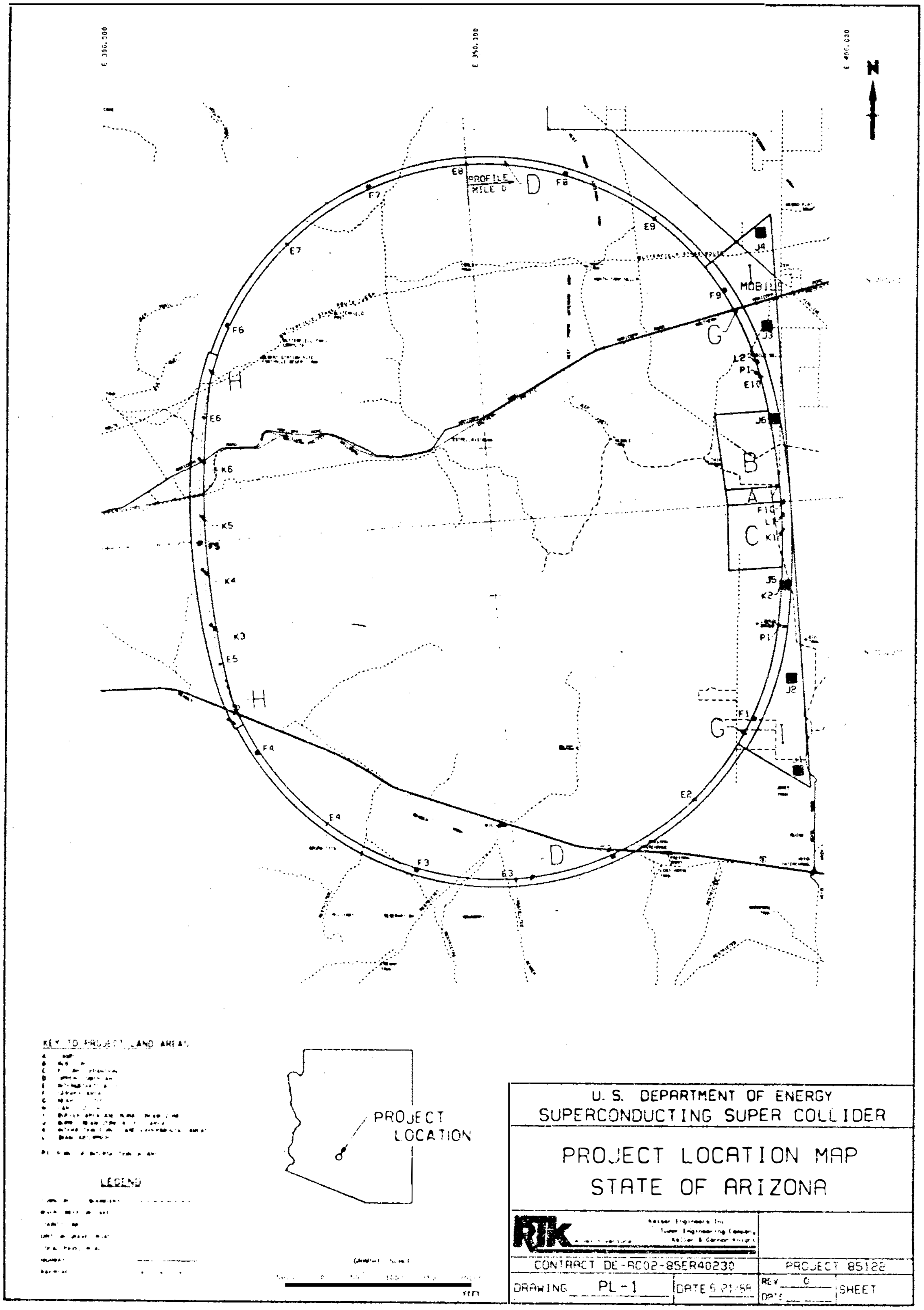


Figure 3-8

PROPOSED ARIZONA SITE



Arizona has proposed four alternatives for the disposal of the rocks and earth material: 1) to use the Sacaton mine, 2) to use the New Cornelia mine, 80 mi away, 3) to spread the excavated material 1 ft thick over a 1 mi area within the high energy booster (HEB) ring, or 4) to take the excavated material to Phoenix (about 70 mi away) for use as building material.

About 288 truckloads per day would be required to haul away the excavated materials if six TBM's operated simultaneously.

The only proposed change to land acquisition is the use of the far cluster lands by a mixture of land withdrawals and right-of-way permits from the BLM. More than 60 percent of the land requirements may be satisfied by land withdrawal and right-of-way permits on lands administered by the BLM. There are approximately 5,075 acres of fee simple lands currently in private ownership. These represent 137 owners, but because of the large number of absent owners would result in only six relocations.

3.4.2 Colorado Site

The proposed site is located approximately 65 mi northeast of Denver and includes portions of Adams, Morgan, and Washington Counties (see Figures 3-9 and 3-10). The entire tunnel would be constructed by tunneling techniques in Pierre shale (a claystone) below the water table. The injector facility would be constructed by cut-and-cover.

This area is primarily a dryland and irrigated farming district. Approximately 90 percent of the lands designated in the proposed fee simple areas are farmlands. The remainder are largely rangelands. Floodplains and swales make up approximately 1 percent of the fee simple area. Small palustrine wetlands located in swales are the most common wetland systems present, although lacustrine and riverine wetlands are also present in the region. There are few perennial aquatic systems in the immediate area of the proposed ring. There are substantial aquatic resources in the region, however, including the South Platte River and several reservoirs and irrigation impoundments.

There are no changes proposed to the technical or conventional systems from that presented in the ISP. Table 3-3 summarizes site-specific adaptations to infrastructure and utilities. Competition for aggregate and water may be increased by the implementation of the project. See Sections 5.1.1, 5.1.3, and 5.2.1 for discussions.

Tables 3-3 and 3-4 summarize the proposed additions and upgrades in transportation and infrastructure systems at the Colorado site. These include 94 mi of new roads, most of which are represented by one new two-lane road extending directly east from Interstate 76. About 90 mi of road upgrading is also included in the proposed site adaptation. Approximately 100 mi of new power lines would be needed to support the service areas.

Figure 3-9

REGION OF THE PROPOSED COLORADO SITE

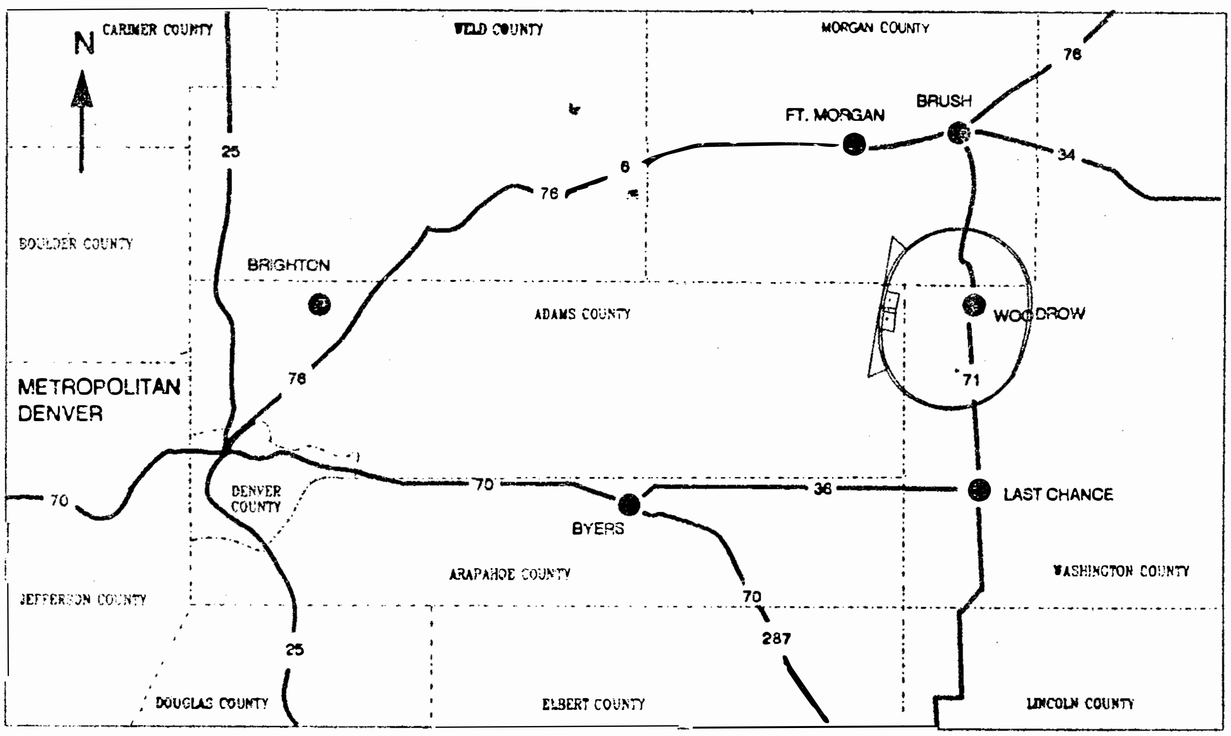
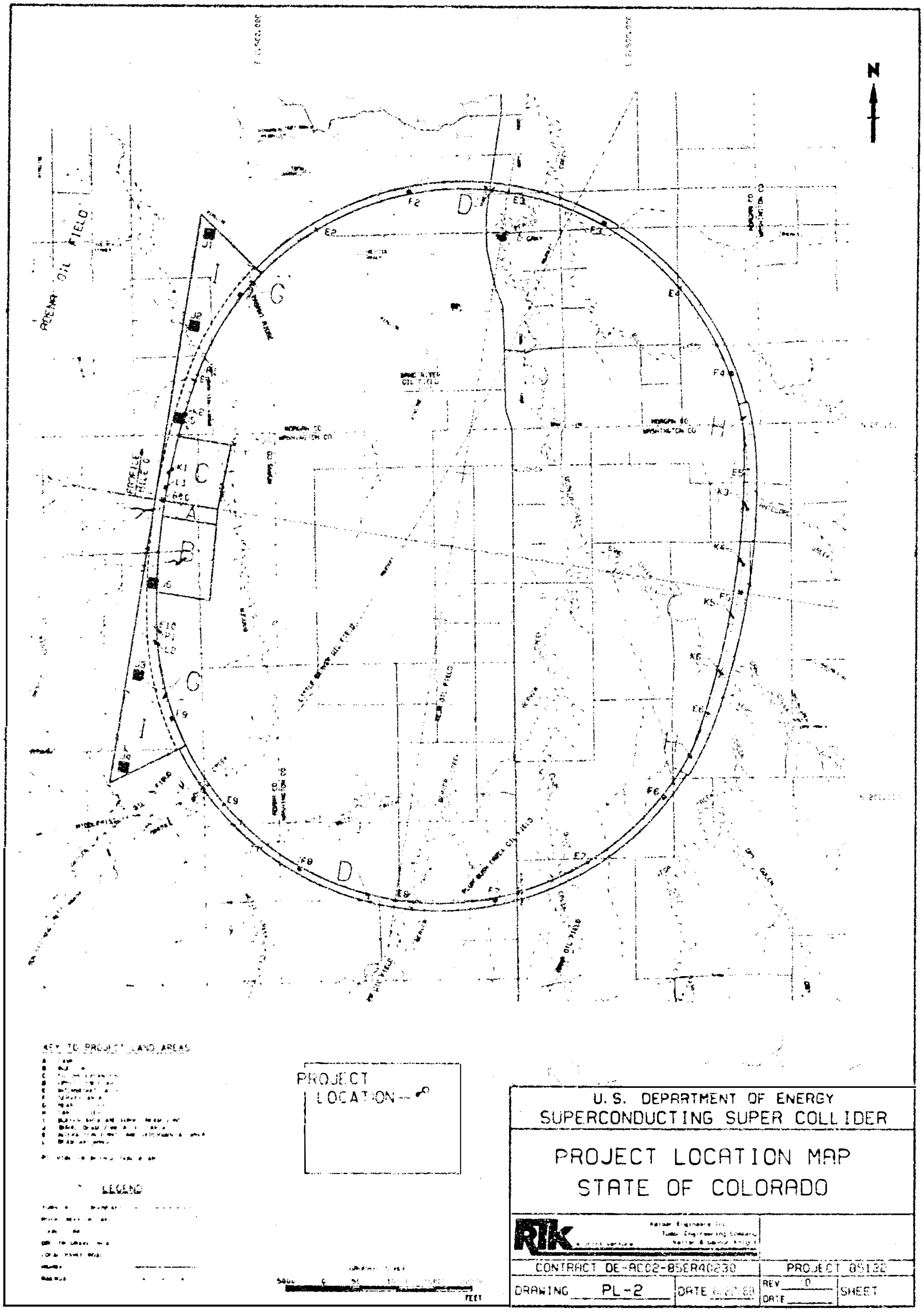


Figure 3-10

PROPOSED COLORADO SITE



Morgan County Quality Water District's existing water wells would be used for project needs. However, there are several alternatives for water supply (see Section 4.3 and Appendix 7). An on-site wastewater treatment plant is proposed (see Table 3-4).

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 2.6 million yd^3.

The four alternatives proposed by Colorado for the disposal of the excavated rocks and earth materials are: 1) to use the excavated materials for the construction of a flood-control structure (levee) near the City of Brush, 2) to use eight disposal sites: approximately 140 acres material height 14 ft and maximum hauling distance, about 11 mi away, 3) to use the material to make lightweight aggregate for foundations in roadway embankments, and 4) to line newly constructed reservoirs.

About 288 truckloads per day would be required to haul away the excavated materials if six TBM's operated simultaneously.

Approximately 95 percent of the proposed land is currently in private ownership. There are 157 parcels within the fee simple estate. However, because the main land use is large scale agriculture, the number of relocations would be small; a total of 23 is estimated.

3.4.3 Illinois Site

The proposed site is located approximately 40 mi west of Chicago in the northeastern portion of Illinois and includes portions of Kane, DuPage, and Kendall Counties (see Figures 3-11 and 3-12). The entire tunnel would be constructed by tunneling methods in dolomite below the water table.

Much of the eastern portion of the site is suburban, intensively used for housing developments and commercial, light industry. The western portion of the site is intensively managed for agriculture. Although the Illinois site contains few ecologically natural areas, there are diverse biological resources in the area. Wetlands are abundant throughout the area. Palustrine wetlands are most common, and lacustrine and riverine wetlands are also present. The Fox River runs north to south through the site, and remnant prairie and savannah areas are present.

There are a number of proposed site adaptations for the SSC in Illinois (see Tables 3-3, 3-4, and 3-5). The principal one is the use of the Fermilab accelerator tunnel, 4 mi in circumference, as the SSC injector. Also there are several existing Fermilab facilities that are proposed to be shared.

Other adaptations include altered shape and location of A, B, and C areas totally within the boundaries of Fermilab, moving or rotating several of the access or service facilities, including: E3, E7, E8, and E9 as well as F3, F5, F6, F7, and F9. The buried beam access zones (J1-J5) are adapted by moving and rotating them slightly.

Figure 3-11

REGION OF THE PROPOSED ILLINOIS SITE

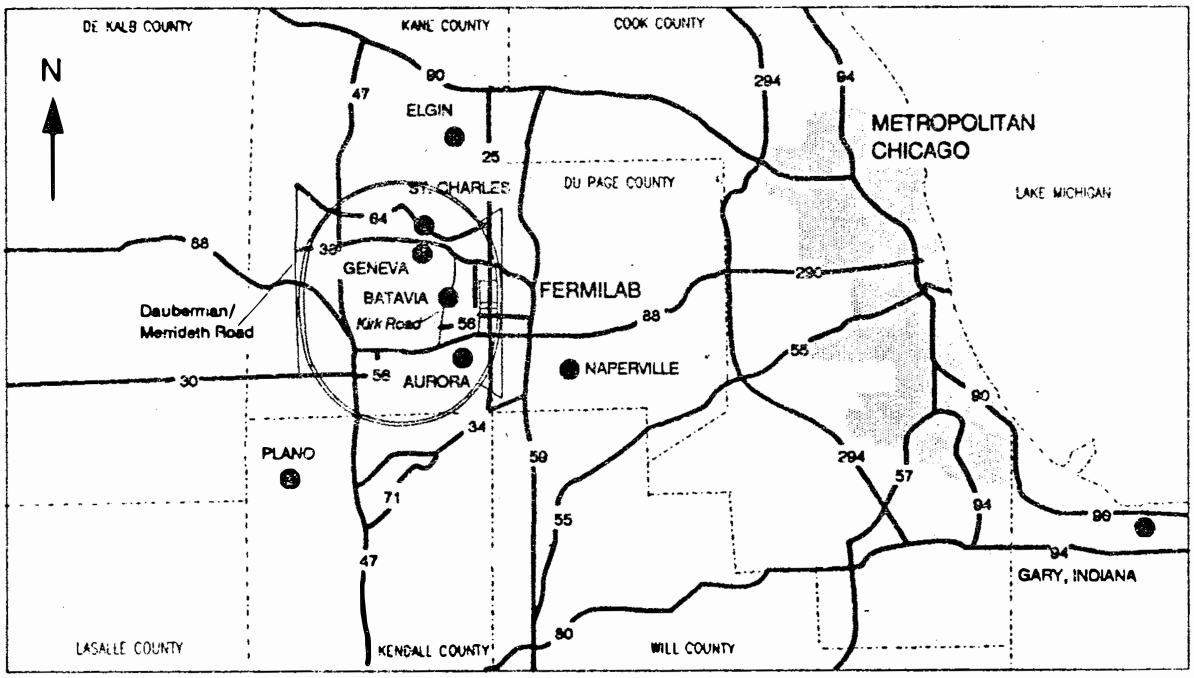
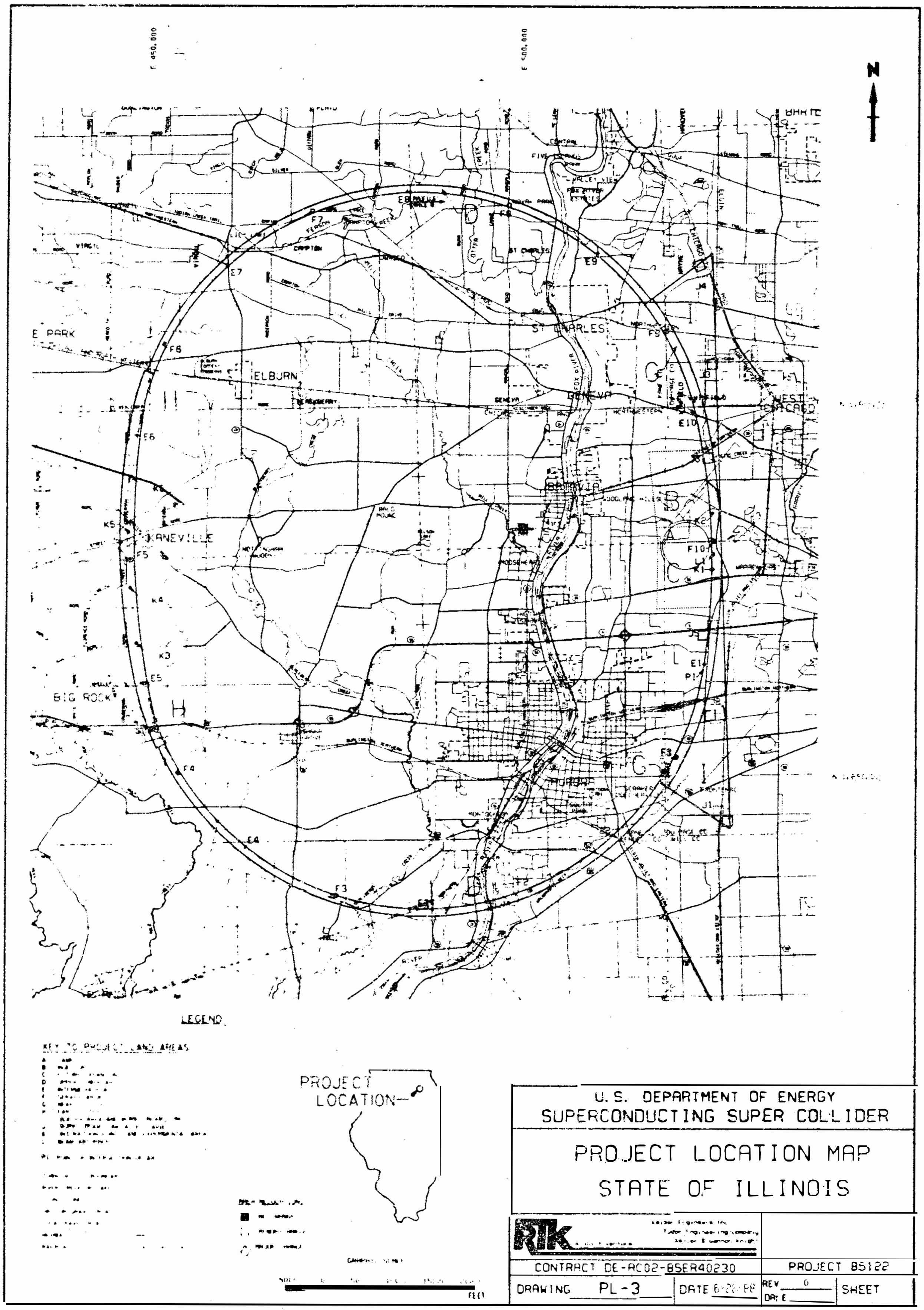


Figure 3-12

PROPOSED ILLINOIS SITE



There are few transportation and infrastructure upgrades proposed. Project water supply will be provided by an expansion of the existing Fermilab well field, a new well field for the far cluster, and connections to municipal supply systems for two of the remote service areas. Existing municipal sewage treatment plants are proposed to service the SSC.

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 3 million yd^3.

Four quarries have been proposed by the state as disposal sites for the excavated material. These quarries would stockpile the excavated material and gradually blend them with their own produced material and sell the combined product. The combined volume capacity of these sites is about 14 million yd^3. The maximum hauling distance to these quarries is about 10 mi.

An additional alternative would be to sell the dolomite if the chemical analysis shows that there is enough alkalinity. About 288 truckloads per day would be required to haul away the excavated materials if six TBMs operated simultaneously.

The lands proposed for the SSC in Illinois are 64 percent in private holdings (see Tables 3-5 and 3-6). Other lands include the Fermilab reservation. In the fee simple area there are 437 parcels. There are 219 relocations estimated. The estimate of relocations may vary as much as 50%.

3.4.4 Michigan Site

The proposed Michigan site is located approximately 35 mi northwest of Ann Arbor in the southern portion of the state (see Figures 3-13 and 3-14). It includes portions of Ingham and Jackson Counties. The entire tunnel would be constructed by tunneling methods through shales, limestones, dolomites, and sandstone below the water table.

The site is ecologically diverse, and includes numerous forest and wetland areas. A variety of wetlands are present including open water, forested, scrub-shrub, and emergent palustrine systems. Diverse land uses exist in the area including agriculture, timber production, game production, and recreation.

The technical system adaptation proposed at the Michigan site is the location of the MEB and HEB 20 ft below the ring. No design or cost estimate exists for an MEB and HEB at this level, which would also involve undesigned access shafts and other unknowns. Therefore, for purposes of the analysis in the EIS, this adaptation was not considered (see Volume IV, Appendix 1). Adaptations to the conventional facilities include reconfiguration of A, B, and C areas, the reduction of the size of C area, and movement of F2, F3, F4, and several J areas (J1-J4).

Figure 3-13

REGION OF THE PROPOSED MICHIGAN SITE

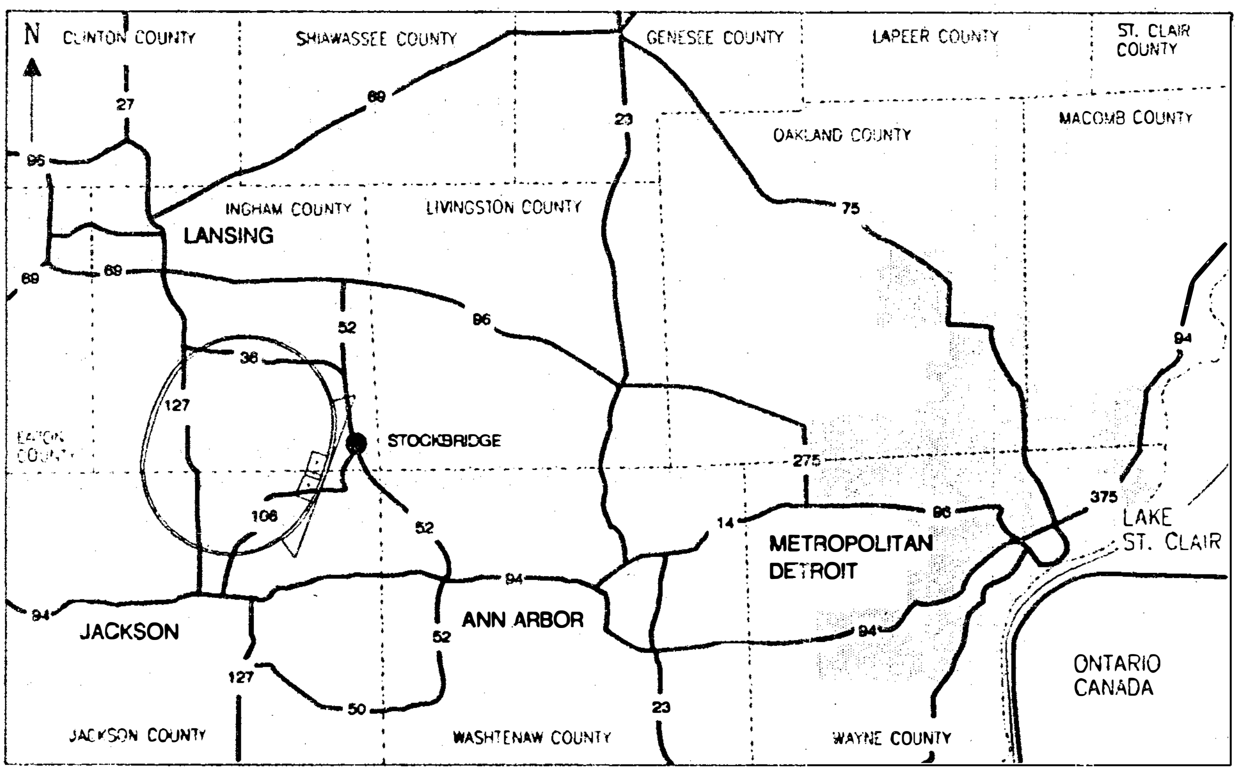
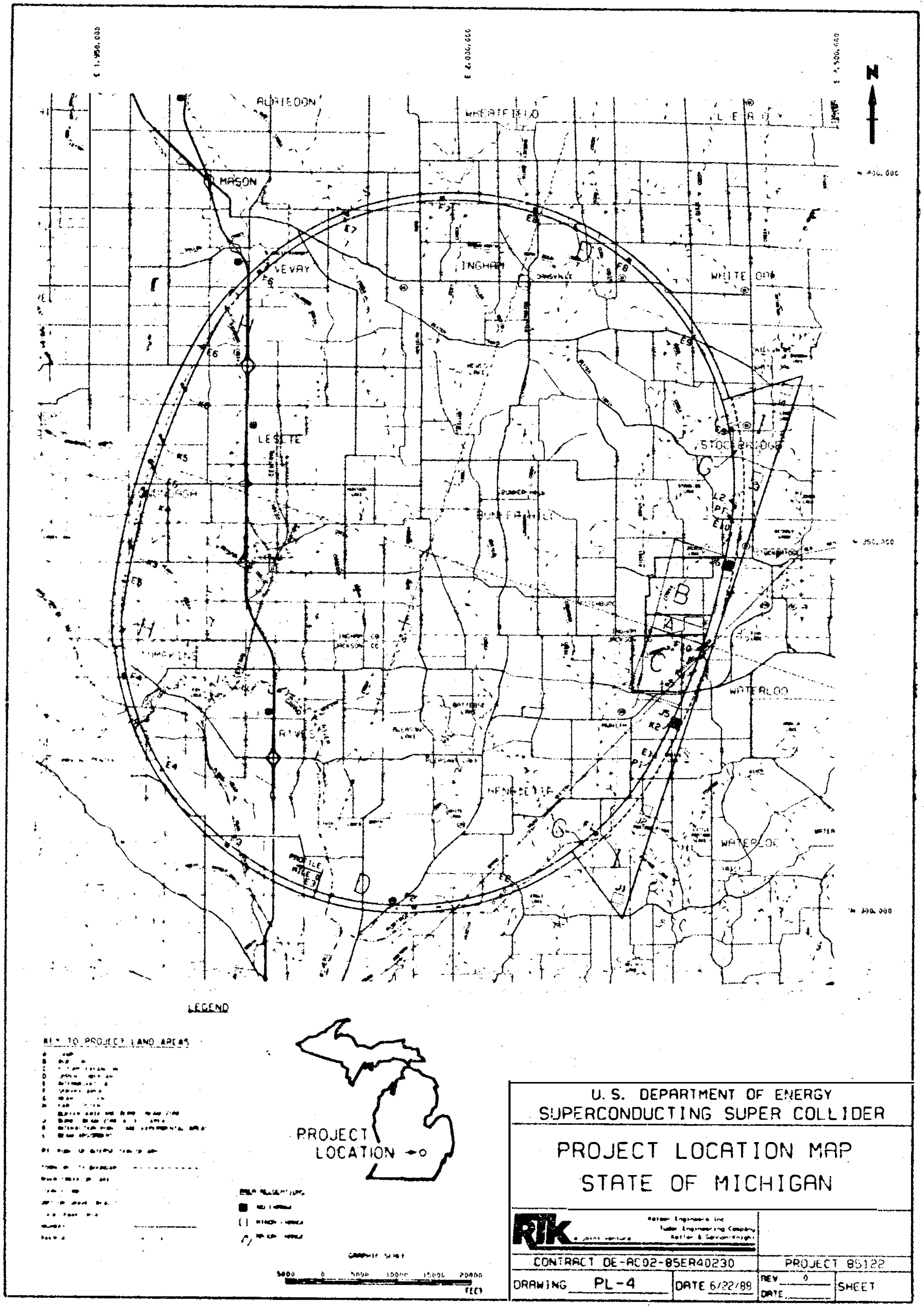


Figure 3-14

PROPOSED MICHIGAN SITE



There are 10 mi of new road proposed; but about 100 mi of road are proposed to be upgraded to serve the SSC. The proposed water source is an expansion of the existing Stockbridge well field and new wells at remote sites. An existing municipal wastewater treatment plant is also proposed for use (see Tables 3-3, 3-4, and 3-5).

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 2.6 million yd^3.

The disposal options for the excavated materials proposed by Michigan include: 1) Commercial processing of acceptable inert material, 2) disposal of inert material unacceptable for commercial processing at any of eight quarries located along the periphery of the collider ring (maximum hauling distance 20 mi), 3) transporting leachable material (shale containing pyrite, coal containing sulfur, and gypsum) to type II or type III landfills.

An alternative to the state's proposals would be to treat leachable materials (pyrite, coal containing sulfur, and gypsum) and make them non-leachable or reduce their leachability significantly.

The proposed Michigan site is almost totally held in private ownership (see Tables 3-5 and 3-6). There are 333 parcels in the proposed fee simple area. The number of relocations estimated to be required are 221.

3.4.5 North Carolina Site

The proposed site is located in the north central portion of North Carolina, approximately 15 mi northeast of Durham (see Figures 3-15 and 3-16). It includes portions of Person, Granville, and Durham Counties. The entire tunnel would be constructed by tunneling in granite and metamorphosed volcanic and sedimentary rocks below the water table.

The North Carolina site is in a biologically rich Piedmont area, in the headwaters of three major streams. Much of the site is undisturbed by farming or urban development and is dominated by forest, including mixed deciduous upland and lowland species and shortleaf pine stands, especially mixed with oak. Wetlands present include emergent and forested palustrine systems associated with streams and farm ponds, riverine systems, and also lacustrine systems in the form of man-made reservoirs. Commercial timbering is much more important than the cropland agricultural production in the area.

There are no adaptations proposed to either the technical or conventional facilities (see Table 3-3). Approximately 40 mi of new road are proposed to be constructed and approximately 10 mi of road upgrading would be required. Twenty-one mi of gas pipeline would also be installed to support the SSC (see Tables 3-3 and 3-4).

Figure 3-15

REGION OF THE PROPOSED NORTH CAROLINA SITE

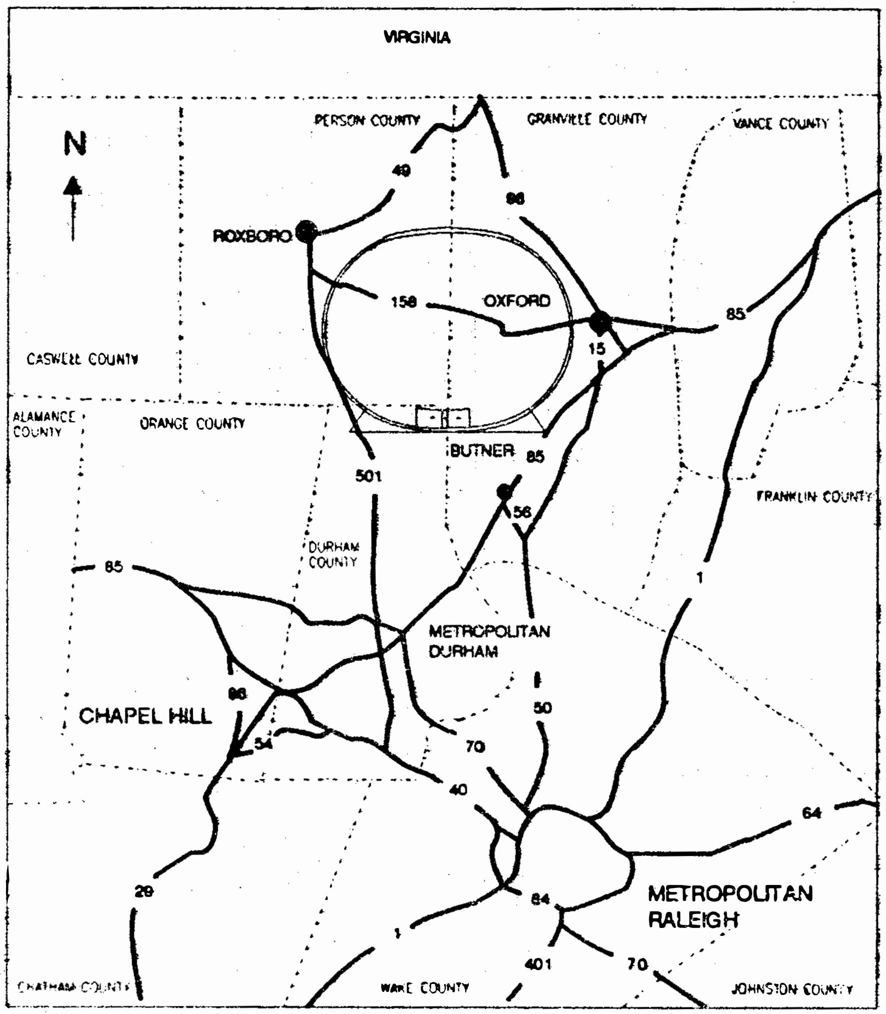
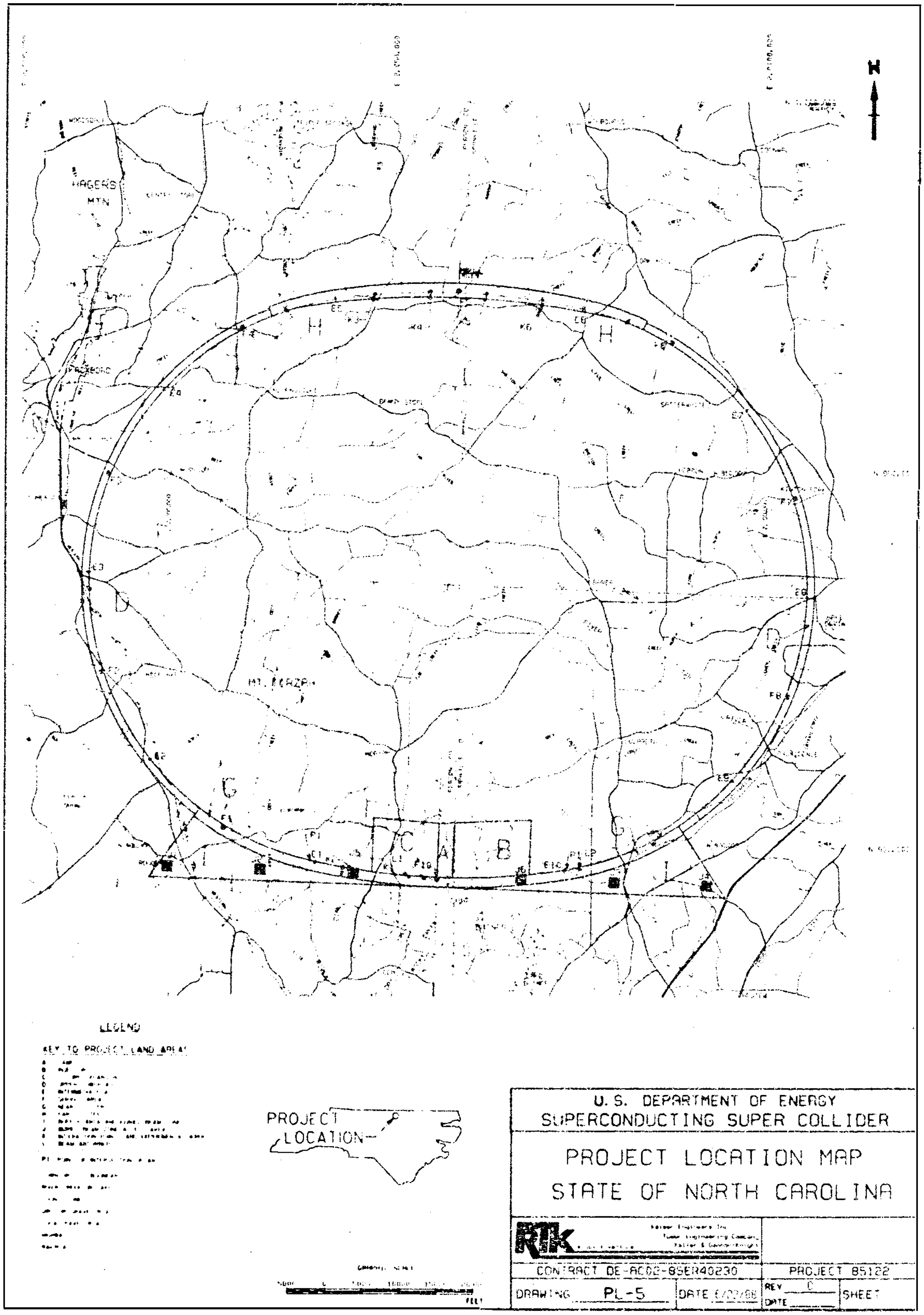


Figure 3-16

PROPOSED NORTH CAROLINA SITE



Water supply for the various facilities is proposed from existing reservoirs including Lake Butner and Mayo Reservoir, and new wells in the area. Sewage treatment would be supported by existing municipal systems (see Table 3-3).

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 2.7 million yd^3.

The State of North Carolina has proposed 1) to dispose of the excavated materials at 17 different locations (maximum hauling distance would be less than 4 mi) or 2) to sell or donate excavated material to local producers of aggregate.

About 288 truckloads per day would be required to haul away the excavated materials if six TBM's operated simultaneously.

Ninety percent of the proposed North Carolina site is in private ownership (see Tables 3-5 and 3-6). There are 687 parcels in the proposed fee simple area. An estimated 180 relocations are required. The number of relocations could vary as much as 70%. The number of relocations are small compared with the number of parcels due to the large number of forests and woodlots.

3.4.6 Tennessee Site

The proposed site is in the central basin of Tennessee, approximately 30 mi southeast of Nashville (see Figures 3-17 and 3-18). The site includes portions of Bedford, Marshall, Rutherford, and Williamson Counties. The tunnel would be constructed entirely by tunneling techniques in homogeneous limestone lying below the water table.

The central basin of Tennessee is one of the most ecologically diverse in the region and is the host of many relict populations. The area is dominated by mixed deciduous forest. Agricultural production is small-scale, as is timber production. Livestock includes the Tennessee walking horse. There are several specialty ranches in the immediate vicinity of the proposed site. Although there are significant wetlands in the region, wetlands are not a prominent feature of the project area. Most of the wetlands present are farm ponds; forested, emergent, and riverine wetlands also occur in the area. Aquatic resources in the region include the Duck River.

The one proposed adaptation to the technical systems at the Tennessee site is the use of an injector facility located near tunnel depth (see Table 3-3). For the purpose of this analysis, all of the booster facilities were assumed to be located at the surface in cut-and-cover construction similar to the other site alternatives.

There are a few adaptations of the conventional facilities: location of E7, and alternate shapes to F2, J1, J2, and J4 (see Table 3-3).

Figure 3-17

REGION OF THE PROPOSED TENNESSEE SITE

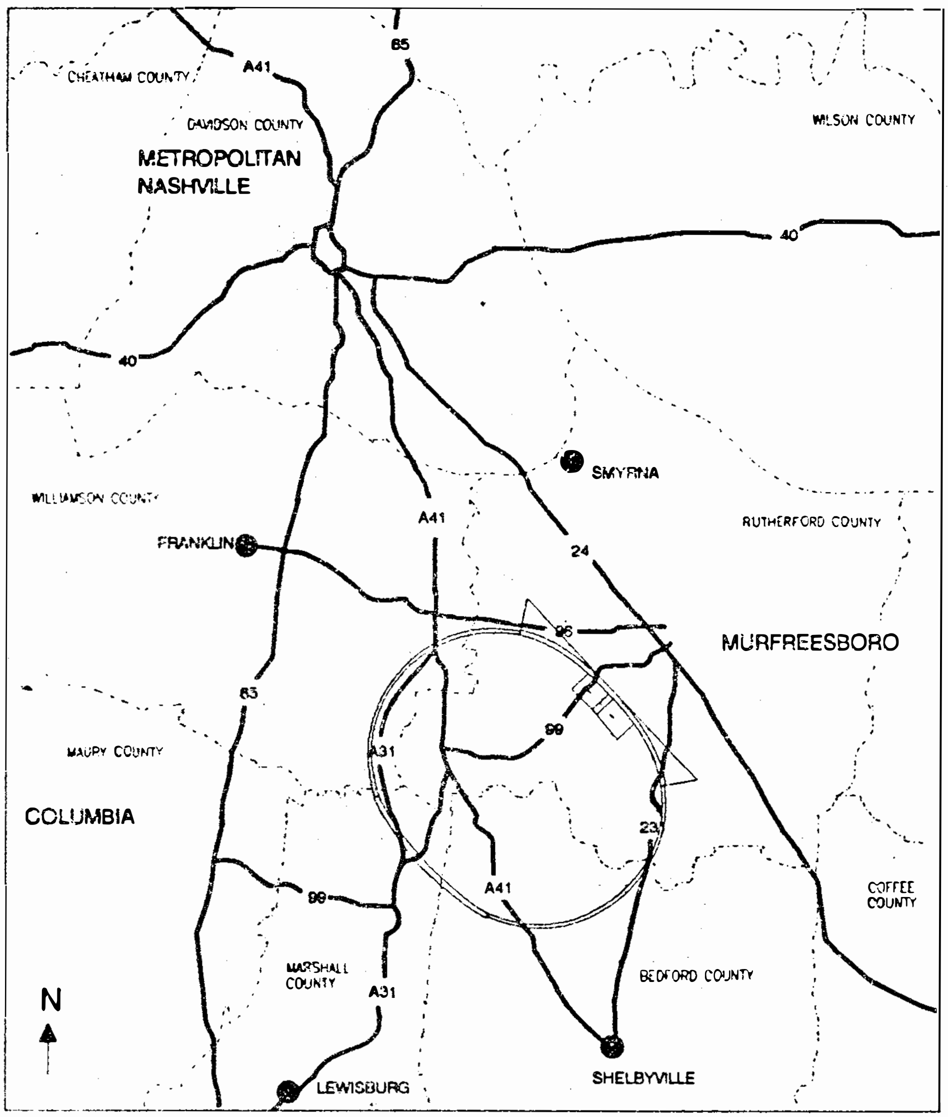
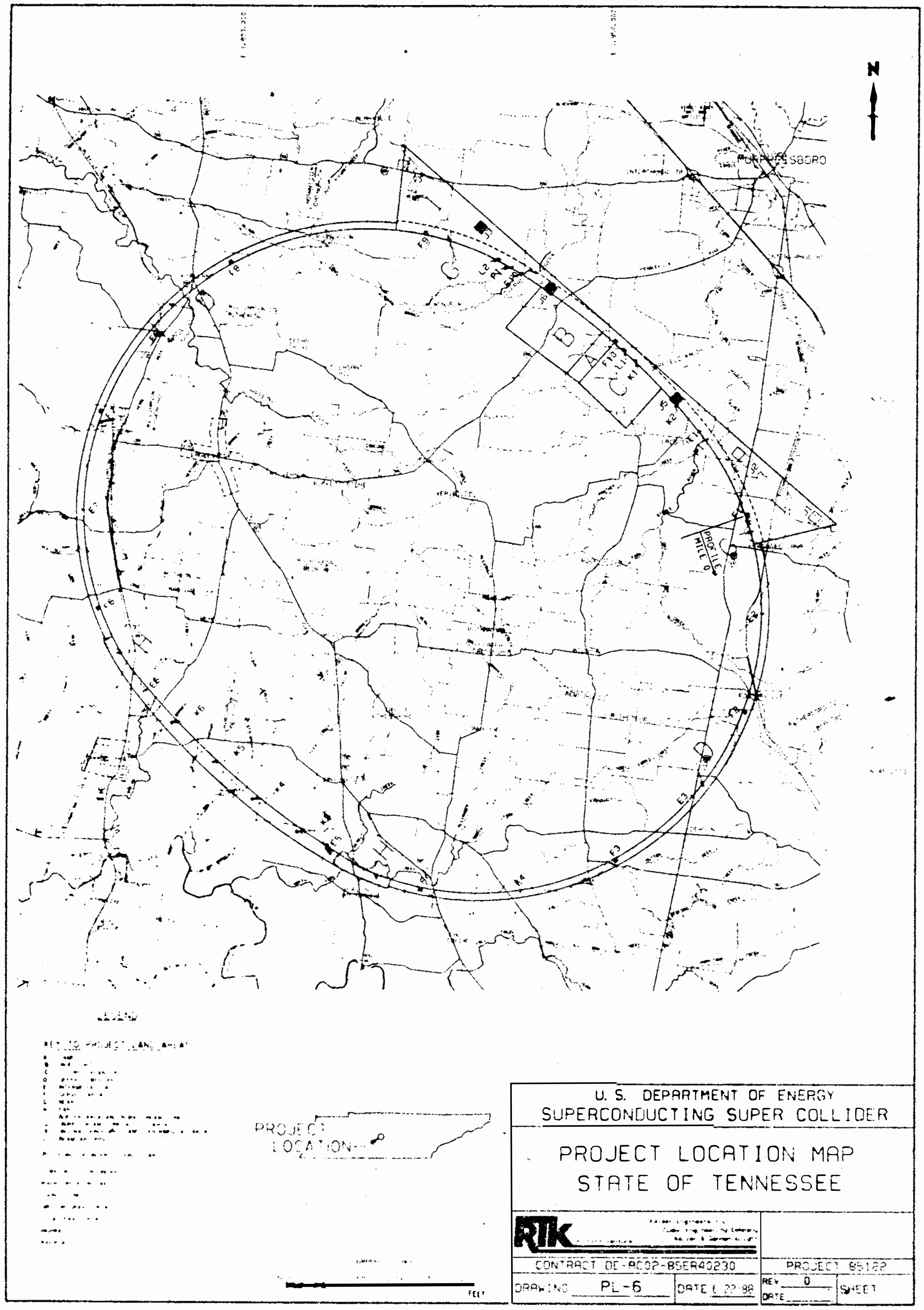


Figure 3-18

PROPOSED TENNESSEE SITE



Minor requirements for transportation and infrastructure development are proposed (see Tables 3-3 and 3-4), including approximately 13 mi of new roads, 30 mi of power lines to substations, and 15 mi of gas service. Tennessee proposes to use the Consolidated Utility District of Rutherford County, Bedford County Utility District, College Grove Municipal System, and Marshall County Board of Public Utilities for water service for the SSC. Sewage treatment would be provided by the municipal facilities, approximately 6 mi from the campus area.

The estimated bulk volume of excavated materials from tunnels and shafts would be about 3 million yd^3.

The State of Tennessee has proposed three alternatives for the disposal of the excavated materials: 1) the limestone could be crushed and used by contractors during site development for roadway surfacing, road bases, asphalt mixes, concrete aggregate, and construction embankment materials, 2) the limestone could be sold, and 3) the limestone could be permanently disposed of at about 34 disposal sites: excavated material hauling distance would be less than 1 mi.

About 288 truckloads per day would be required to haul the excavated materials if six TBM's operated simultaneously.

All proposed lands in Tennessee are currently in private ownership (see Tables 3-5 and 3-6). There are 434 parcels. Anticipated relocations total 128. There are many more parcels than relocations due to agricultural land use.

3.4.7 Texas Site

The proposed site is located in the northeast portion of Texas, approximately 25 mi south of Dallas and 35 mi southeast of Fort Worth (see Figures 3-19 and 3-20). The proposed site is entirely in Ellis County. The facility would be constructed by tunneling techniques in chalk and marl between the underlying regional water table and an overlying, areally extensive veneer of saturated sediments and isolated perched aquifers.

The Texas site is located in the arid transition between the eastern deciduous forest and the plains. The forests in the area are primarily north of the site and have canopy heights which are much lower than those typical of the eastern and midwestern sites since water is relatively scarce. However, there are significant water resources in the area, including Lake Bardwell. Wetlands are not a prominent feature of the project area in Texas. Most of the wetlands are small stock ponds, and some palustrine forested wetlands also occur in the region. Most of the forested wetlands are confined to riparian areas associated with ephemeral streams. Agricultural and livestock production are important in the area of the ring.

Figure 3-19

REGION OF THE PROPOSED TEXAS SITF

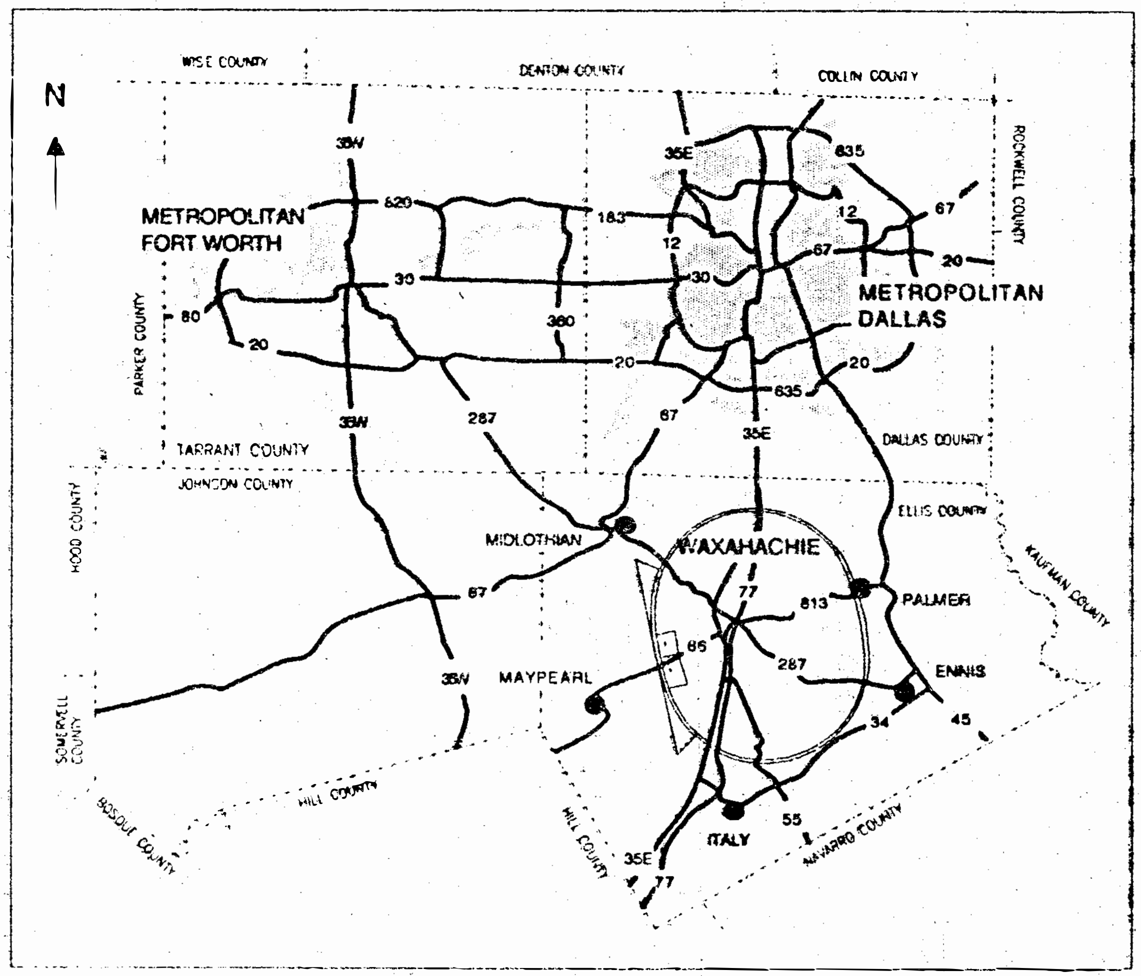
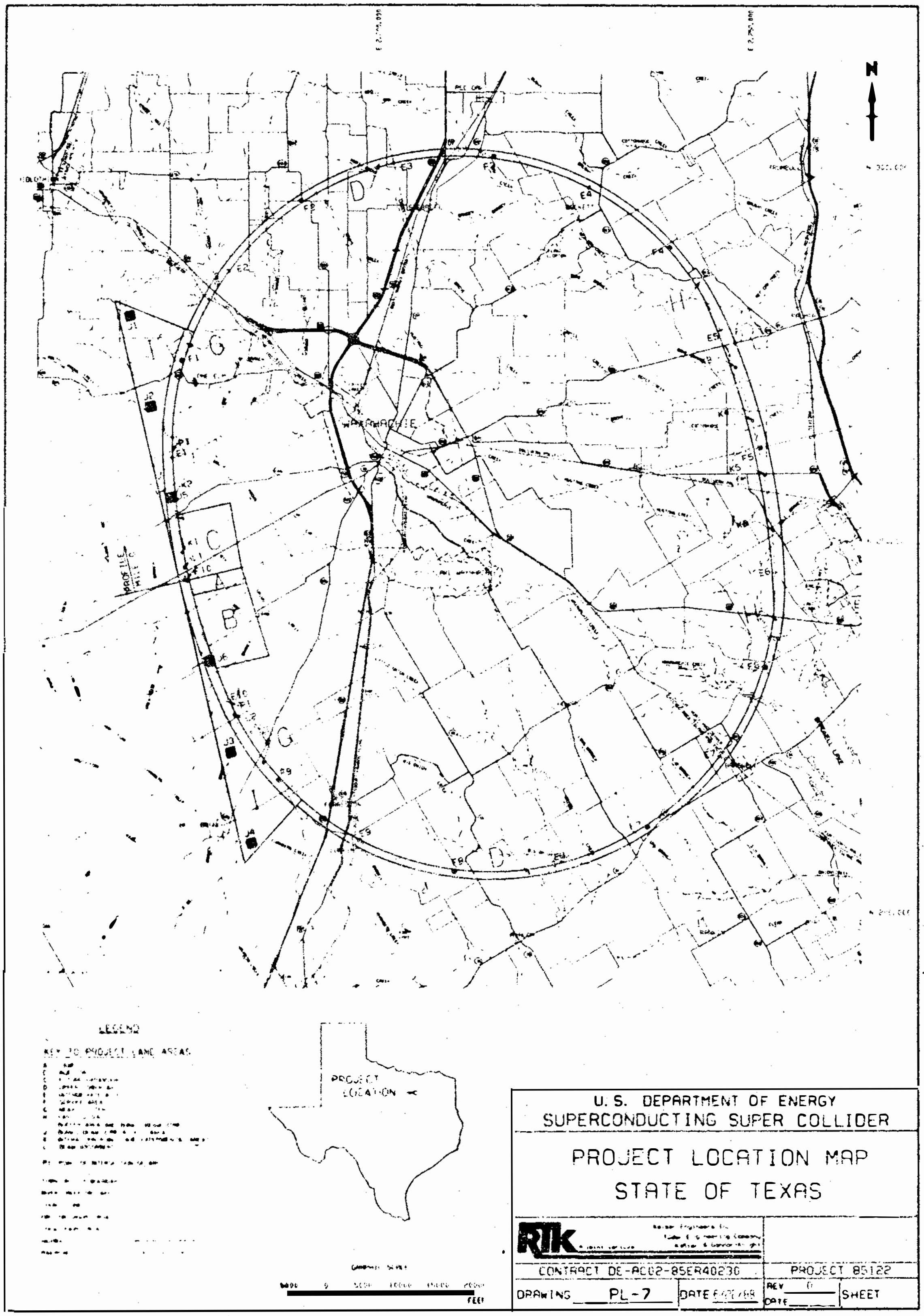


Figure 3-20

PROPOSED TEXAS SITE



There are no proposed site adaptations to the technical or conventional designs (see Table 3-3). Few additional facilities in infrastructure are proposed (see Tables 3-3 and 3-4). About 30 mi of new road and 23 mi of road upgrades are proposed.

Existing municipal water supply facilities are proposed to support the SSC campus and far cluster. These systems have sufficient excess capacity to support project needs. Remote service areas will be supplied by new wells. Sewage will be treated by an on-site plant.

The estimated bulk volume of excavated earth materials from tunnels and shafts would be about 2.6 million yd^3 and would consist of Austin chalk and marl.

The State of Texas has proposed two alternatives for the disposal of Austin chalk and two for marl. These alternatives for chalk are: 1) to sell Austin chalk to the TXI cement manufacturing company - the maximum hauling distance would be about 25 mi (there could be 288 truckloads per day to the TXI plant if six TBM's operated simultaneously); 2) to use Austin chalk for road construction. Marl disposal alternatives are: 1) to dispose of marl in four quarries, or 2) to dispose of marl at new landfills close to shafts.

Approximately 95 percent of the proposed site is currently in private ownership (see Tables 3-5 and 3-6). There are 318 parcels; 175 relocations are anticipated.

3.5 COMPARISON OF IMPACTS AMONG SITE ALTERNATIVES

The impacts of constructing and operating the SSC have been evaluated for each of the seven site alternatives. The detailed analysis of impacts is presented by the type of resource affected, by state, in Chapter 5. The comparison of impacts to resources among sites is summarized in Table 3-7. A preliminary decommissioning plan and order of magnitude cost estimate is given in Volume IV, Appendix 3.

There would be both temporary impacts and irreversible and irretrievable adverse impacts from constructing and operating the SSC at any of the site alternatives. These impacts were estimated assuming that mitigations summarized in Section 3.6 as design-controlled or DOE-committed would be applied. Cumulative impacts which would result from implementing the SSC are discussed below. See Section 5.2 for a more detailed discussion of cumulative impacts.

Natural and depletable resources would be consumed in the construction and operations of the SSC. These resources include sand; gravel; aggregate; derived materials such as cement, gypsum, glass, steel; and power and water. In addition, land would be consumed in the development of the SSC. Construction materials required for the SSC technical and conventional facilities represent less than 5 percent of the annual production of the individual resources (see Section 5.6). Table 3-8 summarizes the impacts of SSC-related consumption of natural and depletable resources.

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Table 3-7

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Loss of oil and gas wells	0	<20[1]	0	<10[18]	0	0	0
Loss of metallic resources	Uneconomic	None	None	None	Uneconomic	Uneconomic	None
Loss of quarries	0	0	0-2[19]	0-2[2]	0-2[17]	0	0
Water supply	Groundwater supply: may initiate local overdraft	Groundwater supply: purchase of groundwater now going to other uses	Groundwater supply: incremental increase to regional overdraft	Groundwater supply: incremental increase to local overdraft	Surface water supply: use of 23% of Lake Butner excess capacity	Surface water supply: use of moderate increment of excess capacity	Surface water supply: use of small increment of excess capacity
Air pollution emissions increase during operations (% increase over baseline conditions)							
CO	0.19	0.55	0.12	0.14	0.45	0.51	0.84
HC	0.04	0.17	0.03	0.04	0.10	0.08	0.29
NOx	0.06	0.14	0.10	0.13	0.04	0.30	0.10
TSP	0.12	0.33	0.41	0.30	0.65	0.29	0.61
Construction ambient noise (acres receiving a noise increase greater than 10 dBA)[3]	9,300	9,300	2,200	2,200	9,300	9,300	9,300
Number of people living in areas with a 70-75 dBA background during construction	0	5	454	62	136	55	25

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Number of people living with a 60-70 dBA background during construction	-0	3	1,246	40B	705	832	314
Number of people living in areas with a 55-60 dBA background during operations	0	3	45	24	60	24	19
Habitat loss: sensitive communities, commercial and recreational	Sonoran desert cactus loss Gila monster/ desert tortoise habitat loss: E, F, B areas where found Bighorn sheep impact-negligible	Short-grass prairie habitat loss negligible; pronghorn antelope habitat loss possible	Agriculture/ urban intensive managed land. Negligible habitat loss Intensive cultivation or urban use. Some remnant prairie loss possible	Cultivated land, some timber habitat loss	Some unique habitat loss possible	Some unusual/ relict plant and animal community loss possible; disturbance to cave system possible	Mostly cultivated; some blackland prairie loss possible
Wetlands[4]	None	4 acre (B, E1)	199 acres (Fermilab(A, B), F4, F8, F9, F10, J6)	190 acres (A, B, E1, E4 E5, F1, F9, F10, K2)	41 acres (A, B, E2, E3, F7)	38 acres (A, B, F1, K2, K5)	3 acres (A, B, K6)

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Radiation							
Increase in dose to maximally exposed individual: (% of background)							
Construction	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Operations	0.002	0.003	<0.001	0.001	<0.001	<0.001	<0.001
(% of limit 40 CFR 61)							
Construction	0	0	0	0	0	0	0
Operations	0.008	0.012	0.016	0.012	0.004	0.008	0.008
Increase in dose (% of background) to collective population due to:							
Construction	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Operations	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Increase in dose (% of background) to collective population due to low level radioactive waste transportation[5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Incremental annual dose (person rem) to each truck driver due to low level radioactive waste transportation[6]	0.499	0.338	0.560	0.640	0.835	0.665	0.575
Construction Traffic							
Injuries/yr	40	10	9.5	16	5.5	2.3	8.2
Fatalities/yr	0.6	0.2	0.1	0.2	0.1	0.1	0.2
Regional Land Use Changes	Major changes	Major changes	Few changes	Moderate changes	Moderate changes	Moderate changes	Moderate changes

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Prime & important farmlands converted for SSC use (acres)	0	819	197	341	955	606	588
Ratio of prime & important farmlands converted for SSC use to affected County inventory	0	0.0005	0.0003	0.0006	0.001	0.0014	0.0015
Scenic/visual	Regional impact[7]	Negligible[8]	Local	Local	Local	Local	Regional[7]
Historical sites	10[9]	To be Identified[10]	103[11]	3[12]	To be identified[13]	To be identified	To be identified[15]
Prehistoric/ archaeological sites	7[9]	To be identified[10]	55[11]	To be identified[12]	To be identified[13]	To be identified[14]	To be identified[15]
Number of jobs							
Direct, peak yr Construction	3,976	3,982	3,452	3,827	3,858	3,775	3,819
% increase	0.27	0.27	0.09	0.17	0.37	0.52	0.18
Indirect, peak yr Construction	5,610	6,453	7,044	5,838	5,859	5,756	5,923
% increase	0.39	0.45	0.18	0.26	0.57	0.81	0.28
Direct, first yr Operations	3,248	3,248	3,248	3,248	3,248	3,248	3,248
% increase	0.18	0.19	0.08	0.14	0.28	0.40	0.13
Indirect, first yr Operations	2,912	3,133	3,796	3,074	3,151	3,638	3,265
% increase	0.16	0.18	0.09	0.13	0.27	0.45	0.13

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Total SSC-related earnings, peak yr Construction (10^6 1988 $)	312.6	327.3	336.0	318.2	266.4	259.9	304.6
% increase	0.88	0.98	0.34	0.54	1.35	1.96	0.58
Total SSC-related earnings, first yr Operations (10^6 1988 $)	180.3	181.7	207.7	185.8	162.5	174.9	186.4
% increase	0.42	0.46	0.20	0.30	0.74	1.18	0.30
Direct SSC sales demand, peak yr Construction (10^6 1988 $)	250.4	265.6	231.4	240.8	238.2	216.2	230.4
Direct SSC sales demand, first yr Operations (10^6 1988 $)	159.1	150.4	146.8	157.4	143.5	152.2	144.5
Total SSC-related sales, peak yr Construction (10^6 1988 $)	370.5	479.8	496.5	465.0	415.2	404.2	446.7
Total SSC-related sales, first yr Operations (10^6 1988 $)	235.8	268.1	301.7	262.1	247.8	281.2	267.9
Total Population Impact, peak yr[20] Construction	13,243	8,349	9,886	6,676	15,057	14,639	9,884
% increase	0.43	0.38	0.13	0.14	0.83	1.12	0.28
Total Population Impact, first yr[20] Operations	10,486	6,299	8,250	5,293	12,960	12,691	7,961
% increase	0.29	0.26	0.11	0.11	0.65	0.93	0.20

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Housing demand, peak yr							
Construction	3,614	2,290	2,700	1,830	4,070	3,990	2,700
Housing demand, first yr							
Operations	2,459	1,520	1,950	1,260	2,870	2,970	1,880
School enrollments, peak yr							
Construction	2,759	1,700	2,029	1,374	2,972	2,968	2,031
% increase	0.4	0.4	0.1	0.1	0.8	1.1	0.3
School enrollments, first yr							
Operations	2,510	1,463	2,004	1,262	2,813	3,058	1,900
% increase	0.3	0.3	0.1	0.1	0.7	0.9	0.2
Additional teachers needed, peak yr							
Construction	143	90	99	63	170	147	113
% increase	0.4	0.4	0.1	0.1	0.8	1.1	0.3
Additional teachers needed, first yr							
Operations	130	78	98	58	161	151	106
% increase	0.3	0.3	0.1	0.1	0.7	0.9	0.2
Total public employment, peak yr							
Construction	477	296	329	210	495	456	368
% increase	0.4	0.4	0.1	0.1	0.8	1.1	0.3

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Total public employment, first yr							
Operations	377	223	275	167	426	396	297
% increase	0.3	0.3	0.1	0.1	0.7	0.9	0.2
Net SSC-related changes in state government revenue peak yr							
Construction ($ million)	11.2	11.4	10.9	12.4	15.2	11.1	5.8
Net SSC-related changes in state government revenue first yr							
Operations ($ million)	4.4	4.5	6.0	4.6	8.4	5.6	3.2
Net SSC-related changes in local government finances, primary counties, peak yr							
Construction ($ million)	(21.5)	3.6	(6.1)	3.1	(1.5)	(1.4)	1.9
Net SSC-related changes in local government finances, primary counties, first yr							
Operations ($ million)	3.7	8.6	5.4	3.2	3.4	2.2	2.9
Miles 4-lane highway	15[16]	0	4	1	25	6	5
Miles 2-lane road	37[16]	92	3	7	12	4	22

Table 3-7 (Cont)

POTENTIAL IMPACTS OF CONSTRUCTING AND OPERATING THE SSC AT SITE ALTERNATIVES

Impacts	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Miles road upgrades	20	91	20	99	10	12	23
Miles 1-lane road	8	2	1	2	2	3	4
Upgrades interchanges	0	0	2	0	3	0	1
Indirect traffic increase (%)	0.4	14	1	1	3	4	3

1. Approximately 30 wells within 1 mi of ring; number affected unknown.
2. Two aggregate quarries near ring; may be affected.
3. Area of land near E and F sites that would experience an increase in ambient noise levels greater than 10 dBA.
4. The maximum acreage of wetlands that could be impacted during construction of surface facilities for the proposed action. Wetlands occurring within Area C, the J sites, and sites K3 and K4 are not considered here because these sites are future expansion areas and may not be developed (see Section 3.7.3).
5. Assumes that low level radioactive wastes would be transported to Richland, Washington.
6. Assumes 2 truck drivers with 12 trips per year to Richland, Washington.
7. Arizona: Due to impacts on regionally important resources. Texas: All are local impacts except one. Views from a regionally important recreational lake may be affected.
8. Because of the very low population density in the Colorado site area, few people would view project facilities.
9. Cultural resource surveys of the Arizona site may have been completed in known impact areas. Other sites may be found in ancillary activity/construction areas. Evaluations of known sites are not completed.
10. Historic and prehistoric/archaeological surveys have not been performed at the Colorado site. However, sites are anticipated, particularly along drainage channels.
11. Known sites based on surveys to date at Illinois site. Further surveys to be performed. Additional sites are anticipated.
12. Prehistoric/archaeological surveys have not been performed at the Michigan site. However, numerous sites are anticipated, particularly in upland and wetland locations.
13. Historic and prehistoric/archaeological surveys have not been performed at the North Carolina site. However, sites may be encountered.
14. Historic and prehistoric/archaeological surveys have not been performed at the Tennessee site. However, sites may be encountered.
15. Historic and prehistoric/archaeological surveys have not been performed at the Texas site. However, sites may be encountered.
16. Road impacts for Arizona are based on an alternative road plan as discussed in Volume I, Chapter 5.
17. Two proposed rock quarries near ring; may be affected.
18. Approximately 25 wells within 1 mi of ring; number affected unknown.
19. Two rock quarries near ring; may be affected.
20. Numbers include natural increase and in-migration.

Sources: Arizona Department of Mines and Mineral Resources 1984; Garner 1988; Manhardt 1988; McHugh 1988; Michigan Department of Natural Resources 1987; Michigan Oil and Gas Commission 1988; Peterson et al. 1985; Petroleum Information Corp. 1988; Reid 1988; State of Colorado 1988; U.S. Bureau of Mines 1988; Witcher et al. 1979.

Table 3-8

NATURAL AND DEPLETABLE RESOURCES IRREVERSIBLY COMMITTED FOR SSC CONSTRUCTION AND OPERATIONS

Resource	Construction* (quantity, units)	Operations* (quantity, units)
Technical Facilities		
Low-carbon steel	44,000 tons	--
Stainless steel	>15,000 tons	--
Copper	<1,000 tons	--
Iron	100,000 tons	--
Niobium	500 tons/yr	--
Titanium	500 tons/yr	--
Helium	60 million ft^3(std)	14 million ft^3(std)
Conventional Facilities		
Steel, including rebar	30,000 tons	--
Cement	100,000 tons	--
Sand	100,000 yd^3	--
Gravel (Roads and Concrete)	600,000 yd^3	--
Fill, stone bedding	200,000 yd^3	--
Wood forms	1 million board ft	--
Concrete pipe, blocks	500,000 tons	--
Glass	100,000 ft^2	--
Water		
Industrial	266 acre-ft	1,775 acre-ft/yr
Potable	77 acre-ft	400 acre-ft/yr
Land		
Disturbed (Facilities and Infrastructure)**	494 - 3,395 acres	227 - 1,327 acres
DOE Title (Fee simple and stratified fee)	15,830 acres	15,830 acres
Energy		
Electric power	42.6 x 10^6 kWh	888 x 10^6 kWh/yr
Natural gas	--	55 MBtu/h

* The quantities listed are order-of-magnitude estimates of major construction and operations resources. These estimates are based on a conceptual design at a generic site with assumed geology, topography, and infrastructure.

** For site specific details, see Table 3-2.

3.6 MITIGATIONS

The flexibility of the SSC design includes the actual placement of the ring footprint, the placement of shafts (and the angle shift from vertical), and the placement of surface facilities. The flexibility associated with proposed sites is one of the site selection criteria, specifically the third subcriterion of "setting." (See Volume III, Chapter 3). The flexibility of the design and the site together provide the major mechanisms for mitigating impacts of the SSC construction and operations. Therefore, the flexibility of the design and the flexibility of the seven site alternatives are discussed within this section addressing mitigations. Alternative site-specific mitigations will be addressed in the Supplemental EIS.

Four types of mitigations have been discussed and assessed in this EIS. The first type includes design and site flexibilities. The second type includes controlled elements that have been included in the conceptual design of the project or in the state proposal for the purpose of reducing the impacts of implementing the proposed project. The third type includes those which would be required of the DOE during project implementation. The DOE is committed to these mitigations either because they are required by policy, statute, or regulation or because they would substantially reduce an adverse impact of large magnitude. The fourth type includes those which could be, but are not required to be, developed during final project design to reduce the anticipated adverse impacts of the project. These types of mitigations are identified in Chapter 5 in response to the identification of adverse impacts that would trigger the need for them. These mitigations may or may not be feasible or even desirable, depending on the final project design. Whether these mitigations could be applied to the SSC project will depend on the selected site, final location and design of facilities, and final design-phase consultations with Federal, State, and local agencies.

3.6.1 Design and Site Flexibilities

The conceptual design of the SSC is presented in the Conceptual Design Report and is the basis of the ISP. The flexibility of each site alternative is summarized in Volume III, Chapter 3.

3.6.1.1 <u>Design Flexibility</u>

The CDR describes a flexible SSC concept with nominal design criteria. These criteria were derived from the requirements of the technical systems.

Both flexibility in setting the boundaries of the final site configuration and adaptability of the SSC design to local conditions are needed to allow development of the conceptual design. The considerations of flexibility and adaptability are important to optimize the design to the characteristics of the particular site and to allow mitigation by avoidance of wetlands, floodplains, etc.

A. Flexibility in Ring Orientation

There is no preferred orientation for the overall ring that is determined by the physics of the design. It is preferred that the collider ring be located in a horizontal plane. There is flexibility such that the tunnel can be tilted if a more effective overall configuration is thereby achieved. However, the amount of tilt from the horizontal must not exceed 0.5 degree.

B. Flexibility in Tunnel Depth

There is great flexibility in tunnel depth since the best overall depth is determined by the topography and the geologic strata along the alignment of the collider tunnel. It is desirable that the experimental facilities be near the surface to provide convenient and economical access for heavy experimental equipment. Consideration needs to be given to shaft depths around the ring since they influence the construction cost and schedule as well as operational efficiency. As a practical matter, it is desirable that shaft depths be no more than several hundred feet.

The accelerators that make up the injection system will be buried underground with a minimum of 15 ft of soil above them due to radiological shielding design constraints. It is desirable to maintain a minimum vertical separation of 20 ft between the high energy booster and the collider to facilitate access to one machine while the other is running.

C. Flexibility in Planar Configuration

The preferred collider ring configuration lies in a horizontal plane. There is some flexibility from a horizontal planar configuration which is technically possible. For example, the collider ring tunnel may follow a gentle undulation of a certain geological layer, or it may follow a gentle terrain to enable cut-and-cover construction. However, these lead to complications in construction, installation, and operation.

To position the experimental halls near the surface, upward folding of the collider ring in the arcs may be desirable. An example of an upward fold configuration is given in the CDR. Design constraints are: 1) the radius of curvature out of the collider plane should not, in general, be less than about 1 million ft, with no local slope larger than 0.5 degree; 2) such curvatures out of the collider plane may occur only in the arc regions.

E. Flexibility in Land Requirements

Land areas to satisfy the previously described considerations are summarized in Table 3-1 and described in detail in Appendix 4 along with summaries of the states' proposed acquisition plans.

Infrastructure developments are summarized in Table 3-4. A road network will be needed in the campus, injector, and experimental areas, as well as to connect the cluster regions and to provide access to the service areas and access points around the 53-mi ring. Existing roads will be utilized as much as practicable. In addition to easements for bringing utilities on site, distribution to the service areas around the ring will be needed. Distribution could be within existing easements or may require new easements. Depending on the construction methods and site characteristics, off-site locations for disposal of the spoils excavated during tunneling will be needed.

There is flexibility in infrastructure requirements. For example, in both the arc and cluster regions, it should be possible to continue to use existing roads, railroads, and utility easements as long as they do not interfere with the construction or use of SSC surface buildings or the operation of the SSC. Because colliding-beam research depends on two small beams accurately hitting each other head-on for many hours, stability of operation is important. Vibration from railroads, highways, quarries, or heavy equipment could be disruptive. A design constraint is that a railroad line should not pass within approximately 3,000 ft of an interaction point and that major public roads should be no closer than about 600 ft from an interaction point.

Unconditional fee simple title is required for all areas listed in Table 3-5, except possibly Areas D and I. For those regions of the arcs in which the center of the tunnel is 50 ft or more below the surface, a stratified fee estate for a strip with a cross section 70 ft by 1,000 ft is sufficient. Although obtaining the abort/external beam areas (Areas I) in unconditional fee simple would be advantageous and give the most flexibility, a stratified fee estate with vertical height 70 ft (35 ft above and below the collider ring center line) is acceptable in those areas with at least a 15-ft separation between the ground surface and the top of the stratified estate.

On proposed Federally-owned land, the DOE must have complete administrative control of those areas identified as requiring unconditional fee simple title. Wherever the requirement for a stratified estate has been identified, a permit or use agreement from the Federal holding agency may be acceptable. Title to land owned by a lesser political subdivision must be transferred to the United States. In Areas D and I, there is flexibility which would allow third party use at the discretion of the DOE.

1. Campus (Area A) The campus area would be facility headquarters. Because of the focus of technical activity on the injector complex, it would be convenient to have the campus in a nearby location. The exact shape is totally flexible.

The campus layout, including the building locations shown in Figure 3-2, has been conceptualized in an efficient arrangement. Other arrangements are possible. The general terrain of the site and the location of existing towns, utility runs, and transportation services would have a major effect upon the shape, extent, and layout of the campus facilities. If required, the campus could even be located within the high energy booster ring, although that may impose growth limitations and should only be implemented after careful consideration.

2. Injector (Area B) Two straight section areas in one of the clusters are set aside for use as injection and beam absorber positions. The injector is near these two sections so that the proton beams can be introduced into the two rings of magnets. Given that the external beams and beam absorbers should be located to the outside of the ring, it is preferable that the injector complex be inside the ring to avoid interference. If the land for the proposed site is better utilized by having the injector on the outside of the ring, the design has this flexibility.

3. Future Expansion (Area C) This area is allowed for future expansion, and it would be advantageous if Areas A, B, and C formed a contiguous block; however flexibility is great in this area (See Chapter 3, Section 3.1.6).

4. Upper and Lower Collider Arcs (Areas D) The 1,000-ft width of the arc regions is set by construction and operation requirements and the need for flexibility of final adjustments of the circumference of the collider ring. For any regions in which cut-and-cover is used to construct the tunnel, construction easements would be necessary for those areas in which the DOE does not have the surface fee title.

5. Intermediate Access and Service Areas (Areas E and F) Points of access to the collider ring are required at 2.5-mi intervals. The service areas (Areas F) are required for supplying cryogenic cooling systems to the magnets and are located at approximately 5-mi intervals around the ring. The intermediate access areas (Areas E) are located midway between the service areas. Since the arrangement of the collider systems is precise, there is no significant flexibility below grade. However, the access shafts can be offset and the surface building locations adjusted. In this manner, these areas could be moved horizontally by a few hundred feet at the surface to avoid local features.

6. Near and Far Clusters (Areas G and H) These areas connect the upper and lower arcs and provide space for the experimental areas as well as the injection and extraction points on the collider ring. The width is primarily set by the need to attenuate muons produced along the tangent directions at the interaction regions. In addition, space for a beam-bypass region has been added along the inside of the far cluster. This

allows the possibility of adding at some future time a bypass to provide additional flexibility in the mode of operation of the experimental detectors. The beam bypass itself would essentially parallel the beam line with a horizontal separation between the two tunnels of about 300 ft.

7. <u>Abort/External Beam Areas (Areas I)</u> These areas are located to the outside of the near cluster (the side containing the injection region). For beam tune-up, at the end of a colliding beam cycle, or in case of power or equipment failure, the beams are quickly extracted and conveyed to special beam absorbers. Intense beams of noninteracting muons are produced at small angles, and the abort/external beam areas provide the shielding necessary to attenuate the muons. In addition, space is provided for the production of high energy beams to test components for the SSC detectors. Depending on the discoveries made at the SSC and elsewhere, it might prove desirable to upgrade these external beams in order to interact high energy beams of mesons and other particles with various target nuclei at rest in the laboratory. The areas shown allow for this possibility. Figure 3-3 shows the preferred arrangement in which Areas I are attached to the same cluster as the injector. If absolutely necessary to mitigate prevailing site conditions, these two areas could be in opposite clusters.

8. <u>Abort/External Beam Access (Areas J)</u> These areas are located as shown in Figure 3-3. As is the case for the service areas (Areas F), these areas could move horizontally several hundred feet from the positions shown and would need road access and utility easements. Although six J areas are shown, it is probable that surface structures will be built at only two of the sites, one in the J1, J2, J3 group, and one in the J-4, J-5, J-6 group.

3.6.1.2 <u>Site Flexibilities</u>

Each of the seven site alternatives has some amount of flexibility associated with the placement of the entire ring footprint and with placement of specific surface facilities. These can be summarized for each state as follows:

- Arizona - Most surface facilities could be adjusted within the design constraints; additional land can be made available; shifting the entire ring is constrained by natural features.
- Colorado - No site limitations to flexibility of either specific facilities or shifts of the ring beyond design constraints.
- Illinois - Within the Federally-owned lands, flexibility is limited only by Fermilab developments; surface facilities flexibility is limited by the density of residences, businesses and other man-made features; shifting the entire ring is constrained by these features as well.

- o Michigan - Most proposed surface facilities could be adjusted within design constraints; shifting the entire ring is constrained by man-made features.

- o North Carolina - Great local flexibility; shifts of local facilities and A/B/C limited to the west only.

- o Tennessee - No site limitations to flexibility of either specific facilities or shifts of the ring beyond design constraints.

- o Texas - No site limitations locally at surface facilities; entire ring shifts limited by Lake Bardwell and Town of Ennis.

DOE will use, as its preferred mitigation, moving the location of a facility, shaft, etc, within the design and site flexibilities available. These flexibilities would allow many impacts to be mitigated by avoidance. During the site-specific conceptual design and preparation of the Supplemental EIS, the SSC surface facilities, shafts, and ancillary facilities would be analyzed in more detail for the selected site. The location of facilities would be selected to minimize impacts to floodplains, wetlands, sensitive habitats, and other important man-made or natural features of the site.

3.6.2 Design-Controlled Elements of the Proposed Project

- o Surface water runoff and erosion control - The SSC project would be designed for protection of cut-and-cover construction activities with a berm to protect the excavation from runoff and erosion where necessary.

- o Effluent water quality - The conceptual design for the SSC project assumes that tertiary treatment is provided at on-site sewage treatment plants. Such plants would be subject to the requirements of a National Pollutant Discharge Elimination System (NPDES) permit.

- o Disposal of spoils - Where surface disposal of spoils was not proposed, spoils disposal impacts would be reduced either by placing the spoils in abandoned quarries or mines or by providing a mechanism for use or sale of the spoils as aggregate.

- o Accidents and hazardous exposure to workers - Protective and emergency equipment would be provided at all facilities. Areas of potential exposure to unacceptable levels of radiological exposure would be shielded.

- o Public radiation exposures - The SSC project would be designed to limit radiation exposure to the general public to levels as low as reasonably achievable (ALARA). Features of the conceptual design which limit radiation exposure include: placing the collider in an underground tunnel, controlling subsurface activities in stratified fee areas, acquiring fee simple lands around the interaction regions in order to control access, designing the beam absorbers and machine controls, and providing for a modular beam absorber that can be removed at decommissioning without disassembly.

3.6.3 DOE-Committed Mitigations

- Occupational health and safety - Worker safety procedures would be instituted and use of protective equipment would be required. A site occupational health and safety officer would require appropriate safety training for employees and enforce compliance with all site regulations, standards, and procedures relating to worker safety.

- Disturbance of unforeseen archeological resources - Surveys, monitoring, and recovery would continue into the construction phase in consultation with the Advisory Council on Historic Preservation and SHPO at the respective sites.

- Air quality - Fugitive dust emissions from construction would be controlled by the application of dust suppressants and paving, if necessary.

- Floodplain encroachment - To the extent practicable, the DOE would avoid placing facilities in the floodplains by changes in building layout or by relocating the facility to nearby higher areas. Where there are no practicable alternatives, facilities in floodplains would be designed to minimize potential harm to and from the floodplain.

- Wetlands damage and loss - It is DOE policy in accordance with Executive Order 11990 to avoid wetland impacts to the maximum extent practicable. Restoration/replacement of lost or impacted wetlands would be implemented after consultation with the COE, or delegated authorities in compliance with Section 404 of the Clean Water Act and the USFWS.

- Compliance with Arizona Native Plant Law - Notify the Commission of Agriculture and Horticulture 30 days in advance of site disturbance to allow the opportunity to salvage cacti and other protected plants. As a means of reducing impacts of the project, commit to mitigating disturbed Sonoran Desert Scrub habitat by collecting all cacti and other protected plants and restoring and revegetating areas not permanently disturbed.

- Threatened and endangered species

  - State would mitigate new road construction in Colorado in consultation with USFWS to mitigate disturbance of bald eagles at Barr Lake and to avoid wetlands/floodplains in road placement to the maximum extent practicable.

- Design considerations would be made toward use of water at Colorado site from a combination of Morgan County wells and/or Colorado-Big Thomson water to prevent effects on flows and water levels in both the Colorado basin and the South Platte river system.

- Sedimentation ponds/control of runoff would be used as necessary to prevent effects on the endangered tan riffle shell mussel and on the Duck River system in Tennessee.

- Design/preconstruction confirmation studies would be required to prevent hydraulic effects on caves (e.g., Snail Shell Cave) in Tennessee or hydraulic connections would be required to prevent impact on the endangered gray bat.

- Investigation of the Snail Cave system with respect to the proposed tunnel, shaft and surface facilities would be conducted and mitigations needed to protect any identified protected species developed.

Surveys for presence of tumamoc globeberry in Arizona, black-capped vireo habitat in Texas, black-footed ferret in Colorado, prairie bush clover and lakeside daisy in Illinois, Indiana bat in Illinois, Michigan, and Tennessee, harperella in North Carolina, and Tennessee purple coneflower, grey bat, and tan riffle shell mussel in Tennessee would be required to avoid potential impacts to endangered species.

3.6.4 Possible Mitigations to Further Reduce Adverse Impacts

- Loss of oil and gas reserves - Slant drilling could be used to tap the reserves.

- Runoff and erosion control - Drainage from the site during construction and operations could be controlled by appropriately sized retention structures that would control and trap sediments from surface runoff and erosion and control flow from the site to stream channels.

- Surface water supply - An additional source of water for the SSC project and surrounding communities would be the Fox River (Illinois) or Lake Michigan (Michigan).

- Surface water quality - Drainage from the site during construction and operations could be controlled by appropriately sized retention structures that would control and trap sediments from surface runoff and erosion.

- Ground water supply - Loss of wells at the various sites can be partially mitigated by replacement wells or hookups to alternative supply sources.

- o Air quality - Fugitive dust emissions from construction could be further controlled by wind screens, enclosures, construction scheduling, or the addition of particulate removal equipment.

- o Noise impacts on people - Spoils hauls could be limited to 12 hours per day. Construction of facilities near residences, schools, and other public institutions could be limited to 16 hours per day. Cut-and-cover tunnel construction could be limited to 16 hours per day. Road construction could be limited to daytime hours. Trucks hauling spoils could be subject to muffler inspections and truck routes could be specified. Certain E and F areas could be bermed to provide a noise screen; and facilities in the E and F areas that produce noise could be provided with acoustic treatment to reduce these noise sources. Such treatments for an F area could be a quiet cooling tower design, an enclosure for the emergency generator, individual enclosures for compressors, providing nitrogen relief valves with silencers, locating cryogenic pipelines in trenches, placing service areas partly below grade or surrounding them with a berm, rearranging site layout to put noise sources in the interior, or providing more land for a buffer zone around an area. Similar treatments could be used at the near and far clusters.

Potential additional mitigation techniques that would be considered during detail design and construction planning could include the following:

The use of quieted construction equipment, use of atmospheric sounding techniques to avoid loud sounds such as blasting when conditions are conducive to atmospheric focussing of sound; inclusion of state-of-the-art noise control materials and techniques in the design of machinery buildings and equipment enclosures; require contractors responsible for design to use verified and validated sound-emission models to identify equipment that would represent a potential noise impact if not subjected to special quieting techniques; require designers and contractors to specify available quiet machinery and components in conjunction with the results of the modeling described above; enforce negative incentives for vendors of service area systems and components, with price penalties for vendors who fail to provide equipment that meets, and continues to meet, DOE system design requirements for sound emission limits.

- o Threatened and endangered species - As an option to survey for habitat, commit to locate and protect riparian habitat with suitable large-diameter trees with sloughing bark by prohibiting cutting and trimming and providing a 100-ft buffer zone around the habitat to prevent effects on the endangered Indiana bat in Illinois, Michigan, and Tennessee. Survey habitat and confirm populations in all areas which could be surface disturbed in Arizona for night-blooming cereus and desert tortoise; develop mitigative plan in conjunction with USFWS, BLM, and Arizona State agencies.

- State-listed species - Consult with states to discuss respective needs for survey/mitigation of State-Listed Species.

- State champion tree - Consult with the State of Michigan to mitigate or avoid effects on the champion pignut hickory tree during preconstruction design planning phase.

- Cedar glades - Survey locations of sensitive cedar glade habitats. Reposition facilities where possible to avoid these habitats.

- Blasting and vibrations - Annoyance of the public and vibrations of adjacent structures as a result of blasting could be mitigated by limiting the charge weight, pre- and postblasting surveys of structures to identify damage, limiting blasting hours, reducing initial charges, and using blast mats.

- Occupational health and safety - To reduce the risk of valley fever to construction workers at the Arizona site, the following mitigations could be implemented: minimizing soil disturbance, confining soil disturbance to low wind periods, application of dust suppressants, imposing contractor restrictions on dust generations, and requiring workers to wear respirators in a high dust environment.

  To reduce the risk of imported fire ant attacks on construction workers at the Texas site, the following mitigations could be implemented: application of an insecticide control program, minimizing disturbance of fire ant mounds in construction areas, training workers to use special procedures when performing manual work tasks in infested areas, and identifying individuals sensitive to the fire ant venom.

  To reduce worker exposure to radionuclides, the following mitigations could be implemented: providing a lining in the tunnel and other underground areas to reduce radon diffusion into the tunnel and maintaining a positive gas pressure in tunnel and other underground areas.

- Vehicle/public safety - Route truck traffic away from areas of highest risk of accident.

- Traffic disruption during ancillary facility construction - Disruption could be reduced or avoided by construction scheduling, detours, flagmen, and construction of bypass roads.

- Rail service interruptions - High impact rail service interruptions could be mitigated during construction by constructing grade separations for road traffic to cross over the rail line.

- Spoils disposal truck traffic - Impacts could potentially be mitigated by the following: the use of State highways instead of local roads; direction of traffic away from residences and schools; use of traffic controls and speed limits; and the development of off-peak oriented disposal schedules to avoid normal urban congestion.

- Traffic due to commuting workers - Congestion during peak worker commute hours could be reduced by encouraging car pooling, providing for buses, staggering shifts, and widening access roads.

- Loss of paleontological resources - Monitoring of construction activities and recovery of affected resources.

- Scenic and visual impacts - Visual impacts could be lessened by adjustments in siting, by design of access shaft areas and services areas, architectural treatment and coloring of structures to blend with the background, planting vegetation, and constructing berms to screen facilities.

- Land use - Agricultural lands not used for project activities could be leased back for activities that would not conflict with project operations.

- Spoils disposal - Spoils could be used for roads and parking lots.

- Disruption of animal movement and migration - Provisions could be incorporated into final design that would allow for animal movement and migration, e.g., specially designed fences could be used for restriction of human access in areas of bighorn sheep, desert tortoise, and pronghorn antelope habitats. Attention would be given in such cases to use appropriate fencing and locate it to avoid direct adverse impacts to wildlife from the fencing itself.

- Noise impacts on bighorn sheep (Arizona only) - Mitigations suggested to lessen noise annoyances to bighorn sheep could simultaneously act to mitigate overall negative impacts to the species. For example, construction, which would result in some noise and disturbance could be scheduled to avoid the rutting and lambing season. Where noise may cause bighorn sheep to avoid traditional water sources, mitigation measures, such as providing alternative water sources, would be taken. In such cases, efforts could be made to reduce adverse impacts to wildlife use of these water supplies by human activities.

3.6.5 Cost of Mitigation

In general, it would be feasible to mitigate the impacts of construction and operations of the SSC (see Table of Potential Impacts, Table 3-7). The costs of mitigation, however, cannot be accurately estimated based on the site adaptations of the conceptual designs. This uncertainty is largely due to the flexibility of the SSC design (see Section 3.6.1.1) and of the proposed sites (see Section 3.6.1.2).

Cost of mitigations can be relatively assessed based on the conceptual design and site-specific adaptations presented in Section 3.1 (also see Volume IV, Appendix 1). The primary mechanism of mitigations, especially for wetlands and floodplains, is avoidance. Consistent with Executive Orders 11988 and 11990, it is DOE policy to avoid wetlands and floodplains unless there is no practical alternative. Avoidance, often, is a cost-saving measure as well as a mitigation. This is particularly the case when avoidance not only serves as a mitigation but also minimizes wetlands or other resource replacement costs.

Until the site-specific conceptual design is prepared, it is not possible to approximate mitigation costs. The cost of total (among the various impacted resources (e.g., air quality, scenic and visual . resources, ecological, etc.) mitigations of significant impacts are expected to be relatively small compared to the overall project, or even solely compared to the construction costs. The life cycle costs at each of the seven site alternatives are similar (± 5 percent). The mitigations which might be required at any site are similar from the cost standpoint and, although mitigation costs have not been yet available in detail, the differences in mitigation costs between site alternatives are estimated to be a small fraction of the uncertainty in the overall SSC cost estimate. Order-of-magnitude cost estimates for mitigations at the selected site will be included in the Supplemental EIS.

3.6.6 Impacts of Mitigation

During the site-specific conceptual design and final design phases, mitigation alternatives would be optimized, and costs estimates increasingly refined from order-of-magnitude to quantitative (± 5 percent). However, in addition to costs, the potential impacts of alternative mitigations must be considered. A mitigation which might be feasible and cost effective for one problem might also cause increased impacts in another area.

For example, some mitigations of the noise of compressors in the service areas (F areas) might be effective for noise abatement but would increase scenic and visual impacts. Trade-off studies will be conducted to evaluate the set of mitigations appropriate for the selected site which would minimize total adverse project impacts. Based on the data available, it is believed that mitigations would include:

- Avoidance (e.g. wetlands, floodplains) by facility relocation within the design and site flexibility.
- Placement of facilities, e.g., placing cooling towers in the center of service areas (F areas)
- Blending of surface facilities with natural landscape and local architectural features.
- Dust suppression.
- Recycling of spoils for usable constituents.
- Selection of HVAC emphasizing solar or wind technologies for power and utilization of waste heat.
- Recycling cooling waters and on-site treatment of water with reuse of treated water for industrial water applications.
- Waste minimization program.
- Minimization of habitat disturbance.
- Careful data recovery and preservation of maximum number of cultural and paleontological finds.

These mitigations are expected to be complementary at most sites and specific areas. Total mitigations will be evaluated for the selected site and will be included in the Supplemental EIS.

3.7 SUMMARY OF CUMULATIVE IMPACTS

3.7.1 Proposed Action

3.7.1.1 Regional Population Growth

The SSC-related regional population growth ranges from 0.13 percent to 1.12 percent based on population projections in each region without the proposed project.

Site	Regional Population Growth
Arizona	0.43%
Colorado	0.38%
Illinois	0.13%
Michigan	0.14%
North Carolina	0.83%
Tennessee	1.12%
Texas	0.28%

The projected growth is relatively small compared to the total population projections for each region. Impacts to the States of North Carolina, with an increase of approximately 15,000, and Tennessee, with a population increase of 14,000, would be highest during construction, with a lesser impact during operations.

In addition, the SSC-related housing unit demand for each of the sites varies from 1,830 to 4,070 units.

Site	Housing Unit Demand
Arizona	3,610
Colorado	2,290
Illinois	2,700
Michigan	1,830
North Carolina	4,070
Tennessee	3,990
Texas	2,700

Local impacts due to the implementation of this project are possible in the housing markets in Fort Morgan and Brush in Morgan County, Colorado, and the village of Stockbridge in Ingham County, Michigan, based on the existing housing market.

3.7.1.2 Construction Materials

Approximately 1.3 to 1.8 million tons of high quality aggregate would be consumed by construction of the SSC project. All sites have abundant aggregate resources with the exception of Colorado. This is due to the rapid past expansion of the Denver area and the projected future growth. Transportation of such materials from outside the region may be required.

3.7.1.3 Water Supply

The proposed SSC project would create an increased demand on water resources, both from direct project requirements and from indirect domestic water requirements due to regional population growth supporting the SSC project. Table 3-9 summarizes the potential impacts to water sources.

3.7.1.4 Air Quality

The contributions of the SSC to air emissions include particulates from construction activities and emission of combustion products from construction equipment, from vehicles of construction/operations workers, and from a proportional increase in the number of vehicles operating in the region due to in-migration. The increase in air pollutant emissions from the SSC relative to existing emissions ranges between 0.10 percent

Table 3-9

POTENTIAL IMPACTS TO WATER SOURCES

Site	Water Source	Potential Impacts
Arizona	Groundwater	Overdraft is possible depending on the extent of other uses of aquifer.
Colorado	Partially met by purchase of existing surface and ground-water allocations	Change in water use pattern due to purchase of existing water rights
Illinois	Groundwater	Indirect SSC water requirements will incrementally increase existing regional groundwater overdraft.
Michigan	Groundwater	Both direct and indirect SSC water requirements could contribute to localized groundwater overdraft.
North Carolina	Surface water	SSC operations would use about 23% of the available excess capacity of Lake Butner.
Tennessee	Surface water/ minor groundwater	Direct and indirect water requirements would be provided by local small to moderately sized municipal water supply systems. Project requirements would use up to 22% of the available excess capacity in Rutherford County (supplies up to 1/3 of water requirements)
Texas	Surface water/ groundwater	Direct and indirect water requirements would be a small increment to existing regional groundwater overdraft.

and 4.2 percent for the construction phase and between less than 0.10 percent and 0.84 percent for the operations phases. This increase in emissions is not expected to cause National Ambient Air Quality Standards (NAAQS) exceedances in any of the BQL states.

The Illinois, Michigan, and Tennessee sites are within regions designated as nonattainment for ozone. Increases in pollutant emissions may result in further degradation in air quality.

Much of the existing Ambient Air Quality Data used in this EIS was obtained from regional air monitoring stations and may not represent SSC site conditions. In several states the carbon monoxide NAAQS appears to be exceeded due to the SSC. Representative background carbon monoxide concentrations (existing levels from man-made and natural sources) are expected to be well below NAAQS limits. The SSC-related contributions to background are not expected to result in a violation of the carbon monoxide NAAQS.

3.7.1.5 Radiation

Impacts from radiation produced at the SSC on the total population are small compared to existing background (typically 0.007 person-rem/yr from the SSC as compared to 11,000 person-rem/yr for background). They thus contribute cumulatively to adverse genetic and carcinogenic effects at a level about 0.00006 percent of that which would be caused by background radiation.

3.7.1.6 Noise

Impacts from noise generated during SSC construction and operations would be limited to the areas adjacent to the project facilities. SSC impacts on local residents would be most pronounced adjacent to service and intermediate areas unless mitigated.

3.7.1.7 Wetlands

At all proposed sites except Arizona, construction of the SSC could disturb or displace wetlands habitats (See Table 3-10). Such impacts would be an incremental addition to the regional rate of wetlands degradation and conversion occurring as a result of agricultural drainage and/or rural/suburban development.

It is DOE policy to avoid and mitigate impacts to wetlands to the full extent practicable. Under Executive Order 11990, "Protection of Wetlands, "and DOE's regulations for compliance with floodplain/wetlands environmental review requirements (10 CFR Part 1022), the potential adverse effects on wetlands at the various alternative sites (Table 3-16) would be substantially minimized through mitigation.

Mitigation measures could include wetland avoidance, enhancement, or replacement. Compliance with Section 404 permitting requirements under the Clean Water Act will be accomplished, as required, with U.S. Army Corps of Engineers' coordination.

Table 3-10

IMPACTS OF SURFACE CONSTRUCTION ON WETLANDS AT THE SSC SITE ALTERNATIVE LOCATIONS

Site	Wetlands[1] (Acres)	Surface Construction Areas[2]
Arizona	0	-
Colorado	4	B, E1
Illinois	199	Fermilab (A, B), F4, F8, F9, F10
Michigan	190	A, B, E1, E4, E5, F1, F9, F10, K2
North Carolina	41	A, B, E2, E3, F7
Tennessee	38	A, B, F1, K2, K6
Texas	3	A, B, K6

1. The maximum acreage of wetlands that could be impacted during construction of the surface facilities.

2. Acreages of wetlands within future expansion areas (area C, the J sites, and sites K3 and K4) were estimated although the percentage of these areas to be developed is undetermined. These total estimates are presented in Chapter 5, Section 5.1.5.3 and Appendix 11. Also see Section 3.7.3.

These actions serve to minimize the cumulative impacts of this project with others locally and nationally.

3.7.1.8 Prairies

Only the sites in Illinois and Texas have prairie remnants. In both cases, the incremental additions of the SSC project to regional impacts on prairie remnants would be limited to secondary impacts due to induced population growth.

3.7.1.9 Cedar Glades

Only the region in the vicinity of the Tennessee site has cedar glades. Approximately 22 percent of the forested land near the Tennessee site contains red cedar with several glades in the vicinity of the proposed site. None of those known glades would be impacted by the project;

however, there could be some secondary impacts from construction. These impacts are incremental additions to other regional impacts (tree harvesting and stock grazing) on cedar glades.

3.7.1.10 Karst Ecosystems

The only proposed site with Karst ecosystems in the affected area is Tennessee. The Snail Shell Cave system is the longest continuous cave in the Central Basin of Tennessee. The system is a braided network of parallel streams with lateral passages with small wet-weather streams and residual pools and upper levels that act as water conduits only during flood stage (Barr 1988). The known fauna of the system includes several endemics, as well as certain small, more widely distributed subterranean species. The system contains three, possibly four, endemic animals limited to caves and other subterranean microhabitats: the blind cave salamander, the cave snail, the Trechine cave beetle, and possibly the cave millipede. Cumulative impacts would include increased cave visitation. Secondary impacts would be likely including dust introduction, increased openings to portions of the caves, and changed water quality.

3.7.1.11 Land Use

SSC project development would probably be an important/significant source of growth in each region. Major projects in the Arizona site vicinity are few; land use changes due to the SSC would be considerably greater in extent and intensity than those expected due to other projects. The predicted indirect effects of the SSC on immigration to the region and the development of housing and supporting infrastructure are difficult to distinguish from the general pattern of regional growth.

For Illinois, Michigan, North Carolina, Tennessee, and Texas, no specific major projects have been identified for the site vicinities, so no direct cumulative impacts are predicted at those sites. Due to the general pattern of growth in Illinois, North Carolina, and Tennessee, there may be local competition for housing that could induce more residential development and supporting infrastructure. For Michigan, SSC project-related growth would be diffused throughout the region, and in Texas the housing market is overbuilt and there would be no competition.

For Colorado, few cumulative land use impacts are expected in the Denver metropolitan region due its distance from the SSC site. Some incremental impacts in the SSC vicinity are expected due to the Pawnee Generating Station Unit II project and the Narrows Dam project, should they be built in the same time frame as the SSC. However, the SSC project without these additional projects has the potential for causing significant land use changes, and the incremental impacts of the other projects would be relatively small.

3.7.1.12 Prime and Important Farmlands

The removal of prime and important farmlands to implement the proposed action would contribute to cumulative impacts at all sites.

Site	Permanently Converted Prime and Important Farmland Acres
Arizona	0
Colorado	819
Illinois	197
Michigan	341
North Carolina	955
Tennessee	606
Texas	588

While there are appreciable acreages of prime and important farmlands proposed to be taken, in no state do they represent more than 1 percent of the State inventory in each of the seven regions. The increment is small and well below the average lost per year to urban development.

3.7.2 Ancillary Facilities

Ancillary facilities to the SSC include roads, railroads, and utilities, which are the responsibility of the selected state. The location of these facilities has not yet been determined, nor have alternatives to their design and location been addressed.

Construction of these facilities would create ecological habitat disturbance in addition to the habitats disturbed in constructing the main SSC facility. If these ancillary facilities were to be located in wetlands or sensitive habitats, impacts to these habitats could occur. However, it is anticipated that these habitats would be avoided during the placement of facilities and final design.

3.7.3 Expansion Area Development

Areas C, the J areas, K3 and K4 are set aside for future expansion of the research program at the SSC. There are no current plans to develop these areas; thus impacts of construction and operation of the SSC in these areas have not been addressed as part of the proposed action. However, land acquisition of these areas are planned now to allow DOE the capacity to develop new programs in the future.

The environmental impact of land acquisition for the expansion areas have been included in this EIS in so far as it is possible to do so. That is, it has been assumed, for example, in the case of wetlands and habitat loss, that whatever is built there eventually will be similar to that which is now planned for Area B. When plans are being made for any such expansion in the future, additional review, in accordance with NEPA, would need to be completed prior to decision or construction.

Some assumptions have been made regarding the type and location of future development. Area C is assumed to contain facilities similar to the injector facility in Area B. Construction of such facilities would require approximately 279 acres during construction, of which 186 acres would be permanently disturbed. It is anticipated that two of the six J Areas could be developed as experimental halls similar to those in the K Areas. Each experimental hall and its support facility would occupy approximately 20 acres.

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CHAPTER 4

AFFECTED ENVIRONMENT

CHAPTER 4 AFFECTED ENVIRONMENT

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TABLES

TABLES (Cont)

CHAPTER 4 AFFECTED ENVIRONMENT

This chapter is a summary of the current conditions and baseline trends characteristic of the seven site alternatives. It is organized according to the primary resources assessed at each site. These resources include earth resources, water resources, air quality, noise, human health (including occupational and public health), ecological resources (including threatened and endangered species, floodplains, and wetlands), waste management facilities, land resources (including parks, wilderness, and prime farmlands), socioeconomics and infrastructure, cultural resources, and scenic and visual resources. The conditions that are described in this section for each of the sites are those that are assumed to continue if the proposed SSC is not implemented. Each of the seven site alternatives is fully described in Appendix 5.

4.1 EARTH RESOURCES

Geological and geotechnical characteristics of the site alternatives are presented in Table 4-1. These characteristics include physiography, topography, stratigraphy at shaft locations, stratigraphy at tunnel depth, geologic structure, geoengineering conditions, geologic hazards, and geologic resources. In addition, surface soils are included in the discussion in Sections 4.8 and 4.9 as prime farmlands and ecological resources, respectively.

4.1.1 Topography

Large areas of flat or very gently sloping topography suitable for siting and development of the SSC surface facilities occur at all the sites. Each site's topography, according to its geologic setting and history, is characteristic of its region (physiographic province).

The topography in Arizona is distinct, reflecting geologically recent tectonic activity. The basin and range setting consists of bedrock mountain ranges rising several hundred to over one thousand feet above sediment-filled valley basins. A bedrock range in the center of the Arizona site is flanked on all sides by gently sloping alluvial fans with numerous intermittent washes. Much of the collider ring is proposed to lie within these alluvial-fan sediments.

Both the Colorado and Texas sites are located in rolling plains underlain by soft sedimentary rock. Streams (largely intermittent) have cut into the bedrock leaving flat uplands among them. In Colorado, the bedrock uplands are overlain by wind-laid loess and dune sand, relics of the colder, drier climate of the Ice Ages. In Texas, erosion of the gently tilted bedrock has produced a scarp-and-prairie topography.

Table 4-1

COMPARISON OF EARTH RESOURCES CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Physiography	Sonoran Desert	Colorado Piedmont	Till Plains	Eastern Lake Lowlands	Piedmont Upland	Nashville Basin	West Gulf Coastal Plain
Topography	Rugged ridges cross center of site, rise 500-1,100 ft above flanking alluvial fans; fans slope to edges of site at a rate of 40-70 ft/mi; frequent dry washes on fans.	Broadly rolling (25-75 ft/mi), loess-covered plain; incised 70-110 ft by intermittent streams with narrow floodplains; longitudinal dunes cover part of ring.	Low (50 ft), irregular hills of glacial moraine and drift; moderately incised dendritic drainage.	Low (30-150 ft), irregular hills of glacial moraine; dendritic drainage; frequent ponds, swamps, and lakes.	Low (50-100 ft high) rolling hills; mature dendritic drainage; deeply weathered bedrock.	Flat to slightly rolling (10-50 ft) bottom lands; local clusters of rounded knobs (350-400 ft); locally karst and landslide potential; mature dendritic drainage.	Rolling plain; 50-70 ft relief; drained (mostly intermittently) by several creek systems; creeks have narrow floodplains.
Stratigraphy at Shaft Locations	In valleys, variably cemented younger and older fanglomerate (gravel, sand, clay, and silt); in mountains, quartz, diorite, granite, basalt flows, tuffs, conglomerate, limestone, and alluvium.	Alluvium (sand and clay), loess (silt and clay), or eolian sand above claystone (Pierre Shale) with minor limestone.	Varying thicknesses of loess (silt), clayey till, outwash (sand and gravel), lacustrine clay and silt, and organic sediments above bedrock of limestone, shale, and dolomite; minor sulfides.	Glacial drift of silty and clayey sands and gravels; bedrock of primarily sandstone, dolomite, shale, thin coal, and limestone; thin coal, local disseminated pyrite.	Soil and weathered rock profile (primarily in-situ chemical weathering); saprolite at surface grades to unweathered rock at tunnel depth; rocks are a succession of metavolcanics and sediments intruded by granitic plutons.	Thin and discontinuous residual soils with some alluvium; bedrock consists chiefly of thick- and thin-bedded limestone with wavy or planar shale partings.	Up to 50 ft of terrace deposits (calcareous clay, silt, and sand) and residual soil (clay, silty clay, and local sand and gravel), above the chalk and calcareous claystone.

Table 4-1 (Cont)

COMPARISON OF EARTH RESOURCES CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Stratigraphy at Tunnel Depth	In valleys, variably cemented fanglomerate (gravel, sand, clay, and silt); in mountains, quartz diorite, granite, basalt flows, tuffs, conglomerate, and limestone.	Entirely within silty and fine sandy claystone, with several thin beds of limestone.	Entirely within massive dolomite beds with occasional chert nodules; beds separated by very thin, wavy, stylolitic clayey dolomite laminae; minor sulfides.	Primarily sandstone; some limestone, dolomite, and shale; minor siltstone, gypsum, anhydrite, and coal; sandstone occasionally pyrite-bearing.	Metamorphosed rocks (volcanic, granite, hornblende diorite, gabbro, diorite-gabbro, and epiclastic); younger rocks include diabase and granite; local disseminated pyrite.	Entirely within limestone, predominantly medium-bedded, nearly pure limestone alternating with abundant, wavy silty or shaley laminae; and potential minor sulfide mineralization.	Entirely within chalk and calcareous claystone.
Geologic Structure	In Maricopa Mountains, tilted beds overlie granitic plutons that are in fault or intrusive contact with schist; two shear zones and a complex of several faults are known within the ring - none known to cross ring; jointing is common in all crystalline units.	Beds of Denver structural basin dip about 12 ft/mi to the NW; no indication of major structures; some minor soft sediment deformation; steeply dipping, widely spaced joints.	Bedrock generally dips 10-15 ft/mi SE; dips increase up to 165 ft/mi locally; joints are steep and widely spaced; faults of little displacement.	SE portion of Michigan basin; beds dip slightly to the NW; several NW-striking and plunging regional folds nearby.	Carolina Slate Belt; metamorphic rocks are folded (Virgilina Synclinorium) and faulted; younger intrusions; brecciated zones cross the ring; joints present in all units with shallow to steep dips.	Beds on flanks of Nashville dome generally dip 25-40 ft/mi with minor folds of a few degrees; average joint spacing of 1 per 5 ft.	Eastern margin of the Texas Craton; beds dip slightly to E; 2 faults mapped across the ring, 7 inside the ring, and 2 within 1.5 mi of the ring (faults are NE-trending, steep, with displacements mostly less than 100 ft); joints are widely spaced and near vertical.

Table 4-1 (Cont)

COMPARISON OF EARTH RESOURCES CHARACTERISTICS
OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Geoengineering Conditions	Fanglomerate - plastic fines, moderate to strong calcareous cement, high friction angle; fair to good quality rocks with high strength characteristics; quartz-bearing rocks are abrasive; all above water table.	Negligible inflows in claystone; loose to moderately dense soils; good rock quality; protection required against slake/swell potential in rock.	Minimal groundwater inflows in tunnel unit; low susceptibility of swelling clay in shale; soil properties are CL and ML; good quality rock units with high strength characteristics.	Bedrock friable and moderately permeable; potential for perched aquifers in glacial tills; glacial tills with soft to very stiff clay; sandstone, limestone, and shale with fair rock quality and strength.	Potential for moderate groundwater inflows during tunneling; shrink/swell potential for clay; joints with low permeability; soil and rocks have good mechanical and physical characteristics.	Soils are CL and CH; good to excellent rock mass quality; potential water inflows at shallow depth; karst features may require treatment.	Local saturated alluvium may cause minor groundwater inflows in shafts; soils with moderate to high shrink/swell potential; good quality rock with tight joints and some clay infilling; slake potential in claystone.
Geologic Hazards	Minor to moderate earthquake risk; Uniform Building Code (UBC) Seismic Zone 2; possible local debris flow.	Minor seismic risk; UBC Seismic Zone 1; possibility of unrecorded oil and gas wells.	Minor seismic risk; UBC Seismic Zone 1; potential for minor gas in glacial drift.	Minor seismic risk; UBC Seismic Zone 1; possibility of unrecorded oil and gas wells.	Minor to moderate seismic risk; UBC Seismic Zone 2.	Minor seismic risk; UBC Seismic Zone 1 frequent shallow sinkhole/collapse features; local potential for landslides.	Very low seismic risk; UBC Seismic Zone 0.
Geologic Resources	Low mineral potential; previous exploration/mining for copper, manganese; feldspar and mica resources to north recently under development; moderate quality aggregate resources near the site.	Oil and gas fields in region produced from the underlying Dakota sandstone.	Sand, gravel, and dolomite produced in the area.	Oil and gas being produced from horizons over 3,000 ft below the tunnel; sand, gravel, stone, and clay mined in the area.	Low mineral potential; explored or exploited commodities in the area include stone, kyanite group minerals, talc, mica, copper, silver, and gold.	Previous minor regional production includes iron, barium, fluorine, and lead; past exploration of zinc and natural gas; operating limestone quarries.	Previous minor oil production from over 800-ft depth; industrial resources include stone, clay, and lime.

In Michigan and Illinois, Ice Age glaciers overrode the sedimentary bedrock and, as they melted, deposited a thick blanket of soil materials on top of the rock. The surface of this blanket is characterized by low, rolling hills. The occasional higher hills, that rise above the general topography, are also glacial deposits (kames, eskers, and end moraines). These glacial landforms control the course of the many perennial streams that drain the sites. The Michigan drainage networks are particularly complex spatially and are very slow to drain.

At both the North Carolina and Tennessee sites, bedrock extends to the surface of the ground. In North Carolina, the bedrock is deeply weathered and, hence, exerts little control on the drainage pattern. The characteristics of the resulting soils govern surface drainage processes. The terrain in both North Carolina and Tennessee ranges from flat to rolling and hilly. In Tennessee, the bedrock has dissolved locally, causing collapsed depressions at the surface. A portion of the surface water drains into these depressions and directly into groundwater, rather than into streams.

4.1.2 Stratigraphy

The stratigraphy of the seven sites varies widely. However, sedimentary rock strata are characteristic at the Colorado, Illinois, Michigan, Tennessee, and Texas sites. These strata are lithologically simple and laterally homogeneous. Glacial materials cover sedimentary bedrock at both the Illinois and Michigan sites. Crystalline rock types make up a significant portion of the geologic units that would be excavated from the tunnel if sited in Arizona or North Carolina. The greatest lateral continuity of rock types at tunnel depth is found in Colorado and Illinois, where the flat-layered sediments have been least deformed by subsequent geologic events.

Wholly sedimentary bedrock occurs at the Tennessee, Illinois, Michigan, Colorado, and Texas sites. Limestone and dolomite predominate bedrock lithology at sites in both Tennessee and Illinois. In Michigan, sandstone occurs within a vertical sequence including dolomite, siltstone, shale, and evaporites. Claystone, with minor limestone, is the major rock type at the Colorado site. Chalk and marl are the major rock types at the Texas site.

Soils vary considerably among these sedimentary-rock sites. Glacial drift deposited over the valleys and hills of the subglacial erosional surface in Illinois and Michigan would constitute a large part of the material intersected by shafts. Thin and discontinuous residual soil, and slightly thicker alluvial materials in stream channels, are the only overburden present in Tennessee and Texas. Eolian sand and loess on uplands, and loess and alluvium in valleys, overlie the claystone in Colorado.

Two different geologic settings occur along the ring in Arizona: 1) fanglomerate in the valleys, and 2) intrusive, volcanic, and sedimentary rocks in the mountains. Basin fill/fanglomerate is also present in small pockets between hills. Recent alluvial materials occur in washes and stream channels.

Crystalline rocks, including intrusive, volcanic, and sedimentary rocks that have been metamorphosed and deformed to varying degrees, compose the stratigraphic column in North Carolina. The oldest of these units are truncated by younger intrusions. Highly weathered rock (saprolite) is the dominant soil precursor; recent alluvial materials occur in stream channels.

4.1.3 Geologic Structure

The gross structure of the sedimentary rocks at the Colorado, Illinois, Michigan, Tennessee, and Texas sites is simple. Only minor, if any, structural features are known to disrupt the subhorizontal strata in Colorado, Illinois, and Tennessee. Strata at the Texas site are broken by several faults; otherwise, the beds dip at very shallow angles to the east. Broad, open folds with shallow-dipping limbs have locally tilted the sediments at the Colorado, Illinois, Michigan, and Tennessee sites.

Metamorphosed sedimentary and volcanic units in North Carolina are faulted, sheared, and deformed into high-amplitude regional folds. Rocks of the Maricopa Mountains at the Arizona site are also tilted and faulted (including shear zones up to 10 ft wide that are not known to intersect the collider tunnel). Intrusive rocks are also characteristic of the Arizona and North Carolina sites.

Local faults have been mapped at the sites in Arizona, Illinois, and Texas. Small-scale structural features in the immediate vicinity of the sites were identified during detailed mapping, and it is possible more will be encountered when geologic verification studies are conducted. Joints have been found in all bedrock units. Crystalline rocks are all moderately to highly jointed; sedimentary units are typically less jointed.

4.1.4 Geoengineering Conditions

Tunnel alignments at six of the sites are completely in competent rocks where rapid excavation tunneling methods using a tunnel boring machine (TBM) can be employed. At the Arizona site, a portion of the tunnel is in basin fill/fanglomerate, which contains weakly cemented sands and clay; here a cut-and-cover method is proposed to supplement TBM excavation.

At the Arizona site, soil properties vary from silty or clayey fine sands with slight plasticity to inorganic clays with high plasticity. Soils at the Colorado site consist of eolian sand, loess, and alluvial deposits. Eolian sand and alluvial deposits are potentially unstable because of noncohesiveness and high plasticity, respectively.

The majority of soils at the seven sites may be described based on the Unified Soil Classification System as CL (silty clay), ML (clayey silt), and SM (silty sands). Soils overlying bedrock at the Illinois, Michigan, North Carolina, Tennessee, and Texas sites are mostly inorganic clays of varying plasticity with local occurrences of gravel and sand.

There is a potential for groundwater inflows into shafts and surface excavations at all but the Arizona site. In Michigan and Illinois, water-bearing glacial overburden consisting of till, outwash, and lake deposits occurs over the entire site area. Permeabilities in this material vary from 10^{-7} cm/s for clay-rich till to 10^{-2} cm/s for uncemented sands and gravels. Water-bearing zones are discontinuous due to the great variability in thickness and composition of the glacial material. In North Carolina, groundwater occurs in the weathered zone of bedrock above the tunnel level. Flow in this zone is primarily along fractures with permeabilities ranging from 10^{-4} to 10^{-6} cm/s. Flow volumes are limited by the low porosity and storage capacity of the weathered zone material. At both the Colorado and Texas sites, groundwater of any significance is generally restricted to thicker sections of alluvial sands and gravels along major streams. Water volumes and thickness of saturated material are quite variable depending on recharge characteristics. Permeabilities for these water-bearing sediments are estimated to range from 10^{-2} to 10^{-1} cm/s. In Tennessee, groundwater occurs in discrete solution cavities and along solution-widened joints in near-surface limestones. Because of the highly discontinuous nature of the solution features, overall rock permeability and water-bearing potential is low. Where water-filled cavities exist, high inflows can be supported.

Potential for swell/shrink in clay soils exists at the Colorado, Illinois, Michigan, and North Carolina sites where tills or Quaternary terrace deposits contain soft to very stiff clay. Residual soils at the Tennessee site originated from the underlying limestone bedrock. The mechanical properties of these Tennessee soils are poorly known. Residual soils at the Texas site have a moderate to high shrink/swell potential.

Rock quality for the sites is variable depending on composition, fracture frequency, weathering, etc. In Arizona, cemented basin-fill alluvium (fanglomerate) has generally low moisture content and plasticity and good strength characteristics. Granitic units at the site show fair to good strength characteristics, largely depending on extent of weathering. Rocks of the Tertiary volcanic assemblage range from weak, poorly cemented conglomerate to dense, high-strength basalt and tuff. In Colorado, the rock at tunnel depth is a uniform silty claystone with occasional thin layers of hard limestone. This claystone shows low-strength, moderate densities and moisture contents, and a moderate-to-high slake potential. In Illinois, the rocks that would be encountered consist of high-strength dolomite and limestone, with thin shale interbeds. Rock at tunnel depth is dolomite; shale would be encountered only in shafts. Rock at tunnel depth in Michigan is variable in character, consisting primarily of low- to medium-strength sandstones, interbedded with low-strength shale and coal lenses, and higher strength limestone bands. Shales have a moderate slake potential. In North Carolina, a complex sequence of metavolcanic and granitic rock underlies the site area. These rocks tend to have similar high-strength characteristics, modified by degree of weathering and fracture prevalence. Fractures are common within most of these units, especially near the contacts of granitic plutons and surrounding metavolcanics. In Tennessee, high-strength, nearly homogeneous limestone extends from surface to below-tunnel depth. Thin shale or shaley limestone interlayers occur in some parts of the section. Solution cavities, sinkholes, and solution-widened joints are common features near the surface around the site. The Texas site is underlain by beds of marl and chalk (with intermediate compositions common). The marl, a calcareous claystone, has low strength and a high slake potential. The chalk is a higher strength, very fine-grained limestone. Rock strength at this site increases in direct proportion to carbonate content and is inversely related to moisture content.

Fractures and natural joint systems with varying orientation and spacing are associated with most of the rocks at the sites. Joints and bedding planes in the rocks are generally tight, with low hydraulic conductivity. Joints with calcite and clay infillings and rough apertures may permit minor water inflows as a result of local excavation-induced disturbances at the Illinois, Michigan, and North Carolina sites.

4.1.5 Geologic Hazards

There is some possibility of encountering small volumes of natural gas during construction at the Colorado, Illinois, and Michigan sites. The Colorado and Michigan sites have had relatively active oil and gas extraction (from strata far below the SSC tunnel depth); there is a small possibility that an unrecorded or improperly abandoned oil or gas well may be encountered along the tunnel alignment at those two sites. Natural gas (principally methane), unrelated to oil and gas wells, has been encountered in excavations in the regions around the Michigan and Illinois sites in the bedrock and overlying sediments respectively.

Surface geotechnical conditions that could be hazardous to construction if not properly handled occur in small portions of the Tennessee site (karst features, landslide-prone slopes) and the Arizona site (potential for debris flows).

The risk of occurrence of a strong earthquake is small at all of the sites. Seismic zone classification for each site is shown in Table 4-1.

4.1.6 Geologic Resources

Stratigraphic equivalents of the rocks at all sites are known to contain a variety of geologic resources that are either presently exploited in the region or have been previously mined or identified as potential targets. Industrial resources (e.g., sand and gravel, crushed stone) are the most common, followed by oil and gas, and a variety of metallic and precious minerals. However, none of the sites contain deposits (other than sand, gravel, and stone) that are unique or of particular economic significance.

Industrial resources in the form of stone or aggregate, as well as a variety of minerals, have been produced in the vicinity of the Illinois, Michigan, North Carolina, Tennessee, and Texas sites. Exposed rocks in Arizona are also potentially viable sources of aggregate. Industrial resources are common throughout all of these regions, and in no case do local operations represent a regionally unique resource.

Oil and gas reserves are most prevalent in units underlying tunnel horizons in Colorado and Michigan. Although several producing fields at both sites occur within a few thousand feet of the vicinity of the proposed collider ring, most of the exploration and production in these areas have been historical and are expected to decline steadily with time. Oil and gas resources have also been explored or produced on much smaller scales in the vicinity of the Illinois, Tennessee, and Texas sites.

4.2 WATER RESOURCES

4.2.1 Surface Water Hydrology and Quality

Characteristics of surface water resources at site alternatives are compared in Table 4-2. Areas of special emphasis are surface runoff and flooding, surface water quality, and surface water use. Discussions of the variation of these characteristics among the sites follow.

4.2.1.1 Runoff and Flooding

The seven sites fall in diverse physiographic and climatic areas of the country, as described in Sections 4.1 and 4.3 of this chapter. Four of the seven sites drain to the Gulf of Mexico (Texas, Illinois, Colorado, and Tennessee). The latter three are within the Mississippi River Basin. The other three sites drain to the Gulf of California (Arizona), Lake Michigan (Michigan), and the Atlantic Ocean (North Carolina). Because of the variation in physiography and climate, these sites have significant differences in hydrologic regime, flow volume, and flooding.

The Arizona site is arid, with no perennial streams and very little surface water. The Colorado site is semi-arid with no perennial streams, very low average flows, and a large range of maximum flows. Part of the reason for low average flows in the Colorado region is the use of impoundments to regulate discharge and withdrawals for water use. The Texas site has relatively low average flows, but a moderately high range of maximum flows. The Michigan and Illinois sites have only slightly higher average flows and a broad range of maximum flows. The North Carolina and Tennessee sites have very similar rainfall amounts, but Tennessee has both higher average flows and higher maximum flows.

Proposed locations of the ring in the local watersheds are also variable. In Arizona, Tennessee, and Texas the ring crosses low-order tributaries with the headwaters mostly inside the ring. The drainage areas of these tributaries are typically less than 100 mi^2. In Colorado, all the tributaries intersected by the ring originate near or within the ring,

Table 4-2

COMPARISON OF SURFACE WATER RESOURCE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
RUNOFF AND FLOODING							
General Characteristics	Gila River basin eventually drains to Colorado River and Gulf of California.	South Platte River basin; eventually drains to Mississippi River and Gulf of Mexico.	Fox River basin, tributary to Mississippi River; eventually drains to Gulf of Mexico.	Grand River basin; drains directly to Lake Michigan.	Divided among Neuse, Tar, and Roanoke River basins; eventually drains to the Atlantic Ocean.	Divided among Cumberland and Tennessee River basins; eventually drains to the Mississippi River and Gulf of Mexico.	Trinity River basin; eventually drains to Gulf of Mexico.
USGS Gauges in Area	Two crest stage recorders; drainage areas 68 and 403 mi^2; no average flows; max. flows 16-39 $ft^3/s/mi^2$.	Five gauges; drainage areas from 111 to 16,852 mi^2; average flows from 0 to 0.1 $ft^3/s/mi^2$, all flows regulated and/or diverted upstream; max flows 2-355 $ft^3/s/mi^2$.	Six gauges; drainage areas from 29 to 1,403 mi^2; average flows from 0.6 to 1.1 $ft^3/s/mi^2$; max flows 5-38 $ft^3/s/mi^2$.	Six active gauges; drainage areas from 9 to 1,230 mi^2; average flows 0.6 to 0.7 $ft^3/s/mi^2$; max flows 6-138 $ft^3/s/mi^2$.	Four active gauges; drainage areas from 43 to 167 mi^2; average flows from 0.9 to 1.2 $ft^3/s/mi^2$; max flows 75-134 $ft^3/s/mi^2$.	Five active gauges; drainage areas from 177 to 481 mi^2; average flows from 1.6 to 1.9 $ft^3/s/mi^2$; max flows 106-269 $ft^3/s/mi^2$.	Five gauges; drainage areas from 63 to 963 mi^2; average flows from 0.2 to 0.4 $ft^3/s/mi^2$; max flows 77-228 $ft^3/s/mi^2$.
Channels Crossing Ring	Only ephemeral washes crossing ring; flash flood potential a concern.	Eight channels crossing ring with drainage areas from 24 to 814 mi^2; width-depth ratios from 3.8 to 12.5; floodplain widths from 1,500 to 10,000 ft.	Fourteen channels crossing ring with drainage areas from 10 to 1,738 mi^2; width-depth ratios generally from 2.8 to 11.7, except the Fox River with ratios from 100 to 125; floodplain widths from 300 to 2,500 ft.	Nine channels crossing ring with drainage areas from 6 to 447 mi^2; width-depth ratios from 1.2 to 15.0; floodplain widths from 75 to 1,000 ft.	Six channels crossing ring with drainage areas from 11 to 141 mi^2 width-depth ratios from 3.3 to 12.0; floodplain widths from 90 to 400 ft.	Nine channels crossing ring with drainage areas from 4 to 72 mi^2; width-depth ratios from 3.3 to 7.0; not all are perennial streams; floodplain widths from 200 to 2,000 ft.	Eight channels crossing ring with drainage areas from 42 to 107 mi^2; width-depth ratios from 2.3 to 5.0; floodplain widths from 300 to 2,000 ft.

Table 4-2 (Cont)

COMPARISON OF SURFACE WATER RESOURCE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Floodplain Maps Available	One Flood Hazard Boundary Map and some preliminary FIRM's for Morgan County including portions of Beaver Creek, Buck Creek, and Shears Draw.	One Flood Hazard Boundary Map and some preliminary FIRM's for Morgan County including portions of Beaver Creek, Buck Creek, and Shears Draw.	Counties in which ring will be located are covered by FIRM.	No FEMA mapping of floodplains in vicinity of ring except for a portion of the Grand River. Some USGS flood-prone area maps are available.	One county covered by FIRM; two counties covered by FHBM; no counties excluded from FEMA mapping.	One county covered by FIRM; three counties covered by FHBM; no counties excluded from FEMA mapping.	Only county in which ring will be located is covered by FIRM.
WATER QUALITY							
Constituent Concentrations	No surface water quality data from immediate vicinity	Levels from one station on South Platte River have the following ranges: DO (mg/l) 0-11 [5] Nitrate (mg/l) 2-6 [0.1] TDS (mg/l) 625-1,105 Lead (µg/l) 6-21 [0.05]	Levels from four stations in site vicinity have the following ranges: DO (mg/l) 4-17 [5] Fecal Col. (#/100 ml) 9-53,000 [200] Nitrate (mg/l) 0-12 TDS (mg/l) 220-1,000 [1,000] Lead (µg/l) 0-100 [100]	Levels from five stations in site vicinity have the following ranges: DO (mg/l) 4-12 [5] Fecal Col. (#/100 ml) 2-92,000 [200] Nitrate (mg/l) 12-17 TDS (mg/l) 270-710 [750] Lead (µg/l) 1-50 [14]	Levels from six stations in site vicinity have the following ranges: DO (mg/l) 2-16 [5] Nitrate (mg/l) 0-2 mg/l Lead (µg/l) 100-200 [25]	Levels from four stations in site vicinity have the following ranges: DO (mg/l) 6-17 [5] Fecal. Col. (#/100 ml) 10-12,300 [200] Nitrate (mg/l) 0.4-1.0	Levels from three stations in the site vicinity have the following ranges: DO (mg/l) 5-14 [*] TDS (mg/l) 150-580 [*]

1. DO = Dissolved oxygen
2. TDS = Total dissolved solids

FEMA = Federal Emergency Management Agency
FIRM = Flood Insurance Rate Map
FHBM = Flood Hazard Boundary Map
[ ] State water quality standard for multiple-use waters
[*] Surface water quality standards in Texas are average annual, not-to-exceed limits, and are, therefore, not applicable to comparison with instantaneous observations.

Sources: Arizona: Brooks 1988b; U.S. Army Corps of Engineers 1982. Colorado: Mcdonold 1988; URS Corp 1988; U.S. Army Corps of Engineers 1977. Illinois: Budd 1988; Fitzgerald et al. 1987; Federal Emergency Management Agency 1981a, 1981b; singh 1988; U.S. Army Corps of Engineers 1984. Michigan: Federal Emergency Management Agency 1984; Miller et al. 1987; U.S. Environmental Protection Agency 1988a. North Carolina: Barker et al. 1986; Federal Emergency Management Agency 1978a, 1978b, 1979a; North Carolina Dept. of Water and air Resources No date; U.S. Environmental Protection Agency 1988b. Tennessee: Baker 1988; Coffee et al. 1984; Federal Emergency Management Agency 1978c, 1979b, 1980, 1981c; Lowery et al. 1987. Texas: Federal Emergency Management Agency 1987; Gancarz 1988a, 1988b; Trinity River Authority of Texas, State of Texas 1988.

except for Beaver and Badger Creeks. Both Beaver and Badger Creeks would be crossed twice by the ring. At the downstream crossings, Beaver and Badger Creeks have drainage areas of more than 800 mi^2 and 300 mi^2 respectively. In North Carolina, the tributaries intersected by the ring originate near the center of the site, except for the Flat River. Each of the drainage areas is less than 150 mi^2. The ring location in Michigan crosses the headwater reaches of streams, mostly within the Grand River watershed, which is nearly 450 mi^2. The Illinois site has the largest channel (the Fox River) crossing a proposed ring location with a watershed area of more than 1,700 mi^2.

Floodplains of the various sites fall into three approximate width ranges: less than 1,000 ft, over 1,000 ft but less than 5,000 ft, and up to 10,000 ft. Arizona's floodplains are not comparable because of the ephemeral nature of streamflow. Flooding widths have not been estimated for the major washes or other flash flood areas. North Carolina is the only site where the floodplains of all channels in the vicinity of their ring crossing are less than 1,000 ft in width. This reflects the topography of the upper Piedmont where streams are typically located in narrow valleys. Illinois, Michigan, Tennessee, and Texas have proposed ring locations crossing streams and rivers with maximum floodplain widths between 1,000 and 2,500 ft. The Colorado ring includes channels that cross the ring and have greater floodplain widths. None of the Colorado floodplains is less than 1,500 ft wide, and one area of channel confluence is estimated to have a 10,000-ft-wide floodplain.

The existence of flood insurance mapping indicates not only an identified flood potential, but also the presence of enough improved property at risk from flooding to be a concern. Thus, areas that may have significant flood potential but little or no development would not need flood insurance mapping. For those areas that do have flood insurance needs, there are different levels of detail and accuracy in the mapping prepared by the Federal Emergency Management Agency (FEMA). A Flood Hazard Boundary Map (FHBM) gives approximate limits of floodplains to identify hazard areas. A Flood Insurance Rate Map (FIRM) is based on more detailed analyses and is necessary where significant flooding occurs in developed areas. At the seven site alternatives, only Illinois and Texas have complete coverage of the ring area with FIRM's. Arizona presently does not have FEMA mapping in the vicinity of its proposed site.

4.2.1.2 Water Quality

The amounts of existing water quality data are highly variable for the seven states. Table 4-2 presents data collected from surface waters in the major drainage basins of each of six site alternatives. (Arizona is not included because the proposed site does not have any surface water streams or rivers on the site.) These data come from streams of various sizes and from stations selected for the purpose of monitoring these streams, often concentrating on problem areas.

In general, the surface waters associated with each of the sites are suitable for multiple uses (recreation, aquatic life, and public water supply after proper treatment). The criteria associated with multiple-use waters are not the same among the sites; dissolved oxygen (DO) should be maintained at not less than 5 mg/l; total dissolved solids should not exceed 1,000 mg/l for Illinois, 750 mg/l for Michigan, 500 mg/l for North Carolina and Tennessee, 300 mg/l and 500 mg/l (both annual average not-to-exceed limits) for Texas; fecal coliform should not exceed 200 colonies per 100 ml for Illinois, Michigan, Tennessee, and Texas; nitrate level should not exceed 0.1 mg/l for Colorado, and 10.0 mg/l for North Carolina; lead level should not exceed 0.05 μg/l for Colorado, 100 μg/l for Illinois, 14 μg/l for Michigan, 25 μg/l for North Carolina, and 50 μg/l for Tennessee.

Dissolved oxygen (DO) does not differ significantly at the seven sites. Nitrate levels in Illinois and Michigan ranged between 10 and 20 mg/l, Colorado's highest value is below 10 mg/l, and North Carolina and Tennessee have values well below 5 mg/l. Colorado and Illinois streams have maximum total dissolved solids (TDS) values around 1,000 mg/l, and Michigan and Texas streams have maximum values less than 1,000 mg/l. Illinois and North Carolina have maximum lead values from 100 to 200 μg/l, while Colorado and Michigan lead levels are between 20 and 50 μg/l. Michigan and Illinois streams have maximum levels of over 50,000 fecal coliform bacteria per 100 ml, while Tennessee has a maximum of 12,000.

An indicator of point source loading of pollutants can be obtained from the number of permitted dischargers under the National Pollutant Discharge Elimination System (NPDES). Such permits are obtained for industrial discharges, cooling water, and any number of other discharges, but are primarily for sewage or wastewater treatment plants. The number of NPDES permits issued in the proposed site vicinities are:

Arizona	-	None
Colorado	-	14
Illinois	-	117
Michigan	-	5
North Carolina	-	15
Tennessee	-	<10
Texas	-	16

4.2.2 Groundwater Hydrology and Quality

Characteristics of the groundwater resources at the site alternatives are compared in Table 4-3. Areas emphasized in the comparison are hydrologic setting, hydrologic controls, piezometric conditions, depth-to-water, groundwater quality, and groundwater use.

4.2.2.1 Groundwater Hydrology

The seven sites represent five different hydrogeologic regimes. The Arizona site is characterized by basin and range structure and unconsolidated to moderately consolidated basin alluvial deposits.

Table 4-3

COMPARISON OF GROUNDWATER RESOURCE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Hydrologic Setting	Unconsolidated to moderately consolidated alluvial fill material derived from surrounding mostly granitic bedrock mountains	Unconsolidated surficial deposits consisting of dune sands, loess, and alluvial deposits along stream channels; underlain by generally impermeable claystone	Unconsolidated glacial drift overlying indurated sediments consisting of dolomites, shales, and sandstones	Unconsolidated glacial drift overlying indurated sediments consisting of sandstone, shale, limestone, dolomite and some siltstone	Saprolite and partially weathered bedrock overlying highly indurated igneous and metamorphic rocks	Indurated bedrock consisting of thick- and thin-bedded limestone, dolomite and some shale	Unconsolidated alluvial deposits along streams; relatively impermeable indurated chalk, marl, and claystone overlying sandstone with interbedded shale
Hydrologic Controls (Flow Mechanism)	Porous media flow in basin alluvium	Porous media flow in surficial deposits; fracture flow in up to 70 ft of weathered claystone; very little, if any flow in relativity impermeable unweathered claystone	Porous media flow in glacial drift; fracture and dissolution flow in dolomites and shales; predominantly porous media flow in sandstones	Porous media flow in glacial drift; fracture and dissolution flow in limestone, shale, and dolomite; predominantly porous media flow in sandstone	Porous media flow in saprolite; fracture flow in partially weathered bedrock zone	Fracture and dissolution flow in limestones, dolomites and shales.	Porous media flow in surficial alluvial deposits and deep sandstone units; limited fracture flow in up to 15 ft of weathered chalk and marl
Piezometric Conditions	Unconfined (water-table) in upper portion of saturated alluvium; confined in deeper sediments	Unconfined in surficial deposits and weathered claystone	Mixed unconfined/confined in surficial glacial deposits; semi-confined to confined in deeper bedrock units	Mixed unconfined/confined in surficial glacial deposits; unconfined to confined in deeper bedrock units	Predominantly unconfined in saprolite; occasionally semiconfined in partially weathered bedrock	Unconfined in upper limestone; confined conditions in deep solution features in limestone	Unconfined in surficial alluvial deposits; deep sandstone aquifer units confined

Table 4-3 (Cont)

COMPARISON OF GROUNDWATER RESOURCE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Depth-to-Water	Ranges from 100 to 700 ft below land surface in basins; throughout site generally greater than 350 ft below land surface	Ranges from near surface to about 60 ft below land surface	Ranges from near surface to 20 ft below land surface	Ranges from near surface to 50 ft below land surface	Ranges from near surface to 30 ft below land surface	Ranges from near surface to about 250 ft below land surface	Near surface in surficial alluvial deposits; water may be encountered in upper 15 ft of chalk and marl; below weathered zone units are essentially dry; depth to water is <15 ft
Groundwater Quality	Some areal variability; sodium chloride type predominant; TDS typically 300 to 550 mg/l - up to 1,800 mg/l in irrigated areas - locally exceed national drinking water secondary standard for TDS; generally soft; no use limiting constituents.	Variable between units; calcium sulfate/bicarbonate type predominant; TDS range 120 to 3,700 mg/l; TDS and sulfate commonly exceed national drinking water secondary standards; high nitrate and hardness typical in shallow alluvial deposits.	Some areal variability and between units; calcium-magnesium bicarbonate type predominant; TDS typically 300 to 1,200 mg/l; TDS, sulfate and iron locally exceed national drinking water secondary standards; high iron very common; typically very hard; elevated* radium in groundwater in area just east of site.	Some areal variability between units; calcium-magnesium bicarbonate type predominant; TDS range 100 to 1,000 mg/l; TDS, iron and chloride locally exceed national drinking water secondary standards; high iron very common; typically very hard.	Little areal variability between units; mixed bicarbonate type predominant; TDS range 25 to 800 mg/l; TDS occasionally and iron commonly exceeds national drinking water secondary standards; variable from soft to very hard.	Variable areally and between units; calcium-magnesium bicarbonate type predominant; TDS range 200 to 12,500 but generally 200 to 1,500 mg/l; TDS, chloride and iron commonly exceed national drinking water secondary standards; hydrogen sulfide odor is common; variable from soft to very hard.	Variable areally and between units; sodium bicarbonate type predominant; TDS range 300 to 3,000 mg/l; TDS, sulfate and chloride locally exceed national drinking water secondary standards; nitrate locally exceeds national drinking water primary standards in shallow alluvium; hardness variable - soft to slightly hard in deep aquifers, very hard in shallow alluvium.

*Groundwater with elevated radium levels may be used as cooling water or for other purposes except as a potable source.

Sources: General: Driscoll 1986; U.S. Environmental Protection Agency 1977. Arizona: Brooks 1987; Cuff 1984; Hollett and Marie 1987; U.S. Environmental Protection Agency 1983a; Wilson 1979. Colorado: Bjorklund and Brown 1957; Colorado GeoLogic, Inc. 1986; Colorado Geological Survey 1988; McGovern 1964; Morgan County Quality Water District 1987; Repplier et al. 1981; Wm. Curtis Wells and Co. 1978. Illinois: Booth and Vaugt 1986; Curry et al. 1988; Hughes et al. 1966; Jennings 1987; Kempton et al. 1987a and 1987b; Schict et al. 1976; Valden et al. 1988; Visocky et al. 1985; Visocky and Schulmeister 1988; Woller and Sanderson 1978; Woller et al. 1986. Michigan: Gilbert/Commonwealth of Michigan, Inc. 1988a, 1988b, and 1988c; Ingham County Health Department 1987; Michigan Department of Public Health 1983; Michigan Geological Survey 1987; Radfar 1979; U.S. Army Corps of Engineers 1970; Western Michigan University 1981. North Carolina: Bain and Thomas 1966; May and Thomas 1968; North Carolina Department of Natural Resources and Community Development 1983 and 1986. Tennessee: Adams et al. 1986; Brahana and Bradley 1986; Geotrans, Inc. 1988; Newcome 1958; Newcome and Smith 1962; Rima et al. 1977; Zurawski and Burchett 1980. Texas: Freeze and Cheery 1979; Mason, Johnston and Associates, Inc. 1987; Nordstrom 1982; Southwestern Laboratories 1987; Texas Water Development Board 1976; Thompson 1967; William F. Guyton Associates, Inc. 1987.

Illinois and Michigan have unlithified glacial drift overlying a typical midcontinent sedimentary sequence. Tennessee is characterized by a shallow karst (limestone) hydrologic regime typical of the west-central Appalachian portion of the country. The North Carolina site is predominantly crystalline rocks with a deeply weathered profile. The hydrogeologic regimes at the Colorado and Texas sites are similar in that shallow permeable alluvial sediments overlie fine-grained sedimentary rocks in which groundwater movement is limited or nonexistent. In Texas, major regional aquifers underlie the fine-grained sedimentary rocks. In Colorado, there are no major regional aquifers at depth.

The hydrogeologic controls that govern movement of groundwater in the unconsolidated deposits vary from site to site. In Arizona, porous media flow is the predominant mechanism for groundwater movement within the basin-fill alluvium. In Colorado and Texas, porous media flow occurs in the surficial alluvial deposits, while fracture flow is likely dominant in the upper, weathered portions of the underlying fine-grained sedimentary rocks. Below the weathered zones, little, if any, groundwater movement occurs in these sedimentary rocks. In Illinois and Michigan, porous media flow occurs in the glacial drift, while dissolution and fracture flow occurs in the carbonate sequences. Porous media flow also occurs in the interbedded sandstone sequences. In Tennessee, dissolution and fracture flow occurs in the carbonate and shale sequences. In North Carolina, porous media flow occurs in the saprolite, and fracture flow occurs in the partially weathered crystalline rocks. Below the weathered zone, a limited amount of fracture-dominated flow is likely.

General piezometric conditions throughout the sites are similar in that groundwater in the shallow, surficial, alluvial, glacial, or weathered bedrock deposits is typically under water table or unconfined conditions, while groundwater in the deeper sediments is typically confined. Both unconfined and confined conditions occur within the alluvial sediments at the Arizona site because of the presence of interlayers of clay. The surficial glacial deposits of the Illinois and Michigan sites also have mixed unconfined/confined conditions because of the variable lithology of the deposits.

Depth-to-water at the sites is typically shallow except in Arizona where it is generally greater than 350 ft below land surface. At the other sites, the water table is typically within the upper unconsolidated and/or weathered/fractured sediments that overlie low to very low permeability bedrock units. In Colorado, Illinois, Michigan, and North Carolina, water is generally from near the surface to 60 ft below the surface, while in Tennessee, water is generally from near the surface to 250 ft below the surface. In Texas, where alluvial deposits occur along stream channels and in the upper weathered portion of chalk and marl, depth-to-water is typically less than 15 ft. For the major aquifer in the Texas project area, depth-to-water is approximately 440 to 880 ft below land surface.

4.2.2.2 Groundwater Quality

Groundwater quality is generally good at all of the sites; however, there are differences in the variability and nature of groundwater quality among the sites. The differences in groundwater quality are the result of differences in rock type and mineralogy and groundwater flow conditions.

Rock type and mineralogy control the ionic composition of site groundwater. Calcium-magnesium bicarbonate-type water is predominant in the carbonate rock terrains of Illinois, Michigan, and Tennessee. A calcium sulfate/bicarbonate-type water in Colorado is likely the result of gypsum in the weathered Pierre shale bedrock. A mixed bicarbonate-type water is predominant in North Carolina, reflecting the availability of all major cations in the mineralogically diverse metamorphic and igneous host rock. Sodium bicarbonate and sodium chloride-type waters are predominant in Texas and Arizona, respectively.

All sites show local variability in groundwater quality, either areally, between hydrogeologic units, and/or with depth. This variation is greatest in Tennessee, Colorado, and Texas. TDS range from slightly in excess of 100 to several thousand mg/l within these sites. There is less variability in groundwater quality in Arizona, Illinois, Michigan, and North Carolina, where TDS typically range from 300 mg/l or less to approximately 1,000 mg/l. Groundwater with TDS of up to 1,800 mg/l occurs beneath irrigated areas in the vicinity of the Arizona site.

Although relatively good quality groundwater is, in general, typical of all sites, TDS and selected chemical constituents locally exceed secondary (recommended) national drinking water standards for public sources of drinking water at all the sites (see Chapter 6). The TDS standard of 500 mg/l is commonly exceeded at the Colorado site. Groundwater beneath irrigated areas in Arizona commonly exceeds the standard, while groundwater outside irrigated areas is commonly within the standard. The TDS standard is only locally exceeded at the Illinois, Michigan, North Carolina, Tennessee, and Texas sites. In general, the higher TDS values are associated with groundwater from deeper aquifers or formations. However, groundwater with TDS in excess of 500 mg/l occurs intermittently within shallow aquifers at all of the sites. The secondary national drinking water standard for iron (0.1 mg/l) is commonly exceeded in Illinois, Michigan, North Carolina, and Tennessee. Secondary standards for chloride and/or sulfate (both 25 mg/l) are locally exceeded in Colorado, Illinois, Michigan, Tennessee, and Texas. Nitrate in excess of the primary standard of 45 mg/l is common in shallow alluvial deposits at both the Colorado and Texas sites.

Water hardness shows some variation among the sites. Soft to slightly hard groundwater is typical of the Arizona site and the deep aquifers at the Texas site. Hard to very hard groundwater is typical for the shallow alluvium at the Texas site and is, in general, typical of the Colorado, Illinois, Michigan, and North Carolina sites. Groundwater at the Tennessee site shows somewhat more variability, ranging from soft to very hard, but relatively hard water is most typical of the site. The one unique groundwater quality identified was naturally elevated radium levels in the region of the Illinois site. In general, data for metals and radiologic constituents and parameters is limited.

The water quality management plans of some of the proposed states include antidegradation provisions to protect the quality of waters. Five of the seven states have specific antidegradation or nondegradation policies which relate to groundwater. Of the remaining two, Texas has a general degradation policy and has a committee that is working on antidegradation rules which may be in place in about a year. Colorado has implemented a system designed to set groundwater standards, classify aquifers, and characterize them based on chemical standards. These antidegradation policies are targeted to "prevent the degradation of water quality" but rely on the "best technical judgment" of their staff rather than on radiological or chemical concentration limits. All of the proposed states allow variances, determined on a case-by-case basis, considering social and economic factors. There are no sole-source aquifers at any of the sites.

4.2.3 Water Use

The characteristics of water use at the site alternatives are compared in Table 4-4. In general, surface water resources are limited at the Arizona and Colorado sites while relatively abundant at the Illinois, Michigan, North Carolina, Tennessee, and Texas sites. Groundwater resources are available but limited in areal extent or with depth at the Arizona, Colorado, North Carolina, and Tennessee sites. Local and regional aquifers and relatively abundant groundwater resources occur at the Illinois, Michigan, and Texas sites.

4.2.3.1 Surface Water Use

Current surface water use in the vicinity of each of the sites is different. The data available for water use for each site, and even for different uses at the same site, is of variable quality and completeness. Nonetheless, some general comparisons can be made concerning the types of uses and, in some cases, the approximate amounts of surface water used in the vicinity of each site.

The Arizona and Colorado sites have little surface water available. Arizona uses the least--only what can be collected in cattle tanks for stock watering. Colorado also has small collection ponds or tanks for stock watering in the site vicinity, but no records exist for this water use. Beyond the immediate site vicinity in Colorado, surface water from the South Platte River is applied to a broader spectrum of uses. Very little surface water is presently used in the Illinois site vicinity except as cooling water at Fermilab. Surface water use in the Texas site vicinity is around 11,000 acre-ft/yr. The water uses in Texas are municipal, industrial, and agricultural. Surface water use in North Carolina and Tennessee is approximately 33,000 and 22,000 acre-ft/yr,

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Table 4-4

COMPARISON OF WATER USE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Water Resource Available	Essentially no local surface water; limited groundwater in alluvial basin aquifers; recoverable groundwater in storage in proposed source (Northern Vekol Valley) estimated 2.0-3.1 million acre-ft.	Surface water limited at site; site streams intermittent; South Platte River heavily used and committed; groundwater limited to alluvial aquifers and weathered zones in Pierre Shale; Hay Gulch aquifer (proposed source) contains 2,000,000 acre-ft storage, annual recharge of 7,000 acre-ft/yr.	Extensive groundwater and surface water resources; perennial streams; groundwater in glacial drift, shallow and deep bedrock; bedrock aquifers most developed; safe yields of 85,000 and 19,000 acre-ft/yr for combined glacial-drift/shallow-bedrock and deep-bedrock aquifers respectively.	Extensive surface and groundwater resources; surface water in perennial streams and reservoirs; groundwater in glacial drift, shallow bedrock; and deep bedrock aquifers.	Extensive surface water resources; surface water in perennial streams and reservoirs; distributed rural water-supply systems; limited groundwater in near surface weathered/fractured zones in metamorphic and igneous rocks.	Extensive surface water resources in perennial streams and reservoirs that are heavily used; limited groundwater development from shallow (up to 200 ft depth) fractures and dissolution zones in limestone bedrock; safe yield estimates suggest 100,000 acre-ft/yr of groundwater available in shallow aquifer beneath the site.	Extensive surface water resources in reservoirs; groundwater resources in shallow alluvium (minor) and deep sandstone aquifers (major).
Current Surface Water Use	Limited to stock watering from ponds; imported surface water used for agriculture in Gila Bend Basin to the west.	Only minor stock and agriculture use except for South Platte River north of site.	Very limited use: Fox River is industrial supply at Fermilab - 1,300 acre-ft/yr; some municipal use.	In two-county area total use is about 125,000 acre-ft/yr, primarily power plant cooling water (97%), remainder (3%) used for irrigation and industrial; surface water largely undeveloped.	Total use in site vicinity is about 47,500 acre-ft/yr; 65% residential, 13% irrigation, 17% cooling, commercial and industrial (5%).	Total use in site vicinity is about 20,600 acre-ft/yr; 50% residential, 29% commercial, and 21% industrial.	Total use in Ellis County is about 5,700 acre-ft/yr; 83% municipal, 9% manufacturing, and 8% livestock.

Table 4-4 (Cont)

COMPARISON OF WATER USE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Current Groundwater Use	About 45,000 acre-ft/yr primarily for irrigation in Waterman Wash; minor rural domestic/stock use; basins to north and west are overdrafted; limited use in proposed source basin; municipal/industrial needs of remote population centers (Maricopa, Avondale, Buckeye) served by water districts each pumping 500 to 6,000 acre-ft/yr of groundwater from a few wells - total annual use is about 12,300 acre-ft/yr; very few wells in the immediate vicinity of site.	About 30,000 acre-ft/yr; primary users include Beaver Creek irrigation 16,300 acre-ft/yr, Fort Morgan and Brush pump 4,700 acre-ft/yr for municipal and industrial uses, utility pumps 5,000 acre-ft/yr for cooling; Hay Gulch aquifer presently pumped at 800 acre-ft/yr; slight local overdraft possible; limited to moderate number of wells in immediate vicinity of site.	Total use in the Kane-DuPage County area is about 148,000 acre-ft/yr, combined shallow and deep aquifer systems each provided about half of the total; approximate distribution 48% residential, 21% commercial, 11% industrial, 20% other; deep bedrock aquifer regionally overdrafted, shallow bedrock aquifer locally overdrafted; project municipal use to decrease as Lake	About 52,000 acre-ft/yr in SSC project area; 90% of use is for public supply, 6% for irrigation, remainder (4%) for industrial and power generation; additional unquantified rural-domestic, and industrial use is small in comparison to municipal use; local overdraft of groundwater near Lansing and Jackson pumping centers; moderate number of wells in site vicinity.	About 1,450 acre-ft/yr, primarily for rural-domestic and irrigation use; industrial/commercial use is minor, no recorded municipal use; pumpage small and unlikely to exceed recharge; moderate to large number of wells in site vicinity.	About 8,000 acre-ft/yr primarily for rural domestic/stock use and municipal supply; irrigation and industrial/commercial is minor; pumpage not likely to exceed recharge; large number of wells in site vicinity.	Total use in Ellis County is about 8,700 acre-ft/yr (67% from Trinity Group, 33% from Woodbine); uses include clude 66% municipal, 32% manufacturing, 2% mining and livestock; pumping has historically exceeded recharge to deep sandstone aquifers and these are regionally overdrafted; use projected to decline after 1990 as municipalities switch to surface water; limited to moderate number of wells in site vicinity.

Table 4-4 (Cont)

COMPARISON OF WATER USE CHARACTERISTICS OF SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
			Michigan use increases; wide-spread use; large number of wells in site vicinity.				
Water Use Trends* (Annual Change)	Increase in ground-water (<1%) use	Increase in surface water (<1%) and groundwater (1-4%) use	Increase in surface water and ground-water use. Total water use should increase 1-3%.	Increase in surface water (<1%) and groundwater (1-3%) use.	Increase in surface water (1%) and groundwater (1%) use.	Increase in surface water (1%) and groundwater (1%) use.	Increase in surface water (5%) use; decrease or stable groundwater use.

*Based on population growth trends and projections by Federal and State agencies (see Appendix 7)

Sources: Arizona: Brooks 1988a; Hollett and Marie 1987. Colorado: Engineering Professionals, Inc. 1987; Halffield 1988; HRS Water Consultants, Inc. 1986; McClary 1988; Norton, Underwood and Lamb, Inc. 1988; Simpson 1988. Illinois: Illinois State Water Survey 1988; Kirk 1987; Visocky and Schulmeister 1988. Michigan: Bartholic et al. 1982; Bedell 1982; Huffman 1985; Van Till and Scott 1986. North Carolina: Carolina Power and Light Company 1977; Mann 1978; North Carolina Department of Natural Resource and Community Development 1988a and 1988b. Tennessee: Tennessee Department of Health and Environment 1988. Texas: Texas Water Development Board 1976 and 1988.

respectively. The uses in North Carolina and Tennessee are municipal, irrigation and other agricultural, industrial, and cooling water. In the Michigan site vicinity, 97 percent of the surface water use is for power plant cooling.

4.2.3.2 Groundwater Use

Groundwater is developed in the vicinity of all of the sites. It is most extensively developed around the Arizona, Colorado, Illinois, and Michigan sites where groundwater use ranges from about 30,000 to approximately 56,000 acre-ft/yr. Groundwater use at the Tennessee and Texas sites is approximately 8,000 to 9,000 acre-ft/yr, and at the North Carolina site, it is approximately 1,450 acre-ft/yr. Irrigation use is dominant in Arizona and Colorado. Municipal supply use is dominant in Illinois, Michigan, and Texas, and is notable in Tennessee. Rural domestic/stock use, while not volumetrically large, is a significant use in Colorado, Illinois, Michigan, North Carolina, Tennessee, and Texas.

Present groundwater use locally exceeds recharge to the most heavily developed aquifers at or near the Arizona, Colorado, Illinois, Michigan, and Texas sites. Overdraft is not large or areally extensive at the Arizona, Colorado, or Michigan sites. Little, if any, regional or localized groundwater overdraft is apparent at the North Carolina or Tennessee sites.

Groundwater use is not projected to increase significantly at any of the sites except in Illinois. Future increased reliance on surface water sources, including transfer of some municipal water supply systems from groundwater to surface water sources near the Illinois and Texas sites, would reduce projected increases in regional groundwater overdrafts. Although no detailed projections are available, only a slow growth in local groundwater use is likely in Arizona, Colorado, Michigan, North Carolina, and Tennessee.

4.3 CLIMATE AND METEOROLOGY

The climates at the site alternatives are compared below in qualitative terms for temperature, precipitation, wind, humidity, and severe weather. Qualitative and quantitative discussions of the sites' climates are presented in Appendix 5. Table 4-5 delineates climatic data for the seven site alternatives.

4.3.1 Temperature

Temperatures at the site alternatives can be characterized both in terms of diurnal variation (average difference between daily high and low temperatures) and annual averages. Temperatures at the Arizona and Colorado sites have the largest diurnal variation, averaging between 25 and 30 degrees F. The Texas site has the next highest average diurnal variation, between 20 and 25 degrees F. The Illinois, Michigan, North Carolina, and Tennessee sites have diurnal variations ranging between 10 and 20 degrees F.

Average annual temperatures are warmest at the Arizona site, followed in descending order by the Texas, North Carolina, Tennessee, Colorado, Illinois, and Michigan sites.

4.3.2 Precipitation

Precipitation at the site alternatives is best characterized by type, amount, and annual distribution. The Arizona site receives all of its annual precipitation as rain. The North Carolina, Texas, and Tennessee sites typically receive most precipitation as rain with little, or none, as snow. The Colorado, Illinois, and Michigan sites normally receive annual precipitation as a combination of rain and snow.

The amount of annual precipitation at each of the sites varies greatly. Arizona typically receives the least precipitation. In ascending order, the Colorado, Texas, Illinois, Michigan, and North Carolina sites receive greater rainfall. The Tennessee site receives the greatest average annual precipitation.

The annual distribution of rainfall also varies greatly by site. The Arizona site has a distinctly bimodal distribution, with winter and summer peaks in the monthly precipitation averages. The Colorado, Illinois, and Michigan sites generally receive the majority of the annual precipitation during the summer growing season. The Texas site receives most of its precipitation during winter and spring. At the Tennessee and North Carolina sites, precipitation is generally well-distributed on an annual basis.

4.3.3 Winds

Average annual winds at the site alternatives range from medium to light. The Texas site has the highest annual average wind speed, followed in decreasing order by the Colorado, Illinois, Michigan, North Carolina, Tennessee, and Arizona sites.

Table 4-5

COMPARISON OF CLIMATE DATA FOR SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Highest monthly high temp (°F)	101	90	85	86	90	91	95
Month of highest temp	Aug	Jul	Jul	Jul	Jun, Aug	Jul	Jul, Aug
Lowest monthly low temp (°F)	64	40	32	33	55	31	57
Month of lowest temp (°F)	Dec	Jan	Jan	Jan	Jan, Dec	Jan	Jan, Dec
Record high temp (°F)	123	105	105	105	105	107	112
Record low temp (°F)	22	-30	-23	-24	-2	-15	-8
Peak monthly heating degree days	474	1,132	1,200	1,181	691	778	625
Total heating degree days per year	1,765	6,283	6,500	6,232	3,191	3,578	2,500
Total cooling degree days per year	3,000	700	1,050	650	1,500	1,800	2,500
Mean annual precipitation (in)	10.33	15.62	33.57	30.68	46.12	50.60	32.21

Table 4-5 (Cont)

COMPARISON OF CLIMATE DATA FOR SITE ALTERNATIVES

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Mean annual snowfall (inches as snowfall)	0.0	36.0	36.0	36.0	4.0	7.0	3.0
Annual average wind speed (mi/h)/direction*	5/W	11/SW	10/NNE	10/NE	8/NE	8/N	13/N
Mean annual relative humidity (%)	40	60	73	73	70	70	63
Mean annual dewpoint (°F)	41	31	40	39	49	49	51
Tornado point return period, yr	4,750	960	770	1,400	2,300	2,300	590
Fastest wind speed, 100-yr return period, mph	77	88	82	87	90	85	70
Thunderstorms, yearly frequency	27	50	57	46	62	77	51

* Direction toward which the wind is blowing

Sources: Baldwin 1974; Changery 1981; Herschfield 1961; Lewis 1983; Thom 1963, 1968; U.S. Department of Commerce 1968.

4.3.4 Humidity

Average annual relative humidity at the site alternatives varies from 75 to 40 percent. The Illinois and Michigan sites have the highest average annual relative humidity, followed in descending order by the North Carolina, Tennessee, Texas, Colorado, and Arizona sites.

4.3.5 Severe Weather

Severe weather, which includes extreme winds, thunderstorms, and tornadoes, is experienced in varying amounts at each of the site alternatives. The North Carolina site has the highest expected 100-yr return period wind speed, followed by the Colorado, Michigan, Tennessee, Illinois, Arizona, and Texas sites. The Tennessee site has the highest annual frequency of thunderstorms, followed by the North Carolina, Illinois, Texas, Colorado, Michigan, and Arizona sites. The site with the highest frequency of tornadoes is Texas, followed in descending order by the Illinois, Colorado, Michigan, North Carolina, Tennessee, and Arizona sites.

4.4 AIR QUALITY

The following discussion compares conditions which affect air pollutant dispersion, background air quality, and emissions inventories for the site alternatives. Detailed discussions of the background data on a site-specific basis are presented in Appendix 5.

4.4.1 Conditions Affecting Air Quality

The primary conditions that affect the ability of the atmosphere to dissipate air pollutants include the height of the mixing layer in the atmosphere, average wind speed within the mixing layer, and amount of incoming solar radiation. The mixing layer in the atmosphere is the region in which relatively vigorous vertical mixing occurs. An increase in the volume of the mixing layer results in greater dispersion of air pollutants. An increase in the average wind speed also produces greater air pollutant dispersion, as does a greater amount of incoming solar radiation.

Through evaluation of the above dissipation factors, the number of days per year of high air pollution potential can be determined. Holzworth's number (Holzworth 1972) is a function of the height of the mixing layer and the average wind speed within the mixing layer. This number reflects only the meteorological potential for high ambient concentrations of air pollutants. In the absence of air pollution sources, high air pollutant concentrations would not be realized (see Section 4.4.3 for potential sources). The potential for an area to have high levels of air pollution is a function of the height of the mixing layer and the average wind speed within the mixing layers.

Based upon Holzworth's analysis (AP-101, 1972), a rough indicator of the potential number of days in 5 years that could have high air pollution potential is:

Arizona	-	10-20
Colorado	-	<10
Illinois	-	<10
Michigan	-	<10
North Carolina	-	10-20
Tennessee	-	20-30
Texas	-	0

This data should be viewed with caution since only mixing height and wind speed data were considered in deriving the above estimates. Several meso- and synoptic scale meteorological variables (i.e., meso-scale corrective precipitation systems, low-level nocturnal jets, wind persistence, and atmospheric turbulence) influence the potential for episodic air pollution conditions.

4.4.2 Ambient Air Quality

Background ambient air quality at each site is compared with the primary National Ambient Air Quality Standards (40 CFR 50) or State Ambient Air Quality Standards (AAQS) in Table 4-6. The monitoring data in Table 4-6 were compiled from a variety of sources. Because of the lack of background data, no PM_{10} (particulates having an equivalent aerodynamic diameter less than 10 microns) values are shown.

Under the Clean Air Act, regions which fail to comply with the AAQS primary standards for specific pollutants are designated as nonattainment areas for that pollutant. Once an area is so designated, it must demonstrate air quality better than the AAQS for a number of calendar quarters before it can be redesignated as attainment. Current SSC possible host regions (meaning county(s) with the SSC facility or some portion actually inside their boundaries) that have previously been designated as nonattainment are as follows:

Illinois	-	Ozone
Michigan	-	Ozone
Tennessee	-	Ozone

On June 6, 1988, the U.S. Environmental Protection Agency (EPA) published a notice of proposed rulemaking in the Federal Register (53 FR 20722) soliciting comments on possible interpretations of the Mitchell-Conte Amendment passed by Congress on December 22, 1987. This amendment proposed the designation of carbon monoxide and ozone nonattainment areas under the Clean Air Act. Numerous potential SSC host counties or portions of them were included on the EPA's list of areas and may be so designated in the near future. The effect of this proposed rulemaking on the SSC is discussed in Section 5.1.3.2.

Table 4-6

COMPARISON OF AMBIENT AIR QUALITY DATA FOR SITE ALTERNATIVES

Pollutant	AAQS[a]	Arizona[1]	Colorado[2]	Illinois[3]	Michigan[4]	North Carolina[5]	Tennessee[6]	Texas[7]
	Concentration (µ/m3)							
Total Suspended Particulate								
- 24-h average	260	91	160	130	107	81	90	55
- Annual geometric mean	75	70	58	46	45	47	44	32
Sulfur Dioxide								
- 24-h average	365	33	21	168	99	90	111	50
- Annual mean	80	2	3	8	15	15	32	8
Nitrogen Dioxide								
- Annual mean	100	15	4	26	34	28	49	28
Carbon Monoxide[b]								
- 1-h average	40,000	13,752	2,292	8,300	23,700[8]	26,000[8]	17,000[8]	11,110
- 8-h average	10,000	6,876	1,146	5,400	10,400[8]	15,000[8]	12,000[8]	8,360
Ozone[b]								
- 1-h average	235	154	183	218	253[9]	228	206	295[9]
Lead								
- Calendar quarter average	1.5	0.3	0.4	0.08	0.06	0.4	0.2	0.7

a. Ambient Air Quality Standards (Primary). All seven states also have secondary AAQS for TSP of 150 $\mu g/m^3$ 24-h average and 60 $\mu g/m^3$ annual geometric mean.

b. Monitoring data in Table 4-6 indicate that not all of these areas are currently above the NAAQS.

1. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Means; SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, NO_2 - Annual, CO - 1 h, CO - 8 h, O_3 - 1 h. Sierra Estrella Sailport, 1978. Pb - Calendar Quarter Average, Tucson, 1986.
2. Points of Measurement: TSP - 24 h, , SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, NO_2 - Annual, CO - 1 h, CO - 8 h, O_3 - 1 h, Pawnee Generating Station, 1985. Pb - Calendar Quarter Average, Denver (CAMP), 1986. TSP - Annual Geometric Mean, Brush, 1985
3. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Mean, West Chicago, 1986. SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, O_3 - 1 h, Pb - Calendar Quarter Average, Elgin, 1986. NO_2 - Annual, Lemont, 1986. CO - 1 h, CO - 8 h, Cicero, 1986.
4. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Mean, Lansing (Holy Cross School), 1986. SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, Lansing (Eastern High School), 1986. NO_2 - Annual, Detroit (Osborn High School), 1986. CO - 1 h, Detroit (Stopel Park), 1986. CO - 8 h, Detroit (West Union), 1986. O_3 - 1 h, Pb - Calendar Quarter Average, Lansing, 1986.
5. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Mean, CO - 1 h, CO - 8 h, Durham, 1985. SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, Pb - Calendar Quarter, Greensboro, 1985. NO_2 - Annual, Winston-Salem, 1985. O_3 - 1 h, Wake Forest, 1985.
6. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Mean, Murfreesboro, 1986. SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, Nashville, 1986. NO_2 - Annual, Memphis, 1986. CO - 1 h, Nashville (9th and Broadway), 1986. CO - 8 h, Nashville (North 7th), 1986. O_3 - 1 h, Nashville (East Health Center), 1986. Pb - Calendar Quarter, Nashville (McCann School), 1986.
7. Points of Measurement: TSP - 24 h, TSP - Annual Geometric Mean, Palmer, 1986. SO_2 - 3 h, SO_2 - 24 h, SO_2 - Annual, NO_2 - Annual, Fort Worth (North-West), 1986. CO - 1 h, CO - 8 h, Fort Worth (Downtown), 1986. O_3 - 1 h, Dallas (North), 1986. Pb - Calendar Quarter, Baton Rouge, Louisiana, 1986. (Texas did not report Pb monitoring.)
8. The only ambient carbon monoxide data available was that associated with sampling in downtown Detroit, Durham, and Nashville. There is no reason to believe these numbers are representative of conditions at the proposed sites. They were used because they were the only quantitative data located and probably represent hypothetical worst case scenarios that are overly conservative in nature. It is not believed that the carbon monoxide NAAQS are or will be exceeded at any of the sites.
9. These O_3 exceedances were measured in large metropolitan centers and are not representative of the rural SSC sit

Sources: Arizona Department of Environmental Quality 1987; Colorado Department of Health and Environment 1987; Illinois Environmental Protection Agency 1987; Michigan Department of Natural Resources 1987; Provident Energy Company 1987; Louisiana Department of Environmental Quality 1987; North Carolina Division of Environmental Management 1986; Tennessee Department of Health and Environment 1987; Texas Air Control Board 1987, U.S. Environmental Protection Agency 40 CFR 50.

4.4.3 Regional Air Pollutant Sources

The ambient air quality at the site alternatives is influenced by the quantity of pollutant emissions in the region and by the dispersion characteristics of the site. Table 4-7 shows the estimated yearly emissions of pollutants from sources in the host counties for each proposed site.

Table 4-7

COMPARISON OF QUANTITIES OF REGIONAL POLLUTANT EMISSIONS FOR SITE ALTERNATIVES

Air pollutant source	AZ[a]	CO[b]	IL[c]	MI[d]	NC[e]	TN[f]	TX[g]
Total suspended particulates (TSP)[1]	295,291	111,648	33,850	34,373	25,893	24,010	22,847
Sulfur dioxide (SO_2)[1]	16,090	32,639	5,152	14,969	114,390	3,855	15,302
Nitrogen dioxide (NO_2)[1]	98,075	52,758	35,610	22,729	81,354	10,950	26,830
Carbon monoxide (CO)[1]	265,095	102,024	175,172	116,742	56,430	49,812	24,780
Volatile organics (VOC)[1]	102,522	25,729	64,250	31,425	20,283	25,571	5,807

1. Ton/yr
a. Maricopa County
b. Adams, Morgan, and Washington Counties
c. DuPage, Kane, and Kendall Counties
d. Ingham and Jackson Counties
e. Durham, Granville, and Person Counties
f. Bedford, Marshall, Rutherford, and Williamson Counties
g. Ellis County

Source: U.S. Environmental Protection Agency 1988a, 1988b.

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4.5 NOISE AND VIBRATION

This section compares background sound levels, sensitive noise receptors, and ambient human-induced vibration conditions for the site alternatives. Detailed site-specific discussions on these topics are presented in Appendix 5.

4.5.1 Noise

Noise is most commonly measured and reported in units of dBA (decibels-A-weighted scale, that which is audible to the human ear), which approximates the frequency-dependent response of the human ear to sound. The specific, all-purpose measure recommended for use is the day/night sound level, A-weighted (L_{dn}). L_{dn} accounts for the increased sensitivity of human receptors to noise during sleeping hours, which are usually at night. The average sound level (A-weighted), L_{eq}, is also a recognized all-purpose measure. L_{eq} makes no special allowance for nighttime sound levels (U.S. Environmental Protection Agency 1982).

The noise environment at each of the site alternatives is characterized by ambient noise level and by major factors that influence that ambient noise level. These major factors, in the absence of large or unusual noise sources, are related to land use. Rural or unindustrialized land use generally has the lowest average background level; highly developed areas have the highest average background levels. Based on land use, the average day/night sound level (L_{dn}) at the Arizona, Colorado, North Carolina, Tennessee, and Texas sites is approximately 40 dBA (U.S. EPA 1982). The average day/night sound level at the Illinois and Michigan sites is approximately 50 dBA (U.S. Environmental Protection Agency 1982).

The noise environment can also be characterized by facilities, animals, or humans present to receive any increases in the ambient noise level. These sensitive receptors, which include residences, churches, parks, and other noise-sensitive land uses, are present in varying quantities at each of the site alternatives. In terms of the number of humans close to project facilities, the Illinois site has the most, followed by North Carolina, Michigan, Tennessee, Texas, Colorado, and Arizona. Noise-sensitive wildlife are addressed under Section 4.7, Ecological Resources.

4.5.2 Vibration

Major influences on ground motion, especially in the lower frequency ranges to which the SSC is sensitive, include local and distant seismic activity, local railroad and freeway traffic, local blasting, and local drilling activities.

Roads cross the plane of the collider ring at each of the site alternatives. Railroads cross the plane of the collider ring at the Arizona, Illinois, Michigan, North Carolina, Tennessee, and Texas sites. Blasting and drilling occur within 5 mi of the vicinity of the Illinois, Michigan, North Carolina, Tennessee, and Texas sites.

4.6 ENVIRONMENTAL HAZARDS AND WASTE

This section describes the existing background radiation at all seven sites in terms of both natural and man-made components. Additionally, nonradioactive environmental hazards are summarized for the seven sites. A description of the availability of nonhazardous waste management facilities is presented. Detailed descriptions of these existing conditions can be found in Appendix 5.

4.6.1 Environmental Radiation

There are three existing sources of individual exposure to radiation: naturally occurring background sources, industrial and agricultural sources introduced by man, and radiation used in medical diagnosis and treatment.

The main source of naturally occurring background radiation is radon. Radon is a radioactive gas that evolves from uranium, thorium, and radium--elements that are present in minute amounts throughout much of the earth's surface. Uranium, thorium, and radium are also present to a greater or lesser extent in rocks and rocky materials both on and below the earth's surface. As a result, stone and brick building materials are also a source of natural background radiation. These and other sources of radioactivity produce a secondary effect which is not negligible. This effect is that all human sources of food, drink, and even air have been inevitably exposed to the natural background and contain very low levels of radioactivity. When they are inhaled or ingested by humans, some of the radioactivity remains in the body, and the human body itself becomes a source of radioactivity. Also contributing to this are the minute fractions of radioactive isotopes naturally occurring in some of the elements the human body requires, such as potassium and phosphorus.

The magnitude of this effect can be expressed with the unit used to measure the biological dose of radiation in humans for any type of radiation--the rem. It is convenient to use a smaller derivation of the rem, the millirem (mrem), which is 1/1000th rem. The average annual radiation dose to an individual from external radiation (terrestrial and cosmic rays) and internal radiation is about 100 mrem; the dose from radon may be as much as 200 mrem.

Industrial and agricultural sources of radioactivity contribute approximately 5 to 13 mrem/yr to the total annual dosage to an individual. These sources include nuclear power plant discharges, the burning of coal (there are usually minute amounts of naturally occurring uranium in coal), and the use of potassium-containing fertilizers in agriculture which contain small amounts of uranium and thorium and their daughters which over time can build up. The use of fertilized lands for residential development housing has a potential impact on possible radiation exposures.

Finally, the largest contributor of man-made radiation dose is medical x-rays which can contribute substantially to the annual dosage to an individual. Through the use of Federally-mandated manufacturing and use standards enforced by state radiation control agencies, the dose has been significantly reduced but not totally minimized. The national average annual dose for an individual is approximately 39 mrem from medical x-rays and 14 mrem from nuclear medicine procedures.

The total average background dose to an individual is approximately 360 mrem/yr.

4.6.1.1 Natural Radioactivity

A. Cosmic Rays

Cosmic rays enter the earth's atmosphere from space. They are attenuated greatly by the earth's atmosphere, so the actual exposure rate to an individual depends upon altitude. All of the proposed sites, except Colorado, are at roughly the same altitude, so cosmic ray background at those sites is approximately the same. The Colorado site's cosmic ray background is about 20 percent higher than the other sites.

B. Radon

Radon is a gaseous radionuclide produced by radioactive decay of radium, which in turn is produced as a result of radioactive decay of uranium and thorium. Although certain geologic conditions are more likely to include uranium and thorium than others, the presence of trace amounts of these elements at any specific location is not predictable in general geologic terms. In fact, a very local concentration of radon may exist in an area where it is otherwise rare, or conversely, a local absence of radon may occur in an area of considerable concentration. It follows that measurements of high levels of radon in one spot or locality do not necessarily indicate a general presence of radon in a wider associated area. Measurements of radon in living areas and basements have been made throughout the United States and, particularly, in many counties within the proposed sites. These measurements are given in Tables 4-8 and 4-9. The differences in levels among the various counties and the various states are probably not significant.

C. Soil/Rock

Radionuclide concentrations in the soil and at tunnel depth at the proposed sites are presented in Tables 4-10 and 4-11. The number of samples from each of the sites was small; consequently, differences among sites are probably not significant.

Table 4-8

COMPARISON OF CURRENT RADON LEVELS IN LIVING SPACE OF HOMES IN THE REGIONS OF THE SITE ALTERNATIVES

		PROPOSED SSC REGION OF INFLUENCE COUNTIES/STATE						
PARAMETER	U.S.	AZ	CO	IL	MI	NC	TN	TX
Radon Levels***								
Geometric Mean pCi/l*								
Counties	1.8	1.8	2.7	NC	NC	1.2	NC	**
State		2.0	3.3	1.5	1.3	2.0	2.6	1.6
Average pCi/l*								
Counties	4.0	2.5	3.2	2.9	1.8	1.6	2.8	**
State		3.2	5.4	2.3	2.4	3.3	3.1	5.5
Percentage of Homes								
<4 pCi/l								
Counties	80	94	61	82	94	100	82	**
State		83	60	87	89	78	80	85
4-20 pCi/l								
Counties	18	4	29	18	6	0	18	**
State		15	37	13	11	20	18	14
>20 pCi/l								
Counties	2	2	0	0	0	0	0	**
State		2	3	0	0	2	2	1

* Rounded to nearest tenth
** Not Available
*** Weighted averages for living plus living/basement spaces
NC - Not Calculated
Sources: Cohen 1988; Gilkeson et al. 1988; Tennessee Department of Health and Environment Division of Radiological Health 1987; U.S. Environmental Protection Agency 1987.

Table 4-9

COMPARISON OF CURRENT RADON LEVELS IN BASEMENTS OF HOMES IN THE REGIONS OF THE SITE ALTERNATIVES

PARAMETER	U.S.	AZ	CO	IL	MI	NC	TN	TX
				PROPOSED SSC COUNTIES/STATE				
Radon Levels***								
Geometric Mean pCi/l*								
Counties	3.4	**	5.1	NC	NC	2.6	NC	**
State		6.4	6.1	2.5	1.9	2.8	3.7	3.5
Average pCi/l*								
Counties	7.9	**	5.2	4.1	3.7	2.9	6.4	**
State		6.8	9.4	3.8	3.2	3.9	6.3	5.8
Percentage of Homes								
<4 pCi/l								
Counties	59	**	14	61	66	100	25	**
State		0	30	71	83	68	55	38
4-20 pCi/l								
Counties	34	**	86	38	34	0	75	**
State		100	63	28	16	32	40	62
>20 pCi/l								
Counties	7	**	0	1	0	0	0	**
State		0	7	1	1	0	5	0

* Rounded to nearest tenth
** Not Available
*** Weighted averages for basement spaces
NC - Not Calculated
Sources: Cohen 1988; Gilkeson et al. 1988; Tennessee Department of Health and Environment, Division of Radiological Health 1987

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Table 4-10

COMPARISON OF BACKGROUND CONCENTRATIONS OF RADIONUCLIDES IN SURFACE SOILS IN THE REGIONS OF THE SITE ALTERNATIVES

				PROPOSED SITE				
Radionuclide	U.S.	AZ	CO	IL	MI	NC	TN	TX
				(pCi/g)*				
Radium-226 (Avg)	(1.1)	(1.3)	(1.3)	(1.0)	(0.5)	(0.8)	(1.1)	(0.8)
Range	0.2-4.4	<0.3-2.0	0.8-1.8	0.7-1.2	0.3-1.2	0.5-1.2	(0.7-1.4)	0.4-1.1
Uranium-238 (Avg)	(1.0)	<LLD	(1.1)	(0.9)	(2)	(0.2)	(1.0)	(0.8)
Range	0.1-3.8		0.8-1.7	0.3-1.2	0.08-15.0	<0.0-0.4	0.7-1.3	0.5-1.5
Thorium-232 (Avg)	(1.0)	(1.3)	(1.2)	(1.0)	(0.1)	(0.7)	(1.0)	(0.9)
Range	0.10-3.4	1.1-1.6	0.9-1.6	0.3-1.2	0.0-0.3	0.6-0.8	0.7-1.5	<0.0-1.5

Avg - Average Value
LLD - Lower limit of detectability
* Rounded to nearest tenth
Sources: Borak 1987; Gilkeson et al. 1988; Jobst 1981; McKlveen 1985, 1987; Myrick 1981; North Carolina Department of Human Resources, Radiation Protection Section 1988b; Teledyne 1988; Texas Department of Health 1988; X-Ray Assay Laboratory 1988.

Table 4-11

COMPARISON OF BACKGROUND CONCENTRATIONS OF RADIONUCLIDES IN ROCK AT TUNNEL DEPTH OF THE SITE ALTERNATIVES

	PROPOSED SITE						
Radionuclide	AZ	CO	IL	MI	NC	TN	TX
				(pCi/g)*			
Radium-226 (Avg)	(1.3)**	(1.5)	(0.3)	(0.4)	(0.3)	(0.4)	(0.6)
Range	<0.3-2.0	1.2-1.9	0.1-0.5	0.2-0.6	0.1-0.8	0.4	0.3-1.3
Uranium-238 (Avg)	<LLD	(0.8)	(0.3)	(0.2)	(0.5)	(0.3)	(0.6)***
Range		0.6-0.9	0.1-0.5	0.0-0.5	0.1-1.7	0.3	0.3-1.3
Thorium-232 (Avg)	(1.3)	(1.3)	(0.1)	(0.1)	(0.4)	(0.4)	(1.0)
Range	1.1-1.6	1.1-1.5	0.0-0.2	0.3-0.5	0.1-1.2	0.4	<0.1-1.6

Avg - Average Value
LLD - Lower limit of detectability
* Rounded to nearest tenth
** Values for Soil
*** Calculated

Sources: Borak 1987; Gilkeson et al. 1988; Jobst 1981; McKlveen 1985, 1987; Myrick 1981; North Carolina Department of Human Resources, Radiation Protection Section 1988b; Teledyne 1988; Tennessee Department of Health and Environment 1987; Tennessee Division of Radiological Health 1988; Texas Department of Health 1988; X-Ray Assay Laboratory 1988.

D. Water

Water provides a major mechanism for the transport of radionuclides in the environment as well as pathways for exposure through drinking and (to a lesser extent) submersion. Table 4-12 lists the radioactivity in surface water at the proposed SSC sites. The radium content of surface waters is low, 0.3 to 1.8 pCi/l (Hess 1985), compared to most groundwaters. Dissolved radium adsorbs quickly to solids and may migrate far from its place of release to groundwater. Radioactivity in groundwater at the proposed SSC sites is listed in Table 4-13. Few samples have been taken from the sites, and differences in surface and groundwater radioactivity measured among the sites are probably not significant.

Although some water supplies in northern Illinois contain higher-than-average radium-226 concentrations, the radon-222 concentrations are not necessarily higher than the national average. Also, the higher radium-226 concentrations in water do not necessarily imply that radium-226 concentrations in the sandstone are higher than normal, but may be caused by conditions favoring the release of radium. Sandstones with high radium-226 concentrations are not expected to be encountered at the proposed tunnel depth in Illinois.

4.6.1.2 Man-Made Radiation

The National Council on Radiation Protection and Measurements has estimated that the annual dose equivalent in the United States population from man-made radiation is 5 to 13 mrem/yr. Table 4-14 summarizes the sources of man-made radiation at the proposed sites. In addition to those listed, other possible sources of radioactivity are:

On-site radioactive byproducts from existing activities	None for any of the sites
Building materials	Normal and identical for all sites
Nuclear power plant exhaust plume within 10 mi	None for any of the sites
Spent fuel storage installation	None for any of the sites
Federal facilities on site	None except Fermilab in Illinois

4.6.1.3 Dose Equivalent Rate from Environmental Background

Because radon is usually the major contributor to environmental background radiation, and because of the uncertainties in predicting the presence of radon on the basis of its existence in local areas, all of the sites appear to be approximately equivalent with regard to the existence of background environmental radiation.

Table 4-12

COMPARISON OF BACKGROUND CONCENTRATIONS OF RADIONUCLIDES IN SURFACE WATERS IN THE REGIONS OF THE SITE ALTERNATIVES

RADIONUCLIDE	PROPOSED SITE: AZ	CO	IL	MI	NC	TN	TX
			(pCi/l)*				
Uranium (Avg)	No surface	<2.1	**	(2.6)	**	**	**
Range	water	<2.1		1.6-3.6			
	found						
Radium-226 (Avg)	No surface	0.7	**	(1.1)	**	**	(0.4)
Range	water	0.7		<0.7-1.8			0.3-0.5
	found						
Gross Alpha (Avg)	No surface	1	1.3***	**	(0.8)	(3)	(7.3)
Range	water	1	0-3.4		1.2-1.5	1-6	0.2-46
	found						
Gross Beta (Avg)	No surface	26	5.3***	**	(0.9)	(1)	10.9
Range	water	26	3.5-6.2		<0.2-1.5	0-3	3.7-51
	found						

Avg - Average Value
*   Rounded to nearest tenth
** Not Available
*** Based on analyses of Fox River water at Elgin in 1976, State of Illinois.
Sources: Borak 1987; Gilkeson et al. 1988; McKlveen 1985, 1987; North Carolina Department of Human Resources 1986, 1987, 1988b; Teledyne 1988; Tennessee Department of Health and Environment 1987; Texas Department of Health 1988.

Table 4-13

COMPARISON OF BACKGROUND CONCENTRATIONS OF RADIONUCLIDES IN GROUNDWATER IN THE REGIONS OF THE SITE ALTERNATIVES

RADIONUCLIDE	PROPOSED SITE AZ	CO	IL	MI	NC	TN	TX
				(pCi/l)*			
Uranium (Avg)	**	(7.8)	**	(1.9)	(1.9)	**	**
Range		2.1-9.9	0.2-2.5	<0.2-5.6			
Radium-226 (Avg)	(0.1)	(0.5)	(7.3)	(1.0)	**	**	(0.5)
Range	0.0-0.2	0.3-0.9	0.5-15.2	<1-1.2			0.4-0.7
Gross Alpha (Avg)	(12.93)	(2.6)	(1.2)	**	(3.1)	(28)	(5)
Range	<8.9-17.1	1.4-5	<LLD-4.6		0.3-8.5	<LLD-121	<10
Gross Beta (Avg)	(7.2)	(10)	(2.8)	**	(2.5)	(9)	(5.2)
Range	6.2-8.2	2.7-26	<LLD-16.1		0.7-4.6	<LLD-39	3.6-7.1

Avg - Average value
LLD - Lower level of detectability
* Rounded to nearest tenth
** Not Available
Sources: Borak 1987; Gilkeson et al. 1988; McKlveen 1985, 1987; North Carolina Department of Human Resources 1986, 1987, 1988b; Teledyne 1988; Tennessee Department of Health and Environment 1987; Texas Department of Health 1988.

Table 4-14

SOURCES OF MAN-MADE RADIOACTIVITY IN THE REGIONS OF THE SITE ALTERNATIVES

Source	Proposed Site AZ	CO	IL	MI	NC	TN	TX
NRC licenses for radioactive material	21	42	125	700	17	25	86
Phosphate-fertilized fields	Low Usage	Low Usage	High Usage	High Usage	Moderate Usage	Moderate Usage	Moderate Usage
Coal-fired power plants	None	Pawnee Generating Station	None	None	Mayo Lake Plant	None	None
Uranium-Thorium mining/milling/processing operations	None	None	Kerr McGee*	None	None	None	None
State Licensees	445	461	1,216	0	533	669	2,145
50-mi emergency planning zone (from SSC campus)	Palo Verde-1 Palo Verde-2 Palo Verde-3	None	Dresden-2 Dresden-3 LaSalle County-1 LaSalle County-2 Braidwood-1 Braidwood-2 Zion-1 Zion-2 Byron-1 Byron-2	None	None	None	None

* Inactive facility

Sources: Conference of Radiation Control Program Directors 1987; NRC Region III 1988.

4.6.2 Nonradioactive Environmental Hazards

4.6.2.1 Hazardous/Toxic Materials

A summary of the hazardous/toxic materials (HTM's) existing at or near, or suspected to be present at or near, the seven sites is presented in Table 4-15. The review of potential environmental hazards at each site was based on the assumption that there are basically two ways that workers or the public could encounter these hazardous substances: 1) from soil or groundwater contamination; or 2) upon release from storage, distribution, or industrial operations. Potential sources were also categorized by location relative to the proposed siting of the SSC facilities and in the area beyond the ring to a distance of 1 mi. Similarly, industrial sources were investigated within the SSC ring, within 1 mi of the proposed ring, and in the area between 1 and 5 mi of the ring.

None of the sites was found to have known soil or groundwater contamination within the area of the proposed SSC facilities. At both the Colorado and Michigan sites, small amounts of soil contamination as a result of residues from former oil and gas operations may possibly be encountered. One such location is within the area of the Michigan site (Grobe 1988) and several other possible locations are former oil wells at the Colorado site (McHugh 1988).

Two of the sites, Michigan (Godbold 1988) and Tennessee (Moore 1988), have locations of known soil and groundwater contamination within 1 mi of the SSC ring. The Colorado site has a number of potentially contaminated locations from former oil well operations within the 1-mi corridor (McHugh 1988).

Illinois has existing industrial sources of HTM's within the proposed ring. Both the Fermilab and an AT&T facility have potentially releasable materials on their site (O'Brien 1988). The Arizona site has a natural gas pipeline and a proposed crude oil pipeline that cross the SSC ring at the same location (beam absorber area only). The proposed Texas site has a total of 13 oil and gas pipelines that cross the SSC footprint at various locations.

Industrial sources of HTM's within 1 mi of the SSC ring were found in Illinois (O'Brien 1988), Michigan (Godbold 1988), North Carolina (Crosby 1988; Butler 1987), and Tennessee (Moore 1988). In addition, industrial sources just beyond the 1-mi corridor were found in Illinois (O'Brien 1988) and North Carolina (Crosby 1988; Butler 1987).

A potential hazard exists at the proposed North Carolina site. A portion of the SSC ring would pass through the edge of the firing range at Camp Butner which could contain unexploded ordnance (North Carolina National Guard 1987).

Table 4-15

POTENTIAL HAZARDOUS/TOXIC MATERIAL SOURCES IN THE IMMEDIATE AREAS OF THE SITE ALTERNATIVES

Category	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Soil or water contaminants within SSC proposed ring	None	Possible small residue from oil well brine pits	None	Possible soil contaminant from former gas desulfurization plant	None	None	None
Soil or water contaminants outside of ring but within 1 mi	None	None	None	Groundwater contaminant from landfill Allied	None	General Smelting & Refining Co. (soil & groundwater contaminants)	None
Industrial sources within SSC ring	Existing natural gas pipeline crosses beam absorber area Proposed crude oil pipeline will cross beam absorber area	None	Fermilab (Waste storage) AT&T	None	None	None	13 existing oil and gas pipelines cross the footprint
Industrial sources outside ring but within 1 mi	None	None	Pride Petroleum Co. Lear Siegler, Inc. Griffin Wheel Co. James River/ Handi-Kup No Sag Products Corp.	Gas processing plant (CONOCO)	Alumark Corp.	General Smelting & Refining Co.	None
Industrial sources more than 1 mi beyond the ring, but less than 5 mi	Proposed small oil refinery; 3 mi from ring near Mobile	None	Valley Maid Ice-cream CAMSCO Produce	None	Eaton Corp. Channel Master Co.	None	None
Ordnance	None	None	None	None	Possible unexploded ordnance from Camp Butner	None	None
Biologic pathogens	Valley Fever Spores	None	None	None	None	None	None

Potentially hazardous geologic materials, such as natural gas and petroleum resources, are discussed in Sections 4.1.5 and 4.1.6.

4.6.2.2 Biological Hazards

Only the Arizona and Texas sites were found to contain any known biological hazards that could potentially affect the SSC project. Flora were not included in the definition of a biological hazard.

A potential hazard exists in Arizona that is unique among the sites. The proposed SSC site is located in an area that is known to be a source of the fungal spore Coccidioides immitis. This pathogen thrives in undisturbed arid soil and through airborne transport can cause a disease in humans known as Valley Fever (Coccidioidomycosis). The spores can be transmitted over long distances by high winds (U.S. Environmental Protection Agency 1983a). The Rainbow Valley (located just north of the SSC site) has been characterized as a source of the spore, as well as the area west of Mobile (Leathers 1982).

The effects of this disease most commonly resemble a bad cold, but can sometimes (in about one-third of the cases) lead to a more serious, debilitating illness. It has been estimated that two-thirds of all adults who have lived in Valley Fever endemic areas have acquired immunity to the disease after having been initially infected, usually manifesting no symptoms (U.S. Environmental Protection Agency 1983a).

The proposed Texas site is located within the area of the southeastern United States that is infested with the imported fire ant, Solenopsis sp. (TDA 1986). Residents near the proposed site have reported heavy infestations on their property and indicate that the ants have caused numerous problems with the operation of home and farm equipment. Fire ants appear to be attracted to electrical equipment and can cause shorts by chewing through insulation and by crowding into spaces around electrical contacts. They are also attracted to moisture (TDA 1986).

In addition, fire ants can pose a potential health risk since their bite is painful and can sometimes lead to other, more serious reactions in human victims. For most people, a fire ant sting would result in the formation of a pustule, accompanied by pain and itching that lasts about a week. If the pustule is broken, infection is possible and would require medical attention. For a few people who are particularly sensitive to the fire ant venom, a sting can result in anaphylactic shock which would require immediate medical attention.

4.6.3 Solid and Industrial Waste Management

A. Existing Sewage Treatment Plants

There are no sewage treatment plants in the area of the proposed Arizona site. Domestic wastes from ranches near the site are disposed of at their point of origin.

There are four existing sewage treatment plants in Colorado within 25 mi of the SSC site. The closest plants are located at Brush and Fort Morgan, about 20 mi away. The cumulative excess capacity of the Brush and Fort Morgan sewage treatment plants is about 2.1 million gal/d. Sewer service in the rural areas of Morgan County is provided by septic tanks.

There are 14 existing sewage treatment plants within about 20 mi of the Illinois campus site. The remaining cumulative excess capacity of these 14 plants is about 27 million gal/d. The existing Batavia wastewater treatment plant is the closest one to the SSC campus (approximately 3 mi). This plant has about 1 million gal/d excess capacity.

There are about 20 sewage treatment plants within 30 mi of the Michigan site. The remaining cumulative excess capacity of these plants is about 64 million gal/d. The existing Stockbridge sewage treatment plant is the closest to the campus (approximately 1 mi). This plant has about 0.04 million gal/d excess capacity.

There are two existing sewage treatment plants within 5 mi of the North Carolina site. The cumulative excess capacity of these plants is about 1.2 million gal/d. The Butner sewage treatment plant is the closest (4 mi) and has an excess capacity of about 1 million gal/d.

There are two existing sewage treatment plants within 20 mi of the Tennessee site. The cumulative remaining excess capacity of these plants is about 7 million gal/d. The Murfreesboro sewage treatment plant is the closest, located about 8.5 mi from the campus, and has about 5 million gal/d excess capacity.

There are about nine existing sewage treatment plants within 20 mi of the Texas site. The cumulative excess capacity of these plants is about 1.75 million gal/d (based on current daily average flowrate). The Waxahachie sewage treatment plant is the closest (6 mi). Based on a daily average flow rate, the remaining excess capacity of this plant is about 0.3 million gal/d.

B. Existing Sanitary Landfills

There are three existing sanitary landfills with remaining excess capacity in the area of the proposed Arizona site, but these landfills presently do not accept solid waste from other communities. The solid waste from the site could go to either of two proposed (southwest and northwest) regional landfills.

In the area of the proposed Colorado site, there are four sanitary landfills each with excess capacity of more than 10 years. The Morgan County landfill is the closest, located about 25 mi from the site. This landfill has about 25 to 50 years of remaining capacity.

There are four sanitary landfills in the area of the proposed Illinois site with remaining excess capacity of more than 12 years. The Settlers Hill landfill (5 mi from the site) and Winnetka Municipal landfill (30 mi from the site) have remaining capacities of 12 and 14 years, respectively.

There are seven sanitary landfills in the area of the proposed Michigan site with more than 10 years of remaining capacity. These landfills are within about 50 mi of the site. The closest one is the Ann Arbor landfill (35 mi) which has a remaining capacity of 10 to 15 years.

There are four landfills with remaining capacity of about 5 years in the area of the proposed North Carolina site. These landfills are located about 25 mi from the site.

There are three landfills with more than 5 years of remaining capacity in the area of the proposed Tennessee site. The Rutherford County landfill (BFI) is the closest (13 mi) and has about 17 years of remaining capacity.

There are about 20 landfills in the area of the proposed Texas site with more than 10 years of remaining capacity. The closest landfill is the Waxahachie landfill which has a remaining capacity of about 15 years and is located about 6 mi from the site.

4.7 ECOLOGICAL RESOURCES

Ecological resources are the biological organisms and the processes (interactions) among populations and communities occupying the terrestrial, wetlands, and aquatic environments in the vicinity of the site alternatives. Species within these natural ecosystems may also have social value. These values include: 1) protected status because of threatened or endangered listing; 2) commercial harvest, especially livestock and stocked fish; 3) recreationally hunted/fished; or 4) culturally important (especially of Native American religious significance). The only culturally important species considered are feral burros in Arizona.

There are three primary levels within ecosystems which may be impacted by the proposed action. These are: 1) populations--the presence, productivity, and distribution of species which are permanent or seasonal residents of the area; 2) communities--the spatial and seasonal patterns exhibited among the various associations of species occupying the area; and 3) system level dynamics--the total energy captured and the nutrients accumulated among the populations and within soils determining sensitivity to disturbance and the rate of recovery from disturbance.

4.7.1 Ecological Resources of the Site Alternatives

The site alternatives contain many of the lowland ecosystems typical of the continental United States. The diversity of the biological communities is high at each site. The sites differ radically in the portion of the sites remaining in natural state and in the numbers/types of important populations including threatened and endangered (T&E) species. The types of habitats present in Areas A and B (Areas A, B, and C for Illinois) are shown for each state in Table 4-15A.

The desert shrub communities at Arizona's proposed site are the most pristine of the seven sites, although ecological resources are widely used for recreational activities. While cattle grazing and off-road vehicle traffic and other recreational activities have had some localized influences in the area, many wilderness characteristics are still apparent. This is reflected in the Wilderness Study Area designation of part of the site vicinity. No wetlands are present at the proposed Arizona site.

Colorado's proposed site is rural but modified from short-grass and mixed-grass prairie to croplands and pasture. The site and surrounding area are typical of the western great plains, occupied by populations of prairie wildlife such as pronghorn antelope, raptors, and migratory birds. Some wetlands are scattered throughout the proposed site area.

The Illinois site has largely been disrupted by development of residential, agricultural, and industrial facilities. This site is perhaps the most ecologically altered of the seven sites. However, biota are plentiful and pockets of natural systems (prairie, wetlands, and woodlots) are found throughout the area. A restored prairie area is maintained on the Fermilab property.

Table 4-15A

ACRES OF HABITAT WITHIN AREAS A AND B

State	A+B Areas Total	AG	NS	UD	Wetlands (Included in NS)
AZ	2,050	0	2,050	0	0
CO	2,050	1,260	790	0	3
IL	2,630[1]	1,000	940	690	620[2]
MI	2,050	1,860	190	0	163
NC	2,050	310	1,730	10	38
TN	2,050	1,510	540	0	35
TX	2,050	1,880	110	60	2

1 Portions of the A, B, and C areas within the Fermilab property.

2 Total area of wetlands on the Fermilab property minus 280 acres of cooling canals and other water bodies associated with the existing Fermilab facilities.

AG = AGRICULTURAL
NS = NATURAL SYSTEMS INCLUDING WETLAND
UD = URBAN/DEVELOPED

Michigan, North Carolina, Tennessee, and Texas are somewhat similar in their rural, populated patchworks of farms, forests, and residential areas. Michigan has a large number and a wide variety of wetlands in the vicinity of the ring. Wetlands in North Carolina are also relatively abundant and diverse in nature. Wetlands are not prominent features of the Tennessee and Texas project areas. Michigan, North Carolina, and Tennessee have forests that provide diverse habitats, especially at the borders between croplands, forests, and wetlands. The Tennessee site is in an area of karst topography. There is a large cave system in the area that supports unique fauna.

Texas has limited but similar forest habitats in the northwest portion of the proposed site. The majority of the Texas site acreage is developed into croplands and pasture.

Table 4-16 summarizes characteristics of the site alternatives. The Arizona site lacks appreciable aquatic habitats or wetlands. The Colorado and Texas sites have relatively few wetlands and aquatic systems in the proposed ring locations. In contrast, the Illinois and Michigan sites contain the greatest number and amounts of wetlands and aquatic systems, while intermediate amounts occur at the Tennessee and North Carolina sites.

Natural ecological productivity of the ecosystems generally declines in the order from the southeastern Piedmont sites to the western sites. The lowest annual productivity is associated with the Sonoran desert systems of the Arizona site. Nutrient conservation mechanisms are important in all systems. Western ecotypes rely more heavily on nitrogen fixation by algae and bacteria than the eastern systems which recover and recycle more than 90 percent of the nitrogen inventory via plant litter decomposition and root uptake of nitrate and ammonium ions.

Economically and recreationally important populations occur at all seven sites. Livestock production is appreciable at all seven sites. The highest cattle production is in the proposed Colorado site region; the highest pig and hog production is in the proposed Illinois site region. Cattle production is lowest in the proposed Arizona site region because of low range carrying capacities. Hunting of mammal and bird populations is popular in all areas as are recreational activities such as birdwatching.

While fishing is an important recreational use of fish species in Colorado, these resources are located 10 to 15 mi northwest of the site. Fishing is also popular in the immediate area of the Illinois, Michigan, North Carolina, Tennessee, and Texas sites.

4.7.2 Drainage Basin Processes and Types

The ecological systems at the site alternatives are as varied as the physiographic regions in which they are found. Sections 4.1 and 4.2 discuss geological and water resources of the regions.

The drainage basin potentially affected by the Arizona SSC site is the Gila River drainage basin. In the area of the proposed site, there is only ephemeral flow in the Gila River because of upstream diversions for earlier developments.

The three subdrainage basins of the Gila River within the site are:

- Vekol Wash in the east which drains into the Gila River northeast of the site (50 percent of the basin)--Arizona Upland Association.

- Waterman Wash which drains into the Gila River due north of the site (40 percent) of the basin)--mostly Lower Colorado Association.

Table 4-16

COMPARISON OF ECOLOGICAL CHARACTERISTICS OF SITE ALTERNATIVES

	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
Drainage basin(s)	Gila River	South Platte River	Fox River, West branch DuPage River	Grand River, Huron River	Neuse, Tar, and Roanoke watersheds	Tennessee River, Lower Cumberland River	Trinity River
Dominant system	Sonoran Desert	High plains, short-grass prairie	Eastern deciduous Forest, remnant prairie	Eastern deciduous forest	Upland deciduous forests, mixed, conifer forests	Eastern deciduous forests; cave systems	Central Texas prairie
Terrestrial ecotypes	Arizona Upland Lower Colorado desert scrub	Croplands, rangelands swales/ floodplains alkali range	Upland forests, savanna, mesic, wet, remnant prairie, croplands	Upland and lowland forests and woodlots, forested and emergent wetlands, cropland	Woodlands, croplands, pasture	Woodlands, Croplands, Pasture	Woodlands, grasslands, croplands, pasture
Aquatic ecotypes	Dry washes, stock ponds, water catchments	South Platte tributaries, reservoirs	Fox River, small ponds, impoundments	Grand River	Neuse, Tar, Roanoke rivers, and tributaries	Duck, Tennessee, Hoover, and Cumberland rivers, ponds, impoundments	Lake Bardwell, numerous small streams
Wetlands	None present	Palustrine, riverine, and lacustrine systems	Palustrine, riverine, and lacustrine systems	Palustrine, riverine, and lacustrine systems	Palustrine, riverine, and lacustrine systems	Palustrine and riverine systems	Palustrine, riverine, and lacustrine systems
Economically, recreationally, and culturally important species (See Appendix 5)	Bighorn sheep, Gambel's quail, rabbits, mule deer, javelina, coyote, burros	Mule deer, pronghorn antelope, white-tailed deer, doves, mallard, pheasant, bass, perch, walleye, crappie, sunfish	Numerous game birds, mammals, numerous game fish	Numerous game birds, mammals, numerous game fish	Numerous game birds, mammals, numerous game fish	Numerous game birds, mammals, numerous game fish	Numerous game birds, mammals, numerous game fish

- o Bender Wash in the west which drains into the Gila River west-southwest of the site (10 percent of the basin)--Lower Colorado Association.

The ecosystems within this drainage basin are moderately undisturbed desert scrub systems that: 1) are slow to recover from disturbance, 2) exhibit stochastic productivity (rapidly growing and reproducing during periods of water availability), and 3) have nutrient cycles that depend on atmosphere/soil (including microbial-invertebrate interactions)/vegetation interactions.

The ecotypes within the Arizona site are two forms of desert scrub, the Arizona Upland and Lower Colorado associations. These associations occupy more than 90 percent of the proposed site. There are negligible aquatic ecosystems in the area. Ephemeral associations are especially associated with temporary catchments used for livestock and wildlife watering. There are no permanent ponds or perennial streams in the area.

The one xeroriparian association in the area is the Sonoran riparian woodlands. The woodland ecotype is limited to the two ephemeral washes traversing the site.

The drainage basin potentially affected by the SSC in Colorado is tributaries to the South Platte River. The subdrainages of the South Platte basin were originally gently rolling grasslands, typical of the Great Plains. The two potentially affected subdrainages are:

- o Beaver Creek, the largest, originates in the high plains to the south near Limon and drains approximately 60 percent of the site.

- o Badger Creek also originates in the high plains, but to the southwest, and flows to the north paralleling Beaver Creek on the west; it drains approximately 40 percent of the site.

The ecosystems within the drainage basin are high plains mixed and short-grass prairie, modified by dryland cropping and some irrigated agricultural areas. These ecosystems are water limited but are productive and recover from stress rapidly. Nutrient cycling of the prairie is dependent on atmosphere/soil/vegetation interactions.

Within the Colorado ROI, the distribution of ecotypes is approximately: cropland (90 percent); mixed-grass (7 percent); short-grass prairie (3 percent); swales, floodplains (1 percent); and alkali range (1 percent). Most of the noncropland areas are grazed.

Aquatic ecosystems include Riverside, Empire, Jackson, Prewitt, Barr, and Horse Creek reservoirs and the Mile-High Lakes Area, which is a series of small ponds and reservoirs north of Bromley Lake managed primarily for waterfowl. Lotic systems in the Colorado region include a series of intermittent and perennial streams within the South Platte

River drainage from its confluence with the Cache La Poudre River to Sterling. There are numerous small streams that are tributaries of Beaver and Badger Creeks.

The proposed Illinois site is located within a transitional zone between the eastern lake and the till plain section of the interior lowlands physiographic province. The great majority of the proposed SSC site lies within the Fox River Drainage Basin. A small portion of the site is drained along the eastern edge by the West Branch of the DuPage River near West Chicago. The final portion of the site, along the northwestern edge, drains west to the South Branch of the Kishwaukee River.

The terrestrial ecotypes in the area of the Illinois site include: upland forests; palustrine, lacustrine, and riverine wetlands; savannah; mesic prairie, and prairie reconstruction; agricultural systems, including timberlands, row croplands, and hayfields; and successional old fields.

Aquatic ecotypes in the area include small ponds and lakes, reservoirs, and numerous miles of first and second order streams and small rivers. The aquatic portion of the three-county area is approximately 8 percent and provides substantial aquatic resources.

The proposed Michigan SSC site is located almost entirely within the Grand River Basin, with a small amount of drainage to the upper reaches of the Huron River Basin to the east.

The site is located within a number of ecotypes: forest, agricultural, and several types of wetlands. Both terrestrial and aquatic ecotypes are diverse throughout the vicinity. The terrestrial ecotypes include: upland and lowland forests and woodlots; agricultural systems, including timber, row crops, orchards, pasture, and rangeland; and palustrine, lacustrine, and riverine wetlands.

The area of the proposed North Carolina site includes several headwaters, first and second order streams, and small reservoirs used for surface water storage. These include:

- o Neuse watershed, including the Flat River, Deep Creek, Lake Michie, Lake Butner, and Knap of Reeds Creek, is a 168-mi^2 watershed in the western portion of the site. Deep Creek flows into Flat River almost due west of the proposed campus, and the river then flows into Lake Michie south of the site; first order streams flow south through the proposed campus and drain into Lake Butner which subsequently flows through Knap of Reeds Creek south to the confluence with Flat River.

- o Tar watershed, including Cub Creek, Shelton Creek, Jackson Creek, as well as a diverse dendritic pattern of first order streams flowing southeast into the Tar River, is approximately two-thirds of the proposed site area but smaller in total size than the Neuse watershed, having an area of 122 mi^2.

- Roanoke watershed, including Mill Creek and Mayo Creek, drains from the northwest portion of the site north into the Mayo Reservoir, which flows into the Roanoke River.

The proposed North Carolina site occupies an area of diverse mesic terrestrial and aquatic ecosystems. Wetland types include palustrine, lacustrine, and riverine systems. The majority of the terrestrial systems are upland communities in some stage of oak-hickory succession. Most are second growth; few are mature deciduous forests. There is a high proportion of cleared land, regrowth area, and planted coniferous woodlands, largely loblolly pine. There are several relatively rare plant communities; the most notable are the Upland Depression Swamp Forests.

The proposed SSC alignment in Tennessee is bisected by the divide between the Tennessee River and the Lower Cumberland River. The Tennessee River basin is located in the south and east and the Lower Cumberland is located to the north and west. Within the area of the ring are the headwaters of the East Fork Stones River, the West Fork Stones River, and the Harpeth River (tributaries of the Lower Cumberland River). Tributary drainage along the north side of the Duck River between Shelbyville and Henry Horton State Park are part of the Tennessee River Basin.

The Tennessee site is in an area of diverse terrestrial communities that vary principally with soil depth and moisture. Hardwood forests and other deep soil communities are intermixed with shallower soil-based red cedar communities and shallow soil cedar glades. Palustrine and riverine wetlands are scattered throughout the area. Small communities may occur around sinkholes that contain species dependent upon higher soil moisture conditions. Both these sinkhole-dependent and cedar glade communities are characterized by the possible presence of endemic, relict, or other unusual plant and animal species.

The site is also located in an area of karst development. The Snail Shell Cave system underlies the site. The system is a braided network of parallel streams with lateral passages which support several endemic species.

Numerous freshwater aquatic communities, including small ponds, streams, and rivers, are present in the area of the SSC site. Some of the smaller streams in the area are subject to seasonal dryness in all but the deepest pools. Wetlands along stream and river courses are not common but do occur. The number and quality of aquatic communities in the area are typical of middle Tennessee, with the exception of the absence of larger rivers.

The Texas SSC site is in the central part of the Trinity River Basin. Major drainage systems within the project site include Red Oak Creek, Waxahachie, Big Onion, and Chambers Creeks. In addition to the various streams transsecting the SSC ring area, other major surface water features of the project area include Lake Waxahachie and Lake Bardwell, located on Waxahachie Creek; several floodwater-retarding structures of the Soil Conservation Service located on tributaries of Waxahachie and Chambers Creeks; and numerous small surface water impoundments.

The productive clay loam soils of the central Texas prairies, commonly referred to as the Blacklands because of the soil color, support extensive agricultural development. Blackland prairie occupies a narrow band up to 60 mi wide oriented along a north-south axis from roughly Dallas in the north to San Antonio in the south.

Most of the upland areas of the proposed Texas SSC site are in cropland or pasture or an area in some stage of secondary succession associated with past cultivation. Lowlands are typically cultivated or in pasture. The few wetlands in the area include palustrine, riverine, and lacustrine systems. Successional communities in the uplands are typically dominated by mesquite. Lowlands in succession, especially those along Waxahachie, Mustang, Grove, and Red Oak Creeks, are dominated by an elm-sugarberry forest.

Native Blackland prairie is rare and the increasing pressure of urbanization in the area is causing the remaining examples to diminish. No intact prairie remnants are present in the area proposed for the SSC, although several examples are found in the county.

4.7.3 Sensitive Terrestrial/Aquatic Communities

Most sites have sensitive communities, relic populations, or unusual, remnant associations. These are often noted by their inclusion in state-managed lands. Each proposing state has state statutes protecting species which have significance in the region or are locally threatened or endangered.

4.7.3.1 Arizona

The Arizona site, as well as large expanses of the surrounding desert, supports populations of three state threatened species, the desert tortoise, Gila monster, and the desert bighorn sheep. The Maricopa Mountains are covered by terrestrial plant and animal communities that are similar to those in the immediate region. The Maricopa Mountains and surrounding areas support a few xeroriparian areas, but these are neither extensive in acreage nor well developed.

Populations of the desert tortoise are limited to mountain pediments rocky slopes, and washes. While the factors limiting tortoise distribution to these areas are not completely understood, requirements provided by these areas may include the availability of ungrazed habitat and water. The hiding places available for the Gila monster may similarly limit its range. The bighorn sheep migrations within the site and the requirements during lambing season will also continue to limit their range. The javelina, mostly located in the bajadas and Maricopa Mountains, are at the northern edge of their range within the area.

Tortoise densities in the northern Maricopa Mountains have been estimated recently as high as 57 individuals/mi^2. The densities of tortoises in the mountain areas are considered to be highly productive, one of the highest in the southwestern United States. Tortoise densities are typically much lower in lowland habitats (Lower Colorado Association).

The bighorn sheep are a State-protected species in Arizona, as are several species which are Federally protected or candidates for threatened or endangered listing. The Mexicana desert bighorn sheep occupy a significant portion of the proposed SSC site. The total population of bighorn sheep in Arizona currently ranges between 2,000 and 3,000 individuals. While they are common in western Arizona, the bighorn sheep are rare or absent from much of their traditional habitat in central and southwestern Arizona.

Over the last decade, the sheep population has been declining in the state. Hunting is severely restricted and probably does not represent the major reason for the decline. Principal threats include encroachment including roads, power lines, land development, and mineral exploration; competition with the burro and cattle; disease; and disruption of the migration routes (U.S. Department of the Interior Bureau of Land Management 1987).

Prime habitat in the project area occurs in the Maricopa Mountains. The density of sheep in the area approximates one to five per 10 mi^2. The population densities, recruitment rate, and characteristics have not been thoroughly documented.

The Gila monster, a venomous reptile, is probably present in the SSC region of influence in stable populations. However, documentation of the populations is minimal, and the species occurs throughout the Sonoran region of the southwestern United States and Mexico. The Gila monster is a USFWS Category 2 species, but is not currently classified as threatened under the State program. However, it is "protected", requiring a Scientific Collecting or Management Research Permit for removal or collection.

4.7.3.2 Colorado

Riparian vegetation is uncommon and consequently of major importance to wildlife populations in northeastern Colorado. These areas are described in Section 4.7.5.2. The Pronghorn antelope is a sensitive species in Colorado. They are disturbed by human presence, fencing, and noise. The species inhabits short-grass and mixed-grass prairie land. The site is also known to support populations of Swainson's hawk and ferruginous hawk, which are both candidate species for Federal listing, and may also contain prairie dog towns, which provide potential habitat for the Federally listed endangered black-footed ferret. The two State-listed species are widely distributed and have large ranges when compared with the area affected by the proposed action.

4.7.3.3 Illinois

Illinois has many small remnant ecotypes which host communities and populations which are sensitive or ecologically important. There are 17 natural areas and nature preserves in the area, including DOE reservations (Fermilab and Argonne National Laboratory (ANL)).

The prairie reconstruction project on the Fermilab site represents a unique opportunity to redevelop an area of mesic prairie in the proposed project site. Approximately seven prairie remnants are located in the vicinity of the proposed SSC site.

Remnant woodland communities are present as are a few acres of savannah. Most of these communities are found in protected lands.

There are no plants or animals common to the area or of economic importance or which are Federally listed threatened/endangered that are at the extent of their range in the proposed SSC site. Because of the patchwork nature of the area, there are numerous transition zones favoring successional development and providing diverse wildlife habitat.

Illinois lists 87 State-protected species whose ranges may include the general region of the site. However, many of these are associated with specific micro habitats in floodplains, wetlands, and protected areas, e.g., parks, and are not expected to be found in the areas proposed to be disturbed.

4.7.3.4 Michigan

Similarly, Michigan contains many small sensitive communities in the area of the proposed site. One tract of black spruce receives special protection and study at the Waterloo Recreation Area. Other plants in the vicinity common to the spaghnum bogs of the area are also protected at the recreation area.

There are several unique communities in the vicinity of the Michigan site. Both the Waterloo Recreation Area and the Haehnle Wildlife Sanctuary contain numerous unique communities. The Haehnle Wildlife Sanctuary is especially important because of the sandhill crane habitat which is protected there. A unique dry, mesic southern forest is located near the recreation area. An unusual wetland bog is located in the recreation area. A good example of a marsh habitat is present at the Haehnle Wildlife Sanctuary.

A state champion pignut hickory tree, largest and oldest known to occur in the state, is located on or near Area B of the proposed collider alignment.

Transitional zones exist throughout the Michigan site because of the diversity of ecotypes.

The Dansville State Game Area is located within the proposed ring. The Waterloo State Recreation Area and Haehnle Wildlife Sanctuary, operated by the Audubon Society, are located on the southeast boundary of the proposed site. Several other small areas of particular ecological interest are in the vicinity of the Michigan site.

Michigan has several protected species in the general area of the site. These are almost all plants and most are present in wetland environments (see Volume IV, Appendix 5, Section 5.7.4).

4.7.3.5 North Carolina

There are no natural ecosystems protected by statute within the proposed North Carolina SSC site area. Natural areas, having unique or unusual resources, have been identified throughout North Carolina by the North Carolina Natural Heritage Program. Several of these natural areas are in the vicinity of the proposed SSC site. Although these sites are defined primarily on the basis of their botanical resources, some of them provide habitat for locally or regionally rare animal species.

These sites are: Goshen Gabbro forest (statewide); Vernon Hill Church Road dry forest (regional); Roanoke, Neuse, and Tar River basins--aquatic habitat (regional); Flat River slopes above Lake Michie (regional); Mayo Creek slopes (local); Timberlake--poorly drained upland forest (local); South Flat River rock outcrops (local); and Flat River slopes at Red Mountain (local). Descriptions of these areas are presented in Volume IV, Appendix 11 along with the discussion of site-specific impacts.

The proposed SSC site in North Carolina is located in the middle of the Piedmont physiographic province and no major transition zones are present. The proposed site area involves the watersheds of three river systems near their headwaters. These three rivers all flow to the Atlantic and support similar flora and fauna.

There is one Federally-listed endangered plant, harperella, and several State-protected species in the area of the proposed North Carolina site. The plants are primarily Piedmont remnant species found in old fields and within transition zones. They occur in areas with circumneutral or basic soils; some have prairie affinities. The Roanoke bass is known in the site headwaters and is particularly sensitive to increased sedimentation and alteration of its habitat.

4.7.3.6 Tennessee

No areas protected by statute are known to occur within the collider ring alignment proposed for Tennessee. State-protected lands, such as Cedars of Lebanon State Park, are nearby.

Middle Tennessee, the site of the proposed SSC alignment, is characterized by many diverse types of habitats. As a result, there are numerous transitional areas. Rock outcroppings and cedar glades are intermixed with pasture lands, croplands, and forests. The relatively large number of bird and small mammal species present in the area is in part a result of this diversity and variability. Additionally, the site traverses a divide between the Tennessee River and the Lower Cumberland River. These two basins, while similar, do have differences in average rainfall and in general terrain.

Many of the threatened and endangered species are found in or associated with cedar glade communities. Cedar glades are the most distinctive botanical resource of the area, occupying flat limestone natural openings in the cedar or cedar-hardwood forests. These openings may range from several square yards to several acres in size. Cedar glades are characterized by assemblages of particular plant species, some of which occur only in cedar glades (endemic). Bridges and Orzell (1986) estimate that there are 16 endemic or near endemic plant species associated with cedar glades in Middle Tennessee. These species are reported to represent approximately 6 percent of the native flora of the area. Cedar glade endemics include plants such as glade cress, necklace glade cress, limestone fameflower, and leafy prairie clover. Cedar glade plant communities are relatively common in the general area of the proposed SSC.

The Snail Shell Cave system is the longest continuous cave in the Central Basin of Tennessee. The system is a braided network of parallel streams with lateral passages with small wet-weather streams and residual pools and upper levels that act as water conduits only during flood stage (Barr 1988). The cave system is physically isolated by shaly noncavernous formations that preclude gene flow among many groups of obligate cave animals. The known fauna of the system include several endemics, as well as certain small, more widely distributed subterranean species. The system contains three, possibly four, endemic animals limited to caves and other subterranean microhabitats: the blind cave salamander, the cave snail, the Trechine cave beetle, and possibly the cave millipede (Barr 1988).

There are several rivers and streams in the area of the proposed site. The riparian communities in these areas are described in Section 4.7.5.6.

4.7.3.7 Texas

In Texas two man-made lakes, Lake Waxahachie and Lake Bardwell, are used for flood control, water supply, and recreation. There are several unique riparian woodland areas in the vicinity of the proposed SSC ring. While these areas are not unique, they are very uncommon and of key importance to many wildlife species for food and cover; they are also the habitat for a number of the less common plant species in the area. The White Rock Escarpment, west of the proposed Texas SSC site, has been known to serve as a unique habitat for several endangered species.

The proposed site falls within the Texas Biotic Province. The Texas Biotic Province is a transition zone between eastern mesic forests and northern and western arid grasslands. On a more local level, the major portion of the Texas site area is agricultural land. Transition zones expected in the vicinity include agricultural/ woodlands, agricultural/wetlands, and woodlands/wetlands. There are no designated wildlife refuges in the project vicinity. Eleven species of animals that exist in Ellis County are listed as threatened or endangered by the State. No State-listed plant species are known to occur in Ellis County.

Some native blackland prairie grasslands occur as remnants in Ellis County, however no extensive surveys of the area are known. The grasslands are very rare due to agricultural practices and urbanization.

4.7.4 Threatened, Endangered, and State-Protected Species

4.7.4.1 Federally Listed Species

Federally listed threatened and endangered species and candidate species in the vicinity of the proposed sites are summarized in Table 4-17. None of the site alternatives is located on or near any of the critical habitats for these species designated by the U.S. Fish and Wildlife Service (USFWS). A review of the descriptions published through October 1, 1986, demonstrates the project will not affect critical habitats if located at any of the site alternatives (U.S. Department of the Interior 50 CFR 17). See the USFWS consultation letters attached to Volume IV, Appendix 11.

In the general areas of the proposed sites, there are few listed threatened and endangered species. By site, these can be summarized as:

State	Number of Federally Listed Species (Identified by the USFWS as Potentially Present)	
	Threatened and Endangered	Candidate and Review
Arizona	1	5
Colorado	9	10
Illinois	5	6
Michigan	1	4
North Carolina	1	6
Tennessee	4	11
Texas	6	0

North Carolina has no listed threatened and endangered species. In Colorado, listed species are associated with the South Platte or Colorado Rivers. These species may require consideration only if there are changes to the water withdrawn from these systems.

The USFWS has indicated that there is one endangered species near the proposed Arizona site, the Tumamoc globeberry. This is a perennial vine which is associated with shrubs and small trees. In the winter, there is no visible growth above ground. Recent surveys identified the globeberry south of Interstate 8 in the vicinity of the southern portion

Table 4-17

FEDERALLY LISTED AND CANDIDATE THREATENED AND ENDANGERED SPECIES IN THE REGIONS OF THE SITE ALTERNATIVES

ARIZONA[1]	COLORADO[2]	ILLINOIS[3]	MICHIGAN[4]	NORTH CAROLINA[5]	TENNESSEE[6]	TEXAS[7]
Tumamoc globeberry (E)	Streaked ragweed (C2)	Forked aster (C1)	Kittentails (C2)	Harperella (E)	Tennessee purple coneflower (E)	Bald eagle (E)
Neolloydia sp. (C1)	Colorado butterfly plant (C1)	Lakeside daisy (T)	Indiana bat (E)	Carolina madtom (C2)	Gray bat (E)	Black-capped vireo (E)
Nightblooming cereus (C2)	Piping plover (T)[8]	Salamander mussel (C2)	Log sedge (C2)	Smooth cone flower (C2)	Indiana bat (E)	Whooping crane (E)
Desert tortoise (C2)	Whooping crane (E)[8]	Illinois mud turtle (C2)	Bog bluegrass (C2)	Barbara's buttons (C2)	Tan riffle shell mussel (E)	Arctic peregrine falcon (T)
Gila monster (C2)	Bald eagle (E)	Kirtland's water snake (C2)	Prairie fringed orchid (C2)	Nestronia (C2)	Tennessee milk-vetch (C2)	Interior least tern (T)
Swainson's hawk (C2)	Peregrine falcon (E)	Eastern massasauga (C2)		Lewis' heart leaf (C2)	Gattinger's lobelia (C2)	Piping plover (T)
	Least tern (E)[8]	Swainson's hawk (C2)		Dwarf wedge mussel (C2)[11]	Tennessee glade cress (C2)	
	Black-footed ferret (E)	Bald eagle (E)			Prairie clover (C2)	
	Swift fox (C2)	Peregrine falcon (E)			Cumberland rosin-weed (C2)	
	Preble's jumping mouse (C2)	Indiana bat (E)			Limestone fame-flower (C2)	
	Ferruginous hawk (C2)	Prairie bush clover (T)[10]			Stone's River bladderpod (C2)	
	Long-billed curlew (C2)				Cleft phlox (C2)	
	Western snowy plover (C2)				Large rock cress (C2)	
	Mountain plover (C1)				Easter blue star (C2)	
	Colorado squawfish (E)[9]				Water stitchwort (C2)	
	Humpback chub (E)[9]					
	Bonytail chub (E)[9]					
	Razorback sucker (C2)[9]					
	Swainson's hawk (C2)					

1. Arizona - Spiller April 26, 1988
2. Colorado - Opdycke May 17, 1988, and July 20, 1988
3. Illinois - Nelson May 10, 1988, and Illinois proposal September 1987
4. Michigan - Kolar May 5, 1988, and Michigan proposal September 1987
5. North Carolina - Gantt May 9, 1988, and Rackley June 24, 1988
6. Tennessee - Winford May 16, 1988
7. Texas - Curtis May 13, 1988
8. Associated with South Platte River
9. Associated with Colorado River
10. Listed in DeKalb County
11. The USFWS has indicated that this species will be proposed for listing as endangered.

E = Endangered
T = Threatened
C1 = Category 1 Candidate
C2 = Category 2 Candidate
PE = Proposed Endangered

of the ring (Bisson 1988). However, surveys of the proposed surface facility sites did not locate any plants (Bisson 1988). It is believed that its microhabitat requirements would make its occurrence in the areas to be disturbed unlikely (see Volume IV, Appendix 5, Section 5.1.5.2.A and USFWS consultation letter attached to Appendix 11).

In addition, the American peregrine falcon occurs statewide during migration and may nest in Arizona in cliff areas near water. Peregrines may forage throughout the Maricopa Mountains and adjacent valleys, but are currently not known to nest in the vicinity of the site (ASV 1988).

The piping plover, least tern, and whooping crane are migrants throughout areas including the Colorado and Texas sites. Although migratory, they are closely associated with aquatic habitats. There are no resident populations in the project area in Texas. Populations are known to reside along the South Platte River in Nebraska.

The Colorado squawfish, the humpback chub, and the bonytail chub are located in the upper Colorado River system. They are presently managed under a recovery program sponsored through a cooperative agreement with the U.S. Department of Interior.

The raptors listed in Colorado, the bald eagle, the American peregrine falcon, and the arctic peregrine falcon, have large ranges and nest in the area of large water bodies not proposed to be disturbed. All are wide ranging migratory birds. The bald eagle range includes the Colorado and Texas sites. The range of the peregrine falcon includes the Colorado site and the arctic peregrine falcon range extends to the Texas site. The bald eagle is more closely associated with waterbodies and in Colorado is known to concentrate along the South Platte River Basin to the north of the site. The arctic peregrine falcon and the American peregrine falcon desire open areas along rivers and coastlines where cliffs or high perches can be found. There are no resident populations of these three raptors at either of the sites. However, a nesting pair of bald eagles is known at Barr Lake, 32 mi west of the site where Colorado has proposed to construct the east-west access highway, which transects the high quality wetlands at the northern end of Barr Lake.

The only fur-bearing endangered species in the Colorado site region is the black-footed ferret. The ferret is associated with prairie dog towns and has a historic range that includes the Colorado site. While prairie dog towns are present throughout the region of influence, there are no data on the location and size of the towns on the site, and only one probable sighting of the ferret has been reported in over 30 years. However, prairie-dog towns do occur on the route of the proposed new two-lane road from Denver.

The USFWS consultation letter for Illinois lists one threatened plant species, the prairie bush clover. There are no known populations on the immediate site. The prairie bush clover is listed in DuPage County at the Hinsdale prairie, one of seven known locations in northeastern

Illinois. It is a rare constituent of established dry gravel/sand prairies and is more rare with the disappearance of established prairies. It is not likely to be found unless remnant prairie patches are present. Another threatened plant, the lakeside daisy, may also be present in remnant prairie habitat, but is not known in the region of influence.

Indiana bats hibernate in mines and caves in Indiana, Kentucky, and Missouri from October through April. During spring and summer they migrate over a wide area including the alternative sites in Illinois, Michigan, and Tennessee. The Indiana bat forages over small streams and rivers where well-developed riparian and upland forests occur. It roosts in mixed hardwood old-growth stands of trees containing cavities or sloughing bark. The species has not been collected at the sites in Illinois, Michigan, or Tennessee.

Harperella, an endangered species of plant in North Carolina, is known to occur in Granville County within the site area. It is located along the Tar River approximately 2 mi downstream of the southeast portion of the ring. The plant is typically found along stream margins in rocky shoals or shallow gravel.

The Gray bat in Tennessee feeds on insects outside of caves, but unlike the Indiana bat, occupies caves in the summer and is associated with a more well-developed cave ecology. The species has not been observed at caves in the site area.

The Tennessee purple coneflower is not reported to be in the specific plant associations in areas which would be disturbed by proposed construction of the SSC at the Tennessee site.

The tan riffle shell mussel may occur in streams potentially affected by the proposed SSC construction at the Tennessee site.

Of the species listed as threatened or endangered in Texas, all but one are migratory waterfowl or raptors. These were discussed above. The black-capped vireo may be associated with the forest-pasture transition. The black-capped vireo is known to exist in counties adjacent to Ellis County near the Texas site and may exist in Ellis County. The vireo is found in habitats consisting of a few small trees (typically oak or juniper) scattered among separated clumps of many bushes (usually oak or sumac). Bushes are in the open and their foliage reaches the ground. Nests are typically found 0.5 to 1 meter above the ground in areas screened by foliage.

The listings on Table 4-17 include species that are candidates for Federal listings as well (C1, C2, etc.). Although there is no requirement for Federal agencies to protect these species, appropriate biological surveys would be conducted during the preconstruction period to confirm their presence or absence from the area of project influence. See Volume IV, Appendix 5 and Appendix 11 for more information.

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Of the candidate species in Arizona, the desert tortoise, Gila monster, and night-blooming cereus are known to be present in the immediate site area. The tortoise population in the North Maricopa Mountains is located in areas of proposed activities, especially E7. Night-blooming cereus specimens have been located near E2, J2, and J6. The Swainson's hawk is considered a migrant in Arizona but would be primarily associated with agricultural areas in the region.

In Colorado, the candidate species listed may be in the general region of the site, however their sensitivity may be related to undisturbed short-grass prairie. There are no reports of these occurring in the site area other than the wide ranging raptors. (See Appendix 5, Section 5.2.9.5 and the USFWS consultation letters attached to Appendix 11.)

The candidate species in the Illinois site area are mostly aquatic and associated with larger tributaries than the Fox River. The raptors are wide ranging migratory birds with no evidence of nesting in the site area. (See Appendix 5, Section 5.4.9, and the USFWS consultation letter attached to Appendix 11.)

Candidate species in the vicinity of the Michigan site consist of a single plant, kittentails, which is known to occur in several distinct populations in Jackson County, although not on the ring alignment. Three other species of plants, bog bluegrass, log sedge, and prairie fringed orchid, may also occur in the region.

There is one species that will be proposed for listing that occurs in the vicinity of the North Carolina site. The dwarf wedge mussel is known to inhabit the Tar River in Granville County. There are five species (see Table 4-17) which are under review for listing by the USFWS (see Appendix 5, Section 5.5.9.5, and the USFWS consultation letter attached to Appendix 10).

In Tennessee, the many candidate/review species are relic-populations which may be in the area (see Appendix 5, Section 5.6.9.5, and the USFWS consultation letter attached to Appendix 11). The Tennessee cave salamander may be found in the Snail Shell Cave of the site. The Copper-cheek darter (review status) is a relic species which is associated with several tributaries in the general region of the site and reported to be associated with the larger tributaries in the area which are not in the immediate area of the proposed injector or ring. Many of the plants are found in unique communities such as the Cedar Glades (see Appendix 11, Section 11.3.6.1).

4.7.4.2 State-Protected Species

State-protected species may be present in the vicinities of the proposed sites. The sites differ substantially in the number of state-protected species near the proposed sites. These differences are primarily due to the content of individual state laws as well as differences in numbers of rare species. These are:

Arizona	5 species
Colorado	3 species
Illinois	87 species
Michigan	27 species
North Carolina	21 species
Tennessee	22 species
Texas	11 species

Consultation with the State Fish and Wildlife Agency would be conducted to determine what, if any, studies would be conducted at the selected site. State-protected species are listed in Table 4-18.

4.7.5 Wetlands

4.7.5.1 Arizona

There are no USFWS classified wetlands in the area of the proposed Arizona site.

4.7.5.2 Colorado

Areas classified as wetlands by the USFWS (see Volume IV, Appendix 11, Table 11.3.2.3-1) are common within the area of the proposed Colorado site. Small palustrine wetlands are most typical, although lacustrine and riverine wetlands are also present in the region. Palustrine wetlands include small ponds, marshes, and emergent areas. Many of the wetlands in the area are riverine or palustrine emergent systems associated with the intermittent or low-order streams that occur throughout the area. Palustrine emergent, flats, and riverine wetlands are also associated with the floodplains and riparian zones of larger streams such as Fort Morgan, Beebe Seep, and Neres canals; Badger and Bijou Creeks; and the South Platte River.

Most of the wetlands are moderately degraded (see Appendix 11, Section 11.3.2.3) as a result of agricultural activities such as crop production and livestock grazing. Some wetlands are severely degraded from overgrazing. In addition, nonwetlands and nonnative plant species are well established within many of the wetlands. The wetlands associated with the Beebe Seep and Neres Canals are regularly utilized by waterfowl. Cottonwood stands within floodplains associated with several streams (e.g., Bijou Creek) provide important habitat for raptor species.

4.7.5.3 Illinois

Wetlands are abundant in the Illinois project area. Palustrine systems are the most common, and primarily include emergent, scrub-shrub, and some forested wetlands. Plants associated with the wetlands include a variety of small trees, shrubs, grasses, forbes, and rushes. In addition, both native and introduced species may be found in the wetlands of the area. Lacustrine and riverine wetlands are also present but less abundant. Riverine, forested palustrine, and emergent palustrine wetlands are associated with the riparian areas of the Fox River, Welch Creek, Kress Creek, and other streams and creeks in the area.

Table 4-18

STATE-PROTECTED SPECIES IN THE REGIONS OF THE SITE ALTERNATIVES

ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
Peregrine falcon (G2)	Bald eagle (E)	Alder buckthorn (E)	Beak grass (T)	Harperella (T)	Tennessee milkvetch (E)	Texas horned lizard (T)
Southern bald eagle (G2)	Plains sharp-tailed grouse (T)	American brookline (E)	Bog bluegrass (T)	Ginseng (S)	Leafy prairie clover (E)	Timber rattlesnake (T)
Desert tortoise (G3)	Sandhill crane (T)	American burreed (E)	Cattail sedge (T)	Lewis' heartleaf (P)	Glade cress (T)	Arctic peregrine falcon (T)
Desert bighorn sheep (G3)		Bog bedstraw (T)	Downy sunflower (T)	Michaux's sumac (E)	Necklace glade cress (T)	Bald eagle (E)
Gila monster (G3)		Common bog arrow grass (E)	Edible valerian (T)	Nestronia (T)	Duck River bladderpod (T)	Black-capped vireo (E)
		Downy yellow painted cup (E)	False arrow feather (T)	Pale coneflower (P)	Shorts bladder-pod (T)	Golden-cheeked warbler (T)
		Downy Solomon's seal (E)	Fire pink (T)	Prairie dock (P)	Gattinger's lobelia (T)	Interior least tern (E)
		False asphodel (T)	Ginseng (T)	Prairie goldenrod (P)	Snow wreath (T)	Swallow-tailed kite (T)
		False dog-bane (E)	Goldenseal (T)	Schweinitz's sunflower (E)	False gromwell (T)	Whooping crane (E)
		Ginseng (T)	Kittentails (T)	Smooth coneflower (T)	Sunnybell (T)	White-faced ibis (T)
		Golden seal (T)	Least shrew (T)	Tall larkspur (E, S)	Limestone fame-flower (T)	Wood stork (T)
		Grass pink orchid (T)	Leiberg's panic-grass (T)	Roanoke bass (S)	Water speedwell (E)	
		Green-fruited burreed (E)	Log sedge (T)	Yellow lance (S)		
		Hairy marsh yellow grass (E)	Mat muhly (T)	Atlantic pigtoe (T)		
		Hairy white violet (E)	Prairie drop seed (T)	Loggerhead shrike (T)		
		Heart-leaved plantain (E)	Prairie fringed orchid (E)	Neuse River water dog (S)		
		Hemlock parsley (E)	Prairie rock- cress (T)	Dwarf wedge mussel (E)		
		Lakeside daisy (T)	Raven's-foot sedge (T)	Notched rainbow (S)		
		Leatherleaf (T)	Small skull cap (T)	Mussel (Lampsilis cariosa) (S)		
		Leafy prairie clover (E)	Spikerush (T)	Mussel (Lampsilis radiata) (S)		
		Long beach fern (E)	Tall green milkweed (T)	Mussel (Villosa delumbis) (S)		
		Marsh speed-well (T)				

G1 - Group 1 (Probably extirpated)
G2 - Group 2 (Near extirpation)
G3 - Group 3 (Jeopardy)
E - Endangered
T - Threatened
R - Rare
S - Special Concern
P - Primary Proposed

Table 4-18 (Cont)

STATE-PROTECTED SPECIES IN THE REGIONS OF THE SITE ALTERNATIVES

ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
		Narrow-leaved sundew (T)	Upland boneset (T)		Tennessee cave salamander (T)	
		New York fern (E)	White or prairie false indigo (T)		Hellbender (R)	
		Northern cranesbill (E)	White lady's slipper (T)		Bald eagle (E)	
		Oval milk-weed (E)	Yellow or orange fringed orchid (T)		Peregrine falcon (E)	
		Pale vetchling (T)	Mitchell's satyr (T)		Bewick's wren (T)	
		Pinweed (E)	King rail (E)		Grasshopper sparrow (T)	
		Prairie clover (E)			Gray bat (E)	
		Prairie lattice (E)			Indiana bat (E)	
		Prairie rose gentian			Birdwing pearly mussel (E)	
		Prairie white-fringed orchid (E)			Coppercheek darter (T)	
		Purple avens (E)				
		Purple flowering raspberry (E)				
		Queen of-the-prairie (T)				
		Rice grass (T)				
		Richardson's rush (E)				
		Rock elm (E)				
		Round-leaved sundew (E)				
		Seaside crow-foot (E)				
		Sedge (E)				
		Showy lady's slipper (E)				
		Slender dog arrow grass (E)				

G1 - Group 1 (Probably extirpated)
G2 - Group 2 (Near extirpation)
G3 - Group 3 (Jeopardy)
E - Endangered
T - Threatened
R - Rare
S - Special Concern
P - Primary Proposed

Table 4-18 (Cont)

STATE-PROTECTED SPECIES IN THE REGIONS
OF THE SITE ALTERNATIVES

ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
		Slender sandwort (T)				
		Small enchanter's nightshade (E)				
		Small yellow lady's slipper (E)				
		Speckled alder (E)				
		Spikerush (E)				
		Spotted coral root orchid (T)				
		White camass (E)				
		White cedar (T)				
		White lady's slipper (E)				
		Woolly milkweed (E)				
		Yellow birch (E)				
		Yellow monkey flower (E)				
		American bittern (E)				
		Bald eagle (E)				
		Barn owl (E)				
		Bewick's wren (T)				
		Black-crowned night heron (E)				
		Black rail (E)				
		Black tern (E)				
		Brewer's blackbird (T)				
		Brown creeper (E)				
		Common gallinule (T)				

G1 - Group 1 (Probably extirpated)
G2 - Group 2 (Near extirpation)
G3 - Group 3 (Jeopardy)
E - Endangered
T - Threatened
R - Rare
S - Special Concern
P - Primary Proposed

Table 4-18 (Cont)

STATE-PROTECTED SPECIES IN THE REGIONS OF THE SITE ALTERNATIVES

ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
		Common tern (E)				
		Cooper's hawk (E)				
		Double-crested cormorant (E)				
		Eskimo curlew (E)				
		Forster's tern (E)				
		Great egret (E)				
		Henslow's sparrow (T)				
		Least tern (E)				
		Loggerhead shrike (T)				
		Long-eared owl (E)				
		Marsh hawk (E)				
		Osprey (E)				
		Peregrine falcon (E)				
		Piping plover (E)				
		Purple gallinule (E)				
		Red-shouldered hawk (E)				
		Short-eared owl (E)				
		Swainson's hawk (E)				
		Swainson's warbler (T)				
		Upland sandpiper (E)				
		Veery (T)				
		Wilson's phalarope (E)				

G1 - Group 1 (Probably extirpated)
G2 - Group 2 (Near extirpation)
G3 - Group 3 (Jeopardy)
E - Endangered
T - Threatened
R - Rare
S - Special Concern
P - Primary Proposed

Table 4-18 (Cont)

STATE-PROTECTED SPECIES IN THE REGIONS OF THE SITE ALTERNATIVES

ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
		Yellow-headed blackbird (E)				
		Yellow rail (T)				
		Bobcat (T)				
		Indiana bat (E)				
		River otter (T)				

G1 - Group 1 (Probably extirpated)
G2 - Group 2 (Near extirpation)
G3 - Group 3 (Jeopardy)
E - Endangered
T - Threatened
R - Rare
S - Special Concern
P - Primary Proposed

Many of the wetlands show some sign of degradation. Causes of degradation include agricultural activities, draining, diking, and/or urban encroachment. Wetlands exhibiting little or no apparent degradation include riparian forested wetlands associated with Welch Creek, and the lacustrine and palustrine wetlands located at the eastern, southern, and southwestern portions of the Fermilab area. The palustrine forested wetland in the southwestern portion of the Fermilab site contains an active heron rookery.

4.7.5.4 Michigan

Wetlands are abundant throughout the Michigan project area. These wetlands are primarily palustrine emergent, palustrine scrub-shrub, and palustrine forested systems. Riverine wetlands are associated with the Grand and Huron rivers, and lacustrine systems are scattered throughout the southeastern portion of the project area. Major concentrations of wetlands are also associated with the Dansville State Game Area and the Waterloo Recreation Area. Vegetation associated with the different types of wetlands includes numerous species of trees, shrubs, herbs, and grasses; both native and introduced species may be found.

Many of the wetlands have been degraded to some extent. Primary causes of degradation include agricultural practices, draining, and residential and industrial development. However, nearly as many wetlands show few signs of degradation. Most of the relatively undegraded wetlands in the area of the Michigan site are less than 5 acres in size.

4.7.5.5 North Carolina

Wetlands are relatively common in the North Carolina project area. Wetlands types include palustrine emergent and palustrine forested systems associated with streams and farm ponds, riverine systems, and lacustrine systems (typically man-made reservoirs). Natural drainages in the area having associated wetlands include the Flat River, Knap of Reeds Creek, Camp Creek, Dickens Creek, and Grassy Creek.

Many of the emergent and scrub-shrub wetlands show signs of moderate to severe degradation, primarily as a result of agricultural practices, grazing activity, residential development, or recent construction activities. In contrast, palustrine forested wetlands (particularly when associated with a natural stream drainage) typically show little evidence of degradation.

4.7.5.6 Tennessee

Wetlands are not a prominent feature of the project area in Tennessee. The majority of the wetlands in the project area are palustrine emergent wetlands. They are generally less than an acre in size and associated with farm ponds. Palustrine forested wetlands are typically associated with the many perennial and intermittent streams found in the area. Riverine wetlands are associated with the Duck, Harpeth, and Stones Rivers.

Most of the wetlands (particularly those associated with farm ponds) are moderately or severely degraded as a result of agricultural activities. These activities include grazing, crop production, and hay cultivation.

4.7.5.7 Texas

Wetlands present in the Texas project area include palustrine, riverine, and lacustrine systems, but are not a prominent feature of the site. Most of the wetlands in the area are moderately degraded from agricultural activities. The wetlands are primarily excavated or diked stock ponds that are used extensively by cattle. Emergent vegetation at these wetlands is limited because of heavy cattle use and seasonal water level fluctuations. The remaining wetlands are associated with the riparian areas of intermittent and low order streams. The beds of these streams typically are highly eroded from past and present agricultural activities and cattle grazing.

Chambers Creek supports the most important wetland area at the proposed Texas site. This permanently flowing stream contains a variety of vegetation types and is of relatively high quality. Because of the quality of this area and the importance of wetland habitat in this area of relatively dry climate, Chambers Creek represents valuable habitat for fish and wildlife. The forested areas surrounding the stream provide habitat for many raptors, and the Texas Parks and Wildlife Department has released deer in the Chambers Creek area of the Texas site.

4.7.6 Commercially, Recreationally, or Culturally Important Species

Each of the site alternatives has commercially and/or recreationally important wildlife populations. In general, these populations are recreationally important due to hunting, trapping, fishing, or biological observation activities. The economic value of these populations at most of the proposed SSC sites is derived primarily from their recreational potential, with the exception of livestock populations. No species of special cultural significance is known to occur in the vicinity of the seven sites, with the exception of Arizona.

In Arizona, species of economic importance include some domestic livestock and two furbearers, bobcat and coyote. There are no aquatic species of economic importance.

Recreational hunting use is typical for a few game species including Gambel's quail, doves, rabbits, mule deer, javelina, coyote, and (traditionally) bighorn sheep.

The only species of special cultural importance in Arizona is the feral burro in the northwestern parts of the site.

In Colorado, several species have recreational hunting value in the area: mule deer, pronghorn antelope, white-tailed deer, rabbits, mallards, mourning dove, ring-necked pheasant, and bobwhite quail. Badger, beaver, coyote, and red fox are trapped. Sportfishing is primarily focused on the reservoirs northwest of the site.

There are many recreationally important species in the area of the proposed Illinois site. Game birds include geese, ducks, partridge, pheasant, and dove. Although much of the area is urbanized, there are opportunities for hunting and trapping game animals. Animals that are hunted include ring-necked pheasant, waterfowl, cottontail rabbit, white-tailed deer, red fox, coyote, and raccoon. Beaver, muskrat, fox, coyote, and raccoon are trapped. Sport and commercial fish include sunfish, trout, bass, crappie, walleye, and perch. Recreational activities dependent on ecological resources also include bird watching.

The vicinity of the proposed Michigan site has numerous species that are recreationally important. Inland sport fisheries are located throughout the region. Species managed in these fisheries include largemouth bass, northern pike, bluegill, crappie, yellow perch, walleye, salmon, and rainbow trout. The major stream fisheries in the site vicinity are along the Grand River and Lower Sycamore Creek.

Game species that are common in the area of the proposed Michigan site include cottontail rabbits, white-tailed deer, waterfowl, and fox squirrels. Other species frequently hunted include ring-necked pheasant, bobwhite quail, wild turkey, woodcock, and ruffed grouse. Commonly hunted waterfowl include wood ducks, mallards, blue-winged teal, and Canada geese. Muskrat, mink, raccoon, red fox, coyotes, opossum, and woodchuck are frequently trapped or hunted in the area.

Bird watching, wildlife observation, and nature photography are important activities in the Dansville State Game Area, Waterloo Recreation Area, and Haehnle Wildlife Sanctuary. Waterfowl nesting habitats are common in these protected areas; the observation of sandhill cranes and great blue herons is especially popular.

In North Carolina, much of the proposed site is rural with excellent hunting and fishing, and a high diversity of fish species and populations of game birds and mammals. Major fishing areas on or near the site include hundreds of farm ponds, five reservoirs, four rivers, and nine streams. Major game fish species are striped bass, largemouth bass, chain pickerel, Roanoke bass, black crappie, white crappie, white perch, white bass, and various sunfishes (bream).

Bird and mammal game species are found throughout the site including white-tailed deer, eastern gray squirrel, bobwhite, wood duck, and many other migratory waterfowl. The largest area available for public hunting within the proposed site is the Butner Game Lands, of which approximately 10 percent lie on the proposed SSC near-cluster location. Management of these State-owned lands by the North Carolina Wildlife Resources Commission as game lands is considered an interim use. Extensive game lands also surround Mayo Reservoir and Mayo Creek.

No public hunting grounds or State Wildlife Management Areas are located within the proposed SSC site area at Tennessee. Hunting, trapping, and fishing do occur, however, on private property and along rivers and streams throughout the area. Common game birds of the region are wild turkey, bobwhite, and mourning dove; waterfowl species such as Canada goose, wood duck, blue-winged teal, and mallard are also reported. Game mammals in the area include eastern cottontail, gray and fox squirrels, and white-tailed deer.

Several ranchers in the immediate construction area of the SSC in Tennessee raise and train Tennessee Walking Horses.

In Texas, both Lake Waxahachie and Lake Bardwell are used for sport fishing. Game fish in Lake Waxahachie include channel catfish, largemouth bass, and white crappie. Major sport fish in Lake Bardwell include white crappie, channel catfish, blue catfish, largemouth bass, white bass, striped bass, and sunfish.

Principal game species in the region of the proposed Texas site are northern bobwhite, rabbit, fox, squirrel, and mourning dove. Commonly hunted waterfowl include green-winged teal, gadwall, and mallard. White-tailed deer are hunted in the area, as are bullfrogs. Raccoon, opossum, striped skunk, gray fox, and spotted skunk are trapped and/or hunted in the area.

4.8 LAND RESOURCES

4.8.1 Jurisdictional Location

The jurisdictional location of each of the site alternatives was determined by the proposers in response to ISP requirements (see Volume III, Methodology for Site Selection). As such, the number of counties directly affected by the project vary. Two states have sites located in one county: Arizona (Maricopa County) and Texas (Ellis County). The Michigan site straddles two counties: Ingham and Jackson. Three states have sites located in portions of three counties: Colorado (Morgan, Adams, and Washington Counties); Illinois (DuPage, Kane, and Kendall Counties); and North Carolina (Durham, Granville, and Person Counties). The Tennessee site is located in portions of four counties (Rutherford, Marshall, Bedford, and Williamson Counties). Table 4-19 presents data on each site's county locations of major project facilities.

4.8.2 Ownership Patterns

Ownership patterns of each of the seven site alternatives were identified based on information provided by the proposers in response to ISP requirements. Ownership patterns for areas directly affected by the project vary from virtually all private ownership in Tennessee (100 percent) to largely public ownership in Arizona (approximately 68 percent). Colorado, Michigan, North Carolina, and Texas have over 90 percent of the lands to be acquired for the project held in private ownership. Illinois has approximately 64 percent of the lands to be acquired for the project held in private ownership. Data on actual acreage to be acquired are presented in Volume IV, Appendix 4. Table 4-20 presents data on each site's predominant land ownership patterns for major project facilities.

Table 4-19

COUNTIES PROPOSED FOR SURFACE FACILITIES LOCATIONS AT SITE ALTERNATIVES

SSC PROJECT FACILITY	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
1.0 Near cluster quadrant	Maricopa	Morgan/Adams	DuPage/Kane	Ingham/Jackson	Durham/Granville	Rutherford	Ellis
1.1 Campus area A	Maricopa	Adams	DuPage/Kane	Ingham	Durham	Rutherford	Ellis
1.2 Injector area B	Maricopa	Adams	DuPage/Kane	Ingham	Granville	Rutherford	Ellis
1.3 Future expansion area C	Maricopa	Adams	DuPage/Kane	Jackson	Durham	Rutherford	Ellis
1.4 Buffer area/buried beam zone access area I	Maricopa	Adams/Morgan	DuPage/Kane	Ingham/Jackson	Granville/Durham	Rutherford	Ellis
1.5 Near cluster ring	Maricopa	Adams/Morgan	DuPage/Kane	Ingham/Jackson	Durham/Granville	Rutherford	Ellis
2.0 Far cluster quadrant	Maricopa	Washington/Morgan	Kane	Ingham/Jackson	Granville/Person	Marshall/ Bedford	Ellis
3.0 Lower arc quadrant	Maricopa	Adams/Washington	Kane/Kendall	Jackson	Person[1]/Durham	Rutherford/ Bedford[2]	Ellis
4.0 Upper arc quadrant	Maricopa	Morgan	Kane	Ingham	Granville[2]	Marshall/ Williamson/ Rutherford[1]	Ellis
5.0 Road and railroad	Maricopa	Morgan/Adams/ Washington	DuPage/Kane/ Kendall	Ingham/Jackson	Durham/Granville/ Person	Marshall/ Williamson/ Rutherford	Ellis
6.0 Utilities	Maricopa	Morgan/Adams/ Washington	DuPage/Kane/ Kendall	Ingham/Jackson	Durham/Granville/ Person	Marshall/ Williamson/ Rutherford	Ellis

1. Corresponds to State's western arc
2. Corresponds to State's eastern arc

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Table 4-20

EXISTING LAND USE IN AREAS PROPOSED FOR SURFACE FACILITIES AT SITE ALTERNATIVES

SSC PROJECT FACILITY	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
1.0 Near cluster quadrant	Public/private	Private	Private/public	Private/public	Private/public	Private	Private
1.1 Campus area A	Private/public	Private	Public	Private	Private/public	Private	Private
1.2 Injector area B	Public/private	Private	Public	Private	Private/public	Private	Private
1.3 Future expansion area C	Public/private	Private	Public	Private	Private/public	Private	Private
1.4 Buffer area/buried beam zone access area I	Private/public	Private/public	Private/public	Private/public	Private	Private	Private
1.5 Near cluster ring	Public/private	Private	Public/private	Private	Private/public	Private	Private
2.0 Far cluster quadrant	Public	Private/public	Private	Private	Private	Private	Private/public
3.0 Lower arc quadrant	Public	Private/public	Private	Private	Private[1]	Public[2]	Private/public
4.0 Upper arc quadrant	Public	Private/public	Private	Private	Private[2]	Private[1]	Private
5.0 Road and railroad	Public/private	Private	Public/private	Private	Private	Private	Private
6.0 Utilities	Public/private	Private	Public/private	Private	Private	Private	Private

1. Corresponds to State's western arc
2. Corresponds to State's eastern arc

4.8.3 Historic Land Use

The historic land use of each of the seven sites differs depending on the degree of development. Development began similarly at each of the seven sites, since proximity to water is the single most required necessity for growth. Once sources of drinking water were made secure, agricultural activities were pursued, with industrialization/urbanization following if there were strong economic forces fostering growth. The Arizona site is located in an underdeveloped portion of Maricopa County, not only because of Federal land and ownership/management policies, but also because of the lack of water for irrigation. The Colorado, Michigan, North Carolina, Tennessee, and Texas sites are still largely agrarian. The Illinois site is the most urbanized of all the sites. There is still an agricultural basis at the Illinois site, but it is changing as urbanization continues to extend farther west from Chicago.

4.8.4 Existing Land Use Plans, Policies, and Controls

The kind and amount of existing land use plans, policies, and controls in effect at each of the sites is contingent on the conditions used to describe the preceding three land use parameters: jurisdictional setting, ownership patterns, and historic land use. The Texas site is the exception to the norm, because the State has not mandated its counties to perform comprehensive land use planning functions. The remaining six sites have such provisions, even though not every county at each site has developed the same sophistication in their planning efforts because of their individual development status. Table 4-21 presents data on each site's dominant zoning designation for major project facilities.

The Arizona site is largely under Federal ownership, managed by the U.S. Department of the Interior, Bureau of Land Management (BLM). Of particular relevance to the SSC project are the following two BLM plans: Lower Gila South Final Resource Management Plan/Environmental Impact Statement (1985) and the subsequent Lower Gila South Final Wilderness Environmental Impact Statement (1987).

4.8.5 Existing Land Use

The kind and amount of existing land use at each of the site alternatives is dependent on both historic use as well as what is currently permitted under the applicable zoning ordinances. Existing land use ranges from a simple pattern in Arizona, where little to no development is the norm, to very complex land use patterns in Illinois, where urbanization is continuing from the east. In between are Colorado, Texas, Tennessee, Michigan, and North Carolina which, while all basically agricultural, show increasingly complex land use patterns. The Michigan site and, particularly, the North Carolina site, exhibit complex patchwork land use patterns, due in large part to their respective vegetative covers and associated forms of agricultural use. Table 4-22 presents data on each site's existing land use for major project facilities.

Table 4-21

LOCAL ZONING DESIGNATIONS OF SITE SURFACE FACILITIES (PUBLIC LANDS EXCLUDED) AT SITE ALTERNATIVES

SSC PROJECT FACILITY	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
1.0 Near cluster quadrant	Rural-190/ Rural-43 [c]	Agricultural	Mixed	Agricultural	Rural/ none	Residential	None
1.1 Campus area A	Rural-190	Agricultural	Residential/ agricultural	Agricultural	Rural	Residential	None
1.2 Injector area B	Rural-190	Agricultural	Residential/ mixed	Agricultural	None	Residential	None
1.3 Future expansion area C	Rural-190	Agricultural	Residential/ mixed	Agricultural	Rural	Residential	None
1.4 Buffer area/ buried beam zone access area I	Rural-190/ Rural-43	Agricultural	Mixed	Agricultural	Rural/ none	Residential	None
1.5 Near cluster ring	Rural-190/ Rural-43	Agricultural	Mixed	Agricultural	Rural/ none	Residential	None
2.0 Far cluster quadrant	Rural-190	Agricultural	Agricultural	Agricultural/ residential	None	None	None/ residential
3.0 Lower arc quadrant	Rural-190	Agricultural	Agricultural/ Mixed	Agricultural/ residential	Rural/ none[a]	None/ residential[b]	None
4.0 Upper arc quadrant	Rural-190	Agricultural	Mixed	Agricultural/ mixed	None[b]	Rural/ residential/ none[a]	None/ industrial/ agricultural
5.0 Road and railroad	Rural-190/ Rural-43	Agricultural	Mixed	Agricultural	Rural	Residential/ none	None
6.0 Utilities	Rural-190/ Rural-43	Agricultural	Mixed	Agricultural	Rural	Residential/ none	None

[a] Corresponds to State's western arc
[b] Corresponds to State's eastern arc
[c] Limited to agricultural and single-family residential uses, 190,000-ft^2 parcel minimum or 1-acre parcel maximum

Table 4-22

EXISTING LAND USE OF SITE-SPECIFIC PROJECT FACILITIES

SSC PROJECT FACILITY	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS
1.0 Near cluster quadrant	Undeveloped	Agricultural/ rural	Institutional/ agricultural/ mixed	Agricultural/ rural	Agricultural/ rural/military	Rural/ agricultural	Rural/ agricultural
1.1 Campus area A	Undeveloped	Agricultural (cropland)	Institutional/ research	Agricultural/ rural	Rural/military	Agricultural	Agricultural/ rural
1.2 Injector area B	Undeveloped	Agricultural (cropland)	Institutional/ agricultural	Agricultural/ rural	Rural/military	Agricultural/ rural	Agricultural/ residential
1.3 Future expansion area C	Undeveloped	Agricultural/ rural (cropland)	Institutional/ mixed	Agricultural/ rural	Rural/military	Agricultural/ rural	Agricultural/ rural
1.4 Buffer area/ buried beam zone access area I	Undeveloped	Agricultural/ rural (cropland/range)	Agricultural/ mixed	Agricultural/ rural	Agricultural/ rural	Agricultural/ rural	Rural/range/ agricultural
1.5 Near cluster ring	Undeveloped	Agricultural/ rural (cropland)	Agricultural/ mixed	Agricultural/ rural/far.	Rural/ military	Agricultural/ open/rural	Agricultural/ pasture/rural/ residential
2.0 Far cluster quadrant	Undeveloped	Agricultural (cropland/range)	Agricultural/ rural	Agricultural/ rural/forested	Agricultural/ rural	Agricultural/ rural	Rural/range/ pasture
3.0 Lower arc quadrant	Undeveloped	Agricultural	Agricultural/ rural	Agricultural/ rural/forested	Rural/ agricultural[a]	Rural/ agricultural[b]	Agricultural/ range/wetlands
4.0 Upper arc quadrant	Undeveloped	Agricultural/ rural (cropland/range)	Agricultural/ residential	Agricultural/ rural/wetland	Agricultural/ rural[b]	Agricultural/ open/rural[a]	Agricultural/ rural
5.0 Road and railroad	Undeveloped	Agricultural/ rural.	Agricultural/ mixed	Agricultural	Rural/ agricultural	Rural	Rural
6.0 Utilities	Undeveloped	Agricultural/ rural	Agricultural/ mixed	Agricultural	Rural/ agricultural	Rural	Rural

[a] Corresponds to State's western arc
[b] Corresponds to State's eastern arc

Portions of the Arizona site are contained in three Wilderness Study Areas (WSA's). These are the North Maricopa Mountains WSA, the South Maricopa Mountains WSA, and the Butterfield Stage Memorial WSA. The WSA's are characterized by desert, mountains, valleys, and plains that are predominantly natural in appearance with minor evidence of human activity. They provide outstanding opportunities for solitude because of their size and variation in topography. The WSA's provide opportunities for primitive and unconfined recreation including hiking, backpacking, sightseeing, horse backriding, wildlife observation, and photography. The WSA's also provide important habitats for desert bighorn sheep and desert tortoise. In addition, several cultural resource values are present, including portions of the historic Butterfield Stage Route. The BLM has recommended that none of the WSA's be nominated for wilderness designation and subsequent protection.

In addition, the SSC project study area in Arizona includes BLM lands that are managed for grazing purposes, including three allotments that would be directly affected by facility construction and two allotments that would be indirectly affected by either access road construction or potential groundwater drawdown caused by well field pumping.

Portions of the Illinois site would be located at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. Fermilab is a 6,800-acre laboratory complex dedicated to high-energy physics research similar to that proposed to be conducted by the SSC. Fermilab's main component is the Tevatron, a 1-TeV particle accelerator and its associated fixed target and collision detectors. The laboratory also includes a 15-story office and laboratory building and other infrastructure to support operations. Fermilab has been owned by the Federal Government since 1969. It is operated by the Universities Research Association (URA) for the DOE. Other land uses at Fermilab include a prairie restoration project, agricultural production in certain leased areas, grazing land for a herd of buffalo, and wildlife habitats.

4.8.6 Prime Farmland Inventories at the SSC Proposed Sites

Prime, unique, and farmlands of statewide importance are described as Important Farmlands (U.S. Department of Agriculture 7 CFR 657.5). Their identification is required to "account the adverse effects of Federal programs on the protection of farmland" (U.S. Department of Agriculture 7 CFR 658.4).

Prime farmland is defined in 7 CFR 657.5 as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oil seed crops.

Unique farmland is defined in 7 CFR 657.5 as land other than prime farmland that is used for the production of specific high value food and fiber crops.

Farmland of statewide importance is defined in 7 CFR 657.5 as land in addition to prime and unique farmlands that is of statewide importance for the production of food, feed, fiber, forage, and oil seed crops.

Although prime farmlands are rigorously defined, the screening of farmlands according to documented criteria (U.S. Department of Agriculture 7 CFR 657.5(a)) is not straightforward and may become inaccurate when the investigated area is as large as 7,700 acres (the generic fee simple area) and is so widely spread over the land surface. The actual prime farmland inventory is an estimate. Unique farmlands are included in prime farmland acreages when identified at a particular site.

Since a majority of states have not yet defined criteria for farmlands of statewide importance, a general definition was used. This definition states that "...farmlands of statewide importance include those that are nearly prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods" (U.S. Department of Agriculture 7 CFR 657.5(c)).

Lands of secondary importance are practically all other lands with the exception of drastically unfarmable surfaces like gullied lands or lands on slopes in excess of 30 to 40 percent.

Soils at the proposed Arizona site are characteristically coarse. This fact, combined with the arid climate, requires that additional water be supplied by irrigation in order to produce cultivated crops. The prime and important farmland inventories are both equal to zero.

Some of the soils not currently in production at the proposed Colorado site have favorable farming characteristics. The area of prime farmland is estimated at zero acres. Important farmland is estimated at 4,198 acres. Roughly one-third of the soil cover in the investigated area is represented by soils with substantial limitations for cultivated crops.

The proposed Illinois SSC site has the most naturally fertile soil cover among the sites with prime farmland estimated to be around 3,076 acres. Important farmland is estimated at 212 acres.

The proposed Michigan site has good agricultural soils but an abundance of surface waters that interfere with farming activities. Prime farmland is estimated to be about 4,002 acres, and important farmland is 2,658 acres.

Compared to other sites, the proposed North Carolina site is characterized by soils with low natural potential for agricultural production. Therefore, liming, fertilization, and erosion-preventing management practices must be consistently used. The estimate of prime farmlands at the site is 4,374 acres, and important farmland is 2,265 acres.

The proposed Tennessee site is characterized by a soil cover with a relatively low potential for cultivated crops. Prime farmland is estimated to be 4,000 acres, and important farmland is 1,839 acres.

The proposed Texas site is characterized by clayey soils. An estimated 3,389 acres are classified as prime farmland, and 1,287 acres as important farmland.

These results are summarized in Table 4-23. Averages for prime and important farmland are provided by the Soil Conservation Service.

Table 4-23

PRIME AND IMPORTANT FARMLAND ACREAGES IN THE FEE SIMPLE AREA

State	Prime	Important
AZ	0	0
CO	0	4,198
IL	3,076	212
MI	4,002	2,658
NC	4,374	2,265
TN	4,000	1,839*
TX	3,389	1,287

* The Tennessee important farmland acreage was estimated using available soil maps.

Source: U.S. Department of Agriculture Farmland Conversion Impact Rating Form AD-1006.

4.8.7 Planned Future Land Use

The kind and amount of future planned land use at each of the sites is dependent on the status of existing land use plans, policies, and controls and the direction that change may take as implied from current land use. Of the seven sites, only Illinois presents a situation where growth is triggering not only an intensification of current use, but also major changes from one category of land use to a new higher development classification. The remaining six sites do not portray this kind of future growth. Table 4-24 presents interpretative data on each site's future planned land use changes without the SSC.

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Table 4-24

FUTURE PLANNED LAND USE IN THE REGIONS OF THE SITE ALTERNATIVES IN THE ABSENCE OF THE SSC*

SSC PROJECT FACILITY	AZ	CO	IL	MI	NC	TN	TX
1.0 <u>Near cluster quadrant</u>	No change	No change	Mixed/Urban	No change	No change	No change	No change
1.1 Campus area A	No change	No change	No change	No change	No change	No change	No change
1.2 Injector area B	No change	No change	No change	No change	No change	No change	No change
1.3 Future expansion area C	No change	No change	No change	No change	No change	No change	No change
1.4 Buffer area/ buried beam zone access area I	No change/ landfill	No change	Mixed/urban	No change	No change	No change	No change
1.5 Near cluster ring	No change	No change	Mixed/urban	No change	No change	No change	No change
2.0 <u>Far cluster quadrant</u>	No change	No change	No change	No change	No change	No change	No change
3.0 <u>Lower arc quadrant</u>	No change	No change	No change	No change	No change	No change	No change
4.0 <u>Upper arc quadrant</u>	No change	No change	Residential/ agricultural/ no change	No change	No change	No change	No change
5.0 <u>Road and railroad</u>	No change	No change	No change	No change	No change	No change	No change
6.0 <u>Utilities</u>	No change	No change	No change	No change	No change	No change	No change

*Forecasted for the year 2000

4.9 SOCIOECONOMICS AND INFRASTRUCTURE

4.9.1 Socioeconomics

The socioeconomic status at the proposed SSC sites can be described by tabulating statistics for the counties defined to be in the socioeconomic region of influence (ROI). The ROI for the sites are:

- o Arizona - Maricopa (P), Pima, and Pinal Counties.
- o Colorado - 13-county area, including Adams (P), Morgan (P), and Washington (P) Counties.
- o Illinois - nine-county area, including DuPage (P), Kane (P), and Kendall (P) Counties.
- o Michigan - 12-county area, including Ingham (P) and Jackson (P) Counties.
- o North Carolina - 20-county area, including Durham (P), Person (P), and Granville (P) Counties, and a portion of southern Virginia.
- o Tennessee - 21-county area, including Bedford (P), Marshall (P), and Rutherford (P) Counties.
- o Texas - eight-county area, including Ellis (P) County.

The primary impacted counties are those hosting SSC facilities and are designated (P). Although Williamson County, Tennessee, hosts a small segment of the ring, it is excluded from primary status due to sparse population in the part of the county affected by the SSC as compared to the rest of the county.

Data used to develop these descriptions of the socioeconomics for each site appear in Volume IV, Appendices 5 and 14. The most recent publicly available statistics were used as the basis of these descriptions.

4.9.1.1 Economic Activity, Labor Force, and Income

Table 4-25 shows ROI economic statistics.

4.9.1.2 Demographics and Housing

Table 4-26 presents ROI population trends as well as housing details.

4.9.1.3 Public Services

Public services provided by local governments were analyzed based on October 1982 employment data. Such local public services include the administration, operation, and maintenance of the government, transportation systems, environmental and housing development, and utilities, as well as the services as detailed below.

Table 4-25

COMPARISON OF ECONOMIC STATISTICS IN THE REGIONS OF THE SITE ALTERNATIVES

Parameter	AZ	CO	IL	MI	NC	TN	TX
Total employment growth 1969-1984 (in %)	117.6	91.1	9.0	3.5	39.2	42.2	74.1
Unemployment (in %, 1984)	4.1	4.8	8.2	10.4	5.8	6.6	3.8
Employment by Sector (in %, 1984)							
Services	25.4	24.6	26.5	25.8	21.2	23.7	23.7
Manufacturing	13.2	12.0	19.3	22.7	24.2	19.8	16.5
Construction	8.0	6.2	3.7	2.8	5.4	5.5	6.6
Other	53.4	57.2	50.5	48.7	49.2	51.0	53.2
Per capita personal income (in FY88 $)	14,557	17,696	16.932	15,716	13,565	13,216	17,405

Sources: Arizona Department of Economic Security 1988; Colorado Department of Labor and Employment 1988; Illinois Department of Employment Security 1988; Michigan Employment Security Commission 1988; North Carolina Employment Security Commission 1988; Tennessee Department of Employment Security 1988; Texas Employment Commission 1988; U.S. Council of Economic Advisors 1988; U.S. Department of Commerce, Bureau of Economic Analysis 1986; Virginia Employment Commission 1988.

Table 4-26

COMPARISON OF POPULATION AND HOUSING IN THE REGIONS OF THE SITE ALTERNATIVES

Parameter	AZ	CO	IL	MI	NC	TN	TX
Population (millions)							
1980 actual	2.13	1.82	7.24	4.63	1.56	1.12	2.66
1985 estimated	2.50	2.04	7.41	4.46	1.65	1.19	3.15
Population growth (1970-1980) (as % of 1970)	53.2	30.2	2.0	-1.8	13.8	19.5	19.3
Total year-round housing units (1980) (millions)	0.84	0.73	2.7	1.7	0.59	0.43	1.0
Housing permits issued 1981-1986 % of Actual Housing 1980	34	18	5	4	18	16	31
1980 vacancy rates (%) for year-round housing units available for occupancy							
- owner-designated	2.8	2.9	2.0	1.3	1.4	1.7	2.5
- rental units	11.7	7.7	6.4	7.2	6.4	7.3	10.2

Sources: U.S. Department of Commerce, Bureau of Census 1982a, 1982b, 1983, 1985, 1987a, 1987/88.

An important indicator used is "Level of Service" (LOS). This is simply the ratio of government employment in a particular sector to the total regional population. This concept is not without flaws. Varying degrees of out-of-region service provisions, differing levels of mechanization by government agencies, varying levels of crime and health problems, etc., can distort the significance of the LOS as an indication of actual service provided. The measure is useful, however, as an indication of the magnitude by which regional population impacts would increase needs for local government employment. Table 4-27 presents the calculated LOS for each site ROI for the following services.

A. General Education

General education includes all services related to primary, secondary, and higher public education provided at the local level.

B. Police Protection

All local government enforcement of law and order are considered, including coroners' offices, training academies, investigation bureaus, and local jails and detention centers.

C. Fire Protection

This category includes local government fire protection and prevention activities, as well as ambulance, rescue, and other services provided by fire protection agencies. Volunteer firefighters who receive compensation per fire were calculated into full-time equivalent (FTE) values as part-time employees.

D. Health

This category includes public services related to health including administration of local public health programs, immunization programs, health and food inspection activities, care institutions and public assistance programs for the needy, and county-operated medical care facilities which provide in-patient care.

4.9.1.4 Public Finance

Sources of income to the states are shown in Table 4-28. Taxes to individuals are also tabulated.

4.9.2 Infrastructure

4.9.2.1 Transportation

A comparison of existing transportation systems among proposed SSC sites is presented in Table 4-29.

Table 4-27

COMPARISON OF LEVELS OF PUBLIC SERVICE IN THE REGIONS OF THE SITE ALTERNATIVES AS MEASURED BY NUMBER IN GOVERNMENT EMPLOYMENT PER 1,000 POPULATION

Parameter	AZ	CO	IL	MI	NC	TN	TX
		(Number of employees per 1,000 population)					
General education	19	19	16	17	20	15	21
Police protection	3	3	4	2	2	2	3
Fire protection	1	1	1	1	1	1	1
Health	3	3	2	3	3	4	3
All other[a]	11	9	10	8	7	9	10

[a]Local government employees not previously classified, including administration and support staff.

Sources: Arizona Department of Education 1987; Colorado Department of Education 1987; Illinois State Board of Education 1987; Michigan Department of Education 1987; North Carolina Board of Education 1987; Tennessee Department of Education 1987; Texas Education Agency 1987; U.S. Department of Commerce 1984; Virginia Department of Education 1987.

Table 4-28

COMPARISON OF STATE GENERAL REVENUES (FISCAL YEAR 1986) AMONG THE SITE ALTERNATIVES

Parameter	AZ	CO	IL	MI	NC	TN	TX
				(millions of dollars)			
General sales tax	1,459	737	3,366	2,687	1,384	1,866	4,328
Sales tax rate (%)	5	3	5	4	3	5.5	6[a]
Income tax							
Individual	702	956	2,645	3,248	2,207	67	NA
Corporate	171	117	860	1,450	512	269	NA
Motor vehicle related (Fuels and licenses)	426	267	1,186	923	620	496	1,655
Other general revenues	1,847	2,473	8,237	8,300	4,181	3.188	13,921

Sources: Commerce Clearinghouse 1987; U.S. Department of Commerce 1987b.

[a] Sales tax rate increased to 6% effective FY 1987.

Table 4-29

COMPARISON OF EXISTING TRANSPORTATION SYSTEMS IN THE REGIONS OF THE SITE ALTERNATIVES

Existing Transportation Systems	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Roads							
Closest major city	Phoenix	Denver	Chicago	Detroit	Durham	Nashville	Dallas
Distance and direction from campus to the geographic center of the closest major city (mi)[1]	35 NNE	65 WSW	32 E	59 E	16 SSW	30 NW	32 N
Closest small city or town	Mobile	Fort Morgan	Batavia	Stockbridge	Butner	Murfreesboro	Waxahachie
Distance and direction from campus to the center of the closest small city or town (mi)	5 N	20 N	3 WNW	3 NE	7 SSE	7 NE	6 NE
Freeway/tollway access to site area	I-10 and I-8	I-76 and I-70	I-90 and I-88	I-96 and I-94	I-85	I-24 and I-65	I-35E and I-45
Distance and direction from campus to the closest freeway/tollway (mi)	9 S	21 N	2 S	9 S	7 SE	5 NE	4 E
Quality of existing on-site access roads	Few roads, largely unpaved	Unpaved	Paved	Paved	Paved and unpaved	Paved and unpaved	Mostly paved
Level of service range on existing freeways/tollways[2]	A - B	A	A - D	B - C	A	A - B	A - B
Level of service range on existing four-lane highways[2]	N/A	N/A	A - D	A	A	N/A	A
Level of service range on existing two-lane highways[2]	B - C	A	A - D	B - C	B - D	A - C	A - D

Table 4-29 (Cont)

COMPARISON OF EXISTING TRANSPORTATION SYSTEMS IN THE REGIONS OF THE SITE ALTERNATIVES

Existing Transportation Systems	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Rail							
Number of rail lines serving the site area	1	2	5	3	3	2	5
Existing siding/rail spur in the site area	Mobile	Fort Morgan	Fermilab	Jackson	North of Rougemont	Murfreesboro	Waxahachie
Distance and direction from the campus to the closest existing siding/rail spur (mi)	5 N	19 N	0	15 SW	7 W	6 NE	6 NE
Closest city in the site area with passenger rail service	Phoenix	Fort Morgan	Naperville	Jackson	None	None	Dallas
Air							
Closest major airport	Phoenix Sky Harbor	Stapleton International	O'Hare International	Detroit Metropolitan	Raleigh-Durham	Nashville Metropolitan	Dallas/Ft. Worth International
Distance from campus to the closest major airport (mi)	35 NNE	60 WSW	22 NE	45 ESE	25 S	28 NNW	39 N
Closest general aviation air-field with corporate jet capability	Casa Grande	Fort Morgan	DuPage	Jackson	Person County	Smyrna	Lancaster
Distance from campus to closest general aviation airfield with corporate jet capability (mi)	30 E	25 N	6 N	16 SW	13 NW	16 NNW	21 NE

Table 4-29 (Cont)

COMPARISON OF EXISTING TRANSPORTATION SYSTEMS IN THE REGIONS OF THE SITE ALTERNATIVES

Existing Transportation Systems	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Waterways							
Port serving the site area:	None	None	Chicago	Detroit	Portsmouth, VA	Nashville	Houston
Distance from campus to the closest port (mi)	N/A	N/A	35 E	58 E	120 ENE	35 NNW	210 SE
Taxi service to the site area	No	No	Yes	No	No	No	No
Public Transportation							
Bus and/or transit commuter service within the site area	No	No	Yes	No	No	No	No

1. All distances are presented as direct straight line distances from the proposed campus location
2. Level of Service:
A: Free flow with individual users virtually unaffected by the presence of others in the traffic stream
B: Stable flow but the presence of other users in the traffic stream begins to be noticeable
C: Stable flow but operations of individual users becomes significantly affected by interactions with others in the traffic flow
D: High density, but stable flow with speed and freedom to maneuver severely restricted and the driver experiences a generally poor level of comfort and convenience

Source: Volume IV, Appendix 5, Sections 5.1.11.2 through 5.7.11.2.

A. Roads

The proposed sites are typically located in rural areas near large metropolitan areas. The exception is the Illinois site which straddles a dividing line between rural areas to the west and urban areas to the east. All of the proposed sites are within reasonable driving distance (approximately 1 h) of major cities.

One or two freeways/tollways are available at each proposed site to provide access from the nearby metropolitan areas to the general site region. These freeways/tollways generally pass close (2 to 9 mi) to the sites. One exception is the Colorado site, which is approximately 21 mi from the closest freeway. These freeways generally experience some traffic congestion during peak hours near the metropolitan areas, with the quality of service improving with distance from the metropolitan areas. For the most part, the level of service is sufficient on the freeways and tollways in the regions of the proposed sites.

Federal four-lane, rural highways are available in Michigan, North Carolina, and Texas to provide access to and/or through the proposed site regions. These highways experience a good quality of service during peak hours. In Illinois, a number of State and local four-lane urban highways are available in the eastern half of the proposed site. These highways and roads in Illinois generally experience a good to moderate quality of service; however, some significant congestion occurs at local points during peak hours.

A network of Federal and state two-lane highways is generally present to provide access between freeways and small cities and towns within the site region. Highways currently experience a good to moderate quality of service during peak hours. Exceptions include Arizona, Colorado, and Illinois. Arizona has paved highways surrounding the site region, but only one dirt road crossing the site. Colorado has only one paved highway crossing the site and a network of dirt roads. The eastern half of the Illinois site has an extensive network of two-lane, Federal and State urban highways. Some of the highways in Illinois experience congestion at local points during peak hours.

Local roads range from a limited number of dirt roads in Arizona to almost totally paved roads in Illinois and Michigan. A number of highway improvements are currently planned for the proposed site regions with or without the SSC. In Arizona, a portion of the Maricopa-Gila Bend Road is currently being upgraded from a dirt road to a two-lane highway to provide access to the new hazardous waste facility under construction. In North Carolina, the Durham Northeast Loop, a four-lane freeway, will be constructed in the late 1990's from 1-85 to the planned new community of Treyburn.

In Tennessee, a new Interstate Highway 840, is planned as a southern belt around Nashville. I-840 will be constructed north of the proposed site in the late 1990's. In addition, U.S. Route 231 from Murfreesboro to Shelbyville, Tennessee, will be expanded from two to four lanes in the late 1990's. In Texas, a 4-mi section of I-35E from 1-20 to south of Belt Line Road in Dallas County will be expanded from four lanes to six lanes in 1991. In addition, U.S. Route 287, northwest and southeast of Midlothian, will be expanded from two lanes to four lanes in 1989. Major freeway and highway improvements are currently planned in the Phoenix, Denver, Raleigh-Durham, Nashville, and Dallas/Fort Worth metropolitan areas.

B. Rail

All of the proposed site regions are served by one or more rail lines equipped with existing sidings/rail spurs. Many of these rail lines actually cross the proposed sites. The Illinois site has an existing rail spur that serves the Fermilab property close to the proposed site. Sidings/rail spurs are located within 15 to 20 mi of the proposed campus location in Colorado and Michigan. The remaining sites have existing sidings/rail spurs within 10 mi.

AMTRAK passenger rail service is available in nearby cities for all proposed sites except North Carolina and Tennessee. In addition, regularly scheduled passenger rail service is available in Michigan along the Detroit-Chicago rail corridor that passes through Jackson and Ann Arbor.

C. Air

All proposed site regions are served by airports that are major hubs in the U.S. transportation system or are quickly becoming established as hubs. Therefore, good airline transportation service is available to all of the sites either through direct flights or single connections. The straight-line distances from these airports to the proposed sites vary from 22 mi in Illinois to 60 mi in Colorado.

All airports serving proposed site regions are growing rapidly. Two airports in North Carolina and Tennessee experience only minimal delays to scheduled airline service. The remaining airports are congested and experience greater delays. Airport expansions, including construction of new runways, are planned in Arizona, Michigan, and Texas to reduce congestion. In Colorado, construction of a new airport is expected to begin in 1989 to alleviate congestion and to serve the forecasted significant increase in future demand. At the present time, there are no plans to construct additional runways at O'Hare International Airport in Illinois.

All of the proposed site regions are served by nearby general aviation airfields capable of handling small, corporate jet aircraft. The straight-line distances to these fields from the proposed campus locations vary from 6 mi to the DuPage County Airport in Illinois to 30 mi to the Casa Grande Municipal Airport in Arizona. Additional general aviation fields capable of handling small piston-engine aircraft are also located near most of the proposed sites. The cities of Waxahachie and Midlothian, Texas, are planning to start construction in 1989 on a new general aviation airfield located above the proposed collider ring near the location of intermediate access shaft E2.

D. Waterways

Water-borne transportation is not directly available to any of the proposed SSC sites. The Illinois, Michigan, and Tennessee sites are served by ports located in Chicago, Detroit, and Nashville, respectively. These ports are located from 35 to 60 mi from the proposed campus and require rail and/or highway transportation to transfer cargo to the proposed sites. The ports at Chicago and Detroit provide access to oceangoing ships through the Great Lakes/St. Lawrence Seaway System, while the port at Nashville provides access to river barges on the Cumberland River connected to the Mississippi, Ohio, and Tennessee river transportation systems. The North Carolina and Texas sites are served by ports at Portsmouth and Houston, respectively. These ports, located from 120 to 210 mi from the proposed sites, provide access to oceangoing ships. Neither the Arizona nor Colorado site is served by a deep-water port.

E. Public Transportation

Public bus and other transit services are generally not available to proposed SSC sites. Typically, service is available in the nearby large metropolitan areas but does not extend out to the proposed site areas. The exception is Illinois which currently has public bus and rail rapid-transit service available to some communities along the Fox River Valley close to the proposed campus; however, service is not provided directly to the Fermilab campus.

Taxi services are also generally not available to the proposed SSC sites. One exception is Illinois which has taxi service available throughout the Fox River Valley, including the proposed campus location. Limited taxi services are available in small cities near all the sites except Arizona and Tennessee. Limited airport limousine service is also available from small cities near the Illinois and Michigan sites.

Rental car services are generally available at the major airports and other locations in the nearby major metropolitan areas for all proposed sites. These services currently provide primary transportation for visitors. Additional limited services are available in small cities near all of the proposed sites.

Ride-sharing, carpool, vanpool, and park-and-ride lot programs are typically coordinated and/or sponsored by public agencies in the nearby metropolitan areas. Except at the Illinois site, these programs generally do not extend out to the proposed site areas.

Para-transit services for aged and handicapped citizens are typically available throughout the nearby major metropolitan areas. These services extend to the proposed site area in Colorado, Illinois, North Carolina, and Tennessee. Services typically offer demand response door-to-door transportation in vans or small buses to prequalified citizens.

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4.9.2.2 Utilities

A comparison of existing utilities systems among the proposed SSC sites is presented in Table 4-30. More detailed information and references are presented for each of the proposed sites in Appendix 5, Sections 5.1.11.2 through 5.7.11.2.

A. Electricity

Each proposed SSC site is served by a fairly complete network of high-voltage (HV) and/or extra-high-voltage (EHV) transmission lines.

The capacities of the utilities are further augmented by their membership in one of the North American Electric Reliability Council (NERC) regions. The stated goals of this organization include the opportunity to preserve the stability and reliability of the member systems, and the desire to promote adequate reserve margins for each. Individual network capability is backed up by regional interties to neighboring electric utility systems (North America Reliability Council 1987).

The majority of electric utilities have planned for future additions to generating capacity. For most states, additional capacity is due online by the mid-1990's. For Illinois and Michigan, it is due by the end of 1988; for Arizona, it is due by 2005 (Arizona Public Service Co. 1986).

Arizona has planned to construct several new 230-kV transmission lines and substations, including a new 230-kV line between the existing Santa Rosa and Gila Bend substations which will serve the SSC. Construction is scheduled to begin in 1996, with a planned in-service date of 1997 (Arizona Public Service Company 1988; U.S. Department of the Interior, Bureau of Land Management, no date).

Plans are currently under way to relieve heavily loaded transmission lines northeast of Denver by uprating certain existing line sections and to construct a new 230-kV line between the Ault Substation and the Ft. St. Vrain Switchyard in the next 3 to 5 years (Eastom 1988).

B. Natural Gas

Each proposed site is served by a network of natural gas pipelines currently supplying both the sites and the surrounding regions. Table 4-30 lists the regional suppliers to each state's proposed site.

C. Telecommunications

Each of the proposed sites is served by at least one major telecommunications carrier. In several states, the telecommunications lines presently available are fiberoptic lines; in others, these are being phased in on an on-going basis.

Table 4-30

COMPARISON OF EXISTING UTILITY SYSTEMS IN THE REGIONS OF THE SITE ALTERNATIVES

Parameter	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Electricity							
Regional utilities	APS, SRP	PSco, Tri-State, MCREA	Commonwealth Edison	CPCo, Detroit Edison	Duke, Piedmont CP&L	TVA	TU Electric
Total capacity of serving utilities (MW)	4,500	4,900	21,400	15,500	29,500	32,100	19,400
NERC region membership	WSCC	WSCC	MAIN	ECAR	SERC	SERC	ERCOT
Capacity of NERC region (MW)	14,500 (AZ portion)	9,357 (CO portion)	48,100	93,500	137,000	137,000	47,400
Serving substations	Santa Rosa/ Gila Bend	Story & Pawnee/ Big Sandy & Daniels Park	Existing Fermilab	Agente-Majestic/ Thompkins	Rexboro-Method/Person-Henderson	Rutherford/ Maury	Big Brown and Venus/Limestone and Watermill
Construction power available (kV)	69	12.5 and 115	12 and 34	25 and 13.2	23	46	69
Future upgrades/ additions (MW)	340 (by 2005)	695 (mid-90's)	1,100 (by 1988)	1,100 (by 1988)	1,000 (mid-90's)	4,800 (mid-90's)	5,000 (by 1998)

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Table 4-30 (Cont)

COMPARISON OF EXISTING UTILITY SYSTEMS IN THE REGIONS OF THE SITE ALTERNATIVES

Parameter	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Natural Gas							
Regional suppliers	APS Southwest Gas El Paso Natural Gas SRP Black Mountain Nat. Gas	CIG PSCo	NI Gas	CPCo Michigan Con-solidated Gas Southeastern Michigan Gas	PSNC	United Cities Gas Co.	Lone Star Gas Co, Valero Energy Corp, Texas Utilities Fuel Co.
Communications							
Regional utilities	Mountain Bell AT&T	Mountain Bell AT&T Wiggins Tel. Co.	Illinois Bell	Michigan Bell Alltel Michigan General Tele-phone of Michigan	GTE South, Central Tele-phone Southern Bell Carolina Telephone	South Central Bell	Southwestern Bell CONTEL
Closest switching center (and distance) (mi)	Maricopa (23)	Fort Morgan (20)	Geneva (5)	Stockbridge (3)	Roxboro (15)	Murfreesboro (7)	Waxahachie (6)
Type of telecommunications line presently available	Copper Cable	Copper Cable	Fiber Optic	Copper Cable	Copper Cable	Fiber Optic Copper Cable Digital Radio Route	Fiber Optic Copper Cable

4.10 CULTURAL AND PALEONTOLOGICAL RESOURCES

4.10.1 Cultural Resources

4.10.1.1 Known National Register Sites/Sacred Sites

Only limited cultural resource surveys have been conducted at the proposed sites. All sites have recorded properties which have not been thoroughly evaluated against the National Register. None of the proposed sites has had a complete intensive cultural resource survey.

No Native American sacred sites have yet been identified at any of the proposed SSC sites, although burials are known from archaeological sites within the vicinity of several of the project areas.

The Butterfield Stage Coach route and the Juan Bautista de Anza Historic Trail are historic thoroughfares which cross the proposed Arizona SSC site and could be eligible for the National Register (U.S. Department of the Interior, National Park Service 1985). In Colorado, six recorded historic sites located along proposed access roads are considered eligible for the National Register (Joyner 1988). In Illinois some recorded sites are currently being evaluated. In Michigan three residences, the Springman Centennial Farm, the Cady Centennial Farm, and structure "R-516", are considered eligible for the National Register. One of these, the Springman Centennial Farm, is located in the proposed injector area; the other two sites, the Cady Centennial Farm and the structure recorded as R-516, are located within 1/4 of a mile of the intermediate access E6 and the future expansion area, respectively. In North Carolina, the Dudley Cunningham house, located within the proposed far cluster, may be eligible. In Tennessee, the Sanders Farm, located within the future expansion area, and the historic archaeological site referred to as the Spain Ranch, located in the campus area, are considered eligible for the National Register (Fielder, Prouty and Spires 1988). No properties in the Texas project area have yet been considered for National Register status.

4.10.1.2 Research in Proposed Project Areas and Significance Potential

A. Arizona

Major BLM environmental overviews pertaining to the proposed Arizona project area involve the Lower Gila South Resource Management Plan (RMP) and the Wilderness Environmental Impact Statement (U.S. Department of the Interior, Bureau of Land Management 1985, 1987). Three hundred and ninety sites were recorded on BLM lands and over 20,000 were predicted within the entire BLM study area which includes the proposed SSC site. Several phases of field research at the proposed Arizona SSC site have been completed by Arizona State University (Schakley and Rice 1986; Bostwick 1986). Seven prehistoric sites have been located: a lithic quarry, two base camps, two sherd scatters, one site with rock piles and sherd scatters, and one site with rock piles. The ten historic sites identified include the route of the Butterfield Stage Coach Line which is associated with Anglo-American settlement of the southwest, and portions of the Juan Bautista de Anza Historic Trail which is associated with Spanish settlement of California. Other historic sites include five historic structures (of which one remains standing in the proposed SSC campus area) and three scatters of historic artifacts which reflect attempts made during the 1930's to establish homesteads on the plains near the Maricopa Mountains. The history of homesteading is an important process in the Euro-American settlement of the arid southwest.

Interviews with elders and religious specialists among the Native American groups residing near the proposed site suggest that the Maricopa Mountains are viewed as wilderness, but no sacred sites have been identified (Bahr n.d.; Butler and Fletcher n.d.).

B. Colorado

Thirty-eight historic and archaeological properties are currently recorded within the general vicinity of the proposed Colorado SSC site including 22 prehistoric archaeological sites, three historic archaeological sites, nine sites with historic standing structures, three historic cemeteries, and an archaeological site with both prehistoric and historic components. Two of the prehistoric sites contain burials. With the exception of the Fort Morgan Post Office and the Rainbow Arch Bridge in Fort Morgan, which are listed on the National Register, none of these sites have been evaluated. Among the sites recorded as to date, only one campsite is recorded as potentially within the boundaries of the proposed collider ring.

Local residents and amateur archaeologists report several additional historic sites near the proposed Colorado SSC site, including two cemeteries, three schools, and an area referred to as God's Half Acre. Located near intermediate access E-4 is Steyaert Ranch which is said to contain 12 to 15 Native American sites. At least six graves are located on Hough Farms within the expansion area. The Pleasant Ridge School is within the collider ring easement between F-1 and E-2. None of these sites have been evaluated.

During an archaeological survey of portions of the proposed new roads to the proposed Colorado SSC site (Joyner 1988), seven prehistoric sites and ten prehistoric isolated finds were identified in potentially affected areas. Six of the sites are open lithic scatters; the other is an open lithic/ceramic scatter. As a result of a corresponding historic survey ten sites were recorded: six irrigation ditches and canals, two schools, one grange hall, and one barn. In consultation with the Colorado Office of Archaeology and Historic Preservation, six of these sites were considered eligible for the National Register: Speer Canal, Fort Morgan Canal, Neres Canal, Denver Hudson Canal, Sunnydale School, and the Work Family Barn.

C. Illinois

Prior to the siting studies for the proposed Illinois SSC site, 88 prehistoric sites were recorded in the nearby townships. A systematic survey was conducted prior to construction of Fermilab (early 1970) and the remainder of the Fermilab property was recently surveyed (Jeske 1986). SSC-related field work completed to date has focused on potentially affected areas of the collider ring. Seventy-eight prehistoric sites have been identified in the project area. One site was identified in intermediate access area E2. Twenty-five sites have been identified within the far cluster, two within the near cluster, and three within acquisition lands near the Fermilab complex (McGimsey et al. 1986).

Sixteen sites could be affected if alterations are made to the location of the proposed collider ring. This could involve three sites located near intermediate access area E2, two each near service areas F3 and F4, five sites in the far cluster, and four sites in the near cluster. In addition, 11 historic archaeological sites have been identified and verified to date within the project area. Ten historic cemeteries have also been identified near the proposed site. One of these is located on the Fermilab property and one is within the easement corridor of the collider ring alignment.

All unincorporated rural sections associated with the proposed Illinois SSC site have been surveyed during previous historic structures surveys (Illinois Department of Conservation 1972a, 1972b, 1974a, 1974b). Of the 587 standing structures in the project vicinity, only five structures lie within areas designated for intermediate access, service areas, buried beam zone access, or interaction points. One historic structure is located at the proposed intermediate access E7, one each at service areas F4, F7, and F9, 37 within the near cluster, 37 within the far cluster, 30 within beam absorber easement areas, one at J4, and 62 in the collider ring easement.

D. Michigan

One hundred and twenty-five prehistoric archaeological sites are recorded within the vicinity of the proposed Michigan SSC site; however, an intensive archaeological survey has not been undertaken at potential impact areas. Seven recorded sites are located within the proposed facilities boundaries. One site each is located in the area of intermediate access E3, intermediate access E2, service area F1, the near cluster, and the buried beam zone; two are located within the collider ring easement. A minimum of 82 historic archaeological sites of varying potential are predicted within the project site.

As a result of an intensive historic buildings inventory, a total of 243 structures were evaluated. One hundred and twenty-one are located within the proposed Michigan SSC site. Three of these structures could meet National Register criteria. The Cady Centennial Farm, an example of

Greek Revival architecture, is situated adjacent to intermediate access E-6. Located within 1/4 mi of the future expansion area is a structure (R-516) which is an example of Gothic Revival architecture. The Springman Centennial Farm (R-104), located within the proposed injector area, is an example of the "gabled ell" type.

E. North Carolina

Essentially no intensive archaeological survey has been undertaken in the actual proposed North Carolina SSC project area and data are not available to predict numbers or projected locations of cultural resources. Extensive historic structure surveys have been completed in Granville and Durham Counties. Eighty-nine prehistoric and historic archaeological sites have been previously recorded in the vicinity including part of the Bennehan-Cameron Plantation, a site determined to be eligible for listing in the National Register. Historic properties include houses, mills, a church, a grove, a bridge, a tobacco factory, two masonic lodges, a courthouse, a depot, and a historic district. One site, the Dudley Cunningham House, is located between intermediate access E5 and service area F6.

Recorded archaeological sites in the vicinity of the proposed North Carolina SSC site indicate that the prehistoric chronology is represented by all phases of the Archaic and Woodland Periods. In addition, it is likely that historic archaeological sites are present. On the basis of information available from historical resource surveys, it appears that the significant historic structures in the proposed project area illustrate vernacular examples of Georgian, Federal, Greek Revival, Victorian, and early 20th-century revival architectural styles. Historic cemeteries are common in the project vicinity.

F. Tennessee

Twenty-six previously recorded archaeological sites are located in the vicinity of the proposed Tennessee SSC site in the area. Several archaeological surveys have been undertaken nearby (Ward 1982, 1985a, 1985b; Duvall 1983; Faulkner and McCollough 1973; Klippel, Elmendorf and Graham n.d.; Dickson 1976; Jolley and Newman 1982). Historical inventories have been completed by the Tennessee Historical Commission pertaining to State Route 99 (Slater 1985).

The Tennessee Division of Archaeology conducted a reconnaissance survey of prehistoric and historic archaeological sites within the proposed Tennessee SSC site (Fielder, Prouty and Spires 1988). Three prehistoric archaeological sites were identified. Two sites are located just outside the collider ring near intermediate access E10. Another site is located on a terrace along North Fork Creek within the proposed far cluster. Eighteen possible historic archaeological sites, including the Thomas Spain Ranch, are located within the campus, injector, and future expansion areas; 25 potential historic archaeological sites are in the far cluster (Fielder, Prouty and Spires 1988).

The Tennessee Division of Archaeology and the Tennessee Historical Commission also conducted a reconnaissance survey to identify historic structures. Forty buildings were recorded in the future expansion areas. One farm complex, the Sanders Farm, is considered to be eligible for the National Register. The survey also noted a total of 10 cemeteries near the project area dated from 1813 to 1856.

F. Texas

Several recent studies near the proposed Texas SSC site are indicative of the cultural resources which could be located in the area. The Texas Archaeological Salvage Project conducted archaeological studies before the construction of Lake Bardwell; 15 sites were located (Shafer 1964).

Archaeological studies were undertaken prior to the construction of Lakeview Lake, located partially in Ellis County; 17 prehistoric sites and 25 historic sites were located. A similar study of the Richland Creek Reservoir recorded 447 archaeological sites and 488 historic sites (Raab et al. 1982).

A historical survey of the nearby city of Waxahachie identified 1,988 structures which predate 1935 (Hardy, Heck and Moore 1985a); 65 of these buildings have been listed on the National Register. The city of Ennis similarly features 1,286 historic structures including National Register properties (Hardy, Heck, and Moore 1985b).

The Texas State Historic Preservation Office literature search and reconnaissance survey of the proposed Texas SSC site identified 17 recorded prehistoric archaeological sites. Historic structures include houses and farmsteads, a cemetery, a truss bridge, and a cotton gin/weigh station. None of these will be directly affected by SSC activities. Information from previous studies within the Texas SSC study area and nearby indicate that archaeological site density is low in upland prairie environments such as the project vicinity. However, all prehistoric cultural periods are likely to be represented. Those sites which have been identified are usually situated along larger streams such as Mustang, Waxahachie, and Chambers Creeks, or adjacent to perennial springs.

Historic farmsteads dating from 1850 to 1935 are present within the project vicinity and may contain a variety of structural types. Other rural historical resources include mid-19th or early 20th-century cotton gins and weighing stations, churches, cemeteries, and bridges, gas stations, and grocery stores. A brief field reconnaissance of the project vicinity indicates that rural historic resources are more densely concentrated in the north, east, and central sections of the project site. No information is available pertaining to historic archaeological sites.

4.10.2 Paleontological Resources

4.10.2.1 Scientific Background and Known Paleontological Localities

A. Arizona

No known paleontological localities have been recorded in the proposed Arizona SSC project area.

B. Colorado

The Pleistocene alluviums at the proposed Colorado SSC site have produced large mammal fauna including mammoth, camel, horse, buffalo, and small ground mammals (Hunt 1954; Scott 1962, 1963). The Peoria Loess has produced giant ground sloth, peccary, camel, horse, and badger and other small mammals. Holocene deposits, such as the Piney Creek Alluvium, have produced faunal material. Petrified wood and isolated bone fragments were recovered from nearby streams (Indeck 1988).

One Mesozoic invertebrate fossil locality is located near the proposed Colorado SSC site in the Pierre Shale, on a tributary drainage to Badger Creek (Sharps 1980). Fish and marine reptile remains and part of a mosasaur have been recovered from the Pierre Shale near Flagler.

The late Cretaceous Fox Hills Sandstone is not present in the area of the proposed Colorado SSC collider ring but is potentially affected by access road construction. Fossil plants, invertebrates (marine mollusks), fish-scales and vertebrae, sharks' teeth, and an insect are from the Fox Hills Sandstone. The Laramie Formation and the Denver Formation occur in areas associated with proposed SSC roads (Indeck 1988). Fish, amphibians, reptiles, mammals, and dinosaurs have been recovered from the Laramie Formation. The Denver Formation has produced late Cretaceous leaves and dinosaur bones, and Paleocene leaves, and mammal, reptile and amphibian bones and teeth (Brown 1962; Middleston 1983). Core samples from five areas in the vicinity of the proposed SSC site revealed upper Cretaceous trace fossils, including gastropods, brachiopods, pelecypods, and ammonites (Kaufman and Batt 1987). No other known fossil localities are located in the proposed SSC collider ring.

C. Illinois

At the proposed Illinois SSC site, fossils within the Quaternary drift stratum would have the greatest potential for being affected by construction. The Grayslake Peat may contain pollen, plant macrofossils and vertebrates (King 1981), which generally underlies swamp areas. The Cahokia Alluvium has produced vertebrate fossils and molluscan shells (Hajic 1981; Graham et al. 1981). The Equality Formation has produced vertebrate, invertebrate and plant fossils (Heinrich 1982). The Henry formation has produced vertebrate fossils (Parmalee 1967). The Batavia Member of the formation produced a mastodon, plant macrofossils and molluscan remains from outwash deposits recorded near the project area

(Keyston 1966). The Wedron formation occasionally produced fossil vertebrates, mollusks, and pollen in outwash deposits, Thirteen fossil localities near to the proposed Illinois SSC site contained vertebrate fossils, paleobotanical remains, and mollusks.

D. Michigan

At the proposed Michigan SSC site, glacial remnants such as lakes, bogs, and swamps, and aquatic kettles and basins may be filled with late Pleistocene peat, muck, and marl deposits. These may also contain mammoths and mastodon remains.

Fossils are abundant at some exposures of the Lower Pennsylvania Saginaw formation; the Grand Ledge exposures have produced four major primitive plant groups and invertebrate fossils (Kelly 1936; Dorr and Eschman 1971).

The Mississippian Marshall formation has produced fossils at nearby Stoney Point Quarry including ammonoids, clams, crinoids, nautiloids, and ostracods. The Blue Ridge Glacial Esker has produced abundant clam and invertebrate fossils. The Mississippian Michigan formation and Bayport Limestone have produced fish fossils. The Bayport Limestone has also produced plant remains (Dorr and Eschman 1971).

Pleistocene fossils previously located in Ingham, Jackson, Livingston, and Washtenaw Counties include: giant beaver, meadow vole, muskrat, American mastodon, Jefferson mammoth, peccary, elk, deer, moose, woodland musk ox, and white sucker (Holman 1979, 1986; Skeels 1962; MacAlpin 1940).

E. North Carolina

According to the North Carolina Geological Survey there are no critical paleontological sites within the proposed project area.

F. Tennessee

At the proposed Tennessee SSC site, the Ordivician Stones River Group consists mainly of limestone beds as does the Nashville Group which contains invertebrate fossils. Corals are also present (Miller 1974).

The Mississippian Chattanooga Shale deposits contain the earliest land and vertebrate fossils found in Tennessee. These are generally poorly preserved and are not very abundant, but they include a variety of fish and sharks. Plant fossils, including driftwood, spores, and algae are found. Toothlike or palatelike pieces of an unknown animal, and referred to as conodonts, are present. The most abundant fossils of the Mississippian are the crinoids which are found in the Fort Payne deposits of limestone, shale, and chert in Middle Tennessee (Miller 1974).

Land animals were abundant during the Quaternary Period including mastodons, mammoths, saber-toothed cats, giant ground sloths, camels, jaguars, and giant panthers. Remains have been found in river deposits above the present floodplains and in caves (Matthews 1971).

G. Texas

Although little paleontological research has been completed in the vicinity of the proposed Texas SSC site, nearby Pleistocene and Cretaceous deposits are fossiliferous. Quaternary alluvium and terrace deposits have produced mammoth remains and an assortment of molluscan fauna. The Cretaceous Austin Chalk has produced numerous fishes as well as a specimen of marine reptile (Slaughter and Thurmond 1965).

Two Ellis County finds include bison and mammoth remains located along Pleistocene stream terraces of tributaries of the Trinity River. Several Ellis County localities at quarries contain fossil shark teeth obtained from the Cretaceous Austin Chalk/Taylor Marl, as well as Cretaceous fish from the Midlothian Limestone. Further, the lower jaw of a marine reptile and fish remains were recovered from bedrock deposits of Waxahachie Creek. Pleistocene sediments along Big Mustang Creek produced numerous molluscan specimens as well as fragmentary vertebrate fossils (Slaughter and Thurmond 1965).

4.10.2.2 Characterization of Geological Strata and Paleontological Potential

A. Arizona

The geological setting of the proposed Arizona SSC site is not considered favorable to preservation of fossil remains. Proterozoic granites and schists predate the existence of hard body parts necessary for fossil preservation, and Precambrian soft-tissue organisms are rarely preserved in igneous and metamorphic rocks.

B. Colorado

At the proposed Colorado site, stratigraphic levels that potentially contain fossils include the recent alluvium, eolian sands, the Peoria Loess, and the Upper Cretaceous Pierre Shales. Outside the collider ring, project activities such as road construction could uncover fossils in the Laramie and Denver Formations and Fox Hills Sandstone Formations. Areas with alluvial stream or terrace deposits could yield fossils including Badger, Lost, and Box Elder Creeks (Indeck 1988).

C. Illinois

The eastern and southern parts of the ring have some high probability of surface areas with paleontological resources.

D. Michigan

The proposed Michigan SSC project area contains fossils of two widely separated time periods and of two distinctly different stratigraphic contexts representing Pleistocene and Paleozoic processes. To determine the likelihood and nature of fossils at the proposed Michigan SSC site, seven borings were made along the collider ring. The Saginaw formation yielded fossil plants or traces of fossil plants in five of the seven. The Mississippian Bayport limestone yielded fossil plants in one of the five boreholes and had potentially fossiliferous sediments at levels in all borings. The Michigan formation yielded no fossils in the two borings. The Mississippian Marshall formation was not encountered.

E. North Carolina

There are no known paleontological sites in the immediate vicinity of the proposed SSC site area.

F. Tennessee

Ordovician limestones which occur in the proposed Tennessee SSC area as the Stones River and Nashville deposits contain a variety of invertebrate fossils including large amounts of corals. The Mississippian Period Chattanooga Shale and later limestone, shale and chert Fort Payne deposits may contain important vertebrate fossils. Further, remains of Pleistocene mammals may occur in alluvial deposits of the Quaternary Period or in caves, several of which are located within the proposed Tennessee SSC project area (Miller 1974; Matthews 1978).

G. Texas

At the proposed Texas SSC site, it is possible that fossils are present in formations of the Pleistocene and recent epochs, particularly along stream terraces. It is unlikely that significant land-dwelling or marine vertebrate paleontological remains will occur in the older Austin Chalk and Taylor Marl (Cretaceous). It is more likely that scattered Cretaceous mollusks, clams, sharks, and fish would be encountered.

4.11 SCENIC AND VISUAL RESOURCES

4.11.1 Definition of the Resource

Visual and scenic resources comprise the natural and man-made features that give a particular environment its visually aesthetic qualities. These features may be natural appearing or modified by human activities. Together they form the overall impression of an area, referred to as its visual character. Aside from their physical features, visual and scenic resources also have a social setting that includes: public values, goals, awareness, and concern regarding visual and scenic qualities, termed visual sensitivity. The public's sensitivity over noticeable adverse changes in the quality of the landscape is an indicator of how significant the changes may be.

4.11.2 Visual Character and Sensitivity for the Study Area

The visual characteristics of the proposed Michigan, Tennessee, North Carolina, and Texas sites are populated, agricultural lands, dotted with small-scale farms, pastures, and croplands. Few urban influences have advanced across the sites, although rural residential areas occur throughout as small groups of large-lot homes strung along secondary roads. A few small communities also occur as nodes at crossroads.

Viewsheds are not defined by landforms so much as by vegetation. Views do not characteristically extend far because of intervening forests, woodlots, and fencerows. This is especially true in Michigan and North Carolina, where woodlands extensively cross much of the sites. As a consequence, views center on foreground details, and seldom is any particular feature seen from more than a few nearby locations. Such landscapes are considered to be capable of absorbing considerable visual change with only localized adverse effects. Vegetative screening in Texas is minimal over much of the eastern half of the site, trees being of lower stature than in other states mentioned and fields being more extensive. Views in this area are much broader and more distant than in Michigan, North Carolina, or Tennessee. However, forests are prevalent around the northwest sector of the Texas site, and viewing conditions there are similar to those at the other three states.

For the four states mentioned, visual sensitivity arises primarily from the occurrence of residential subdivisions and rural residential areas close to the proposed sites for project surface facilities around the collider ring. Recreation resources are affected only in North Carolina and Texas. In Tennessee, in addition to residential areas, sensitivity arises out of the State's having designated a U.S./State highway as a scenic route. Several proposed facility sites are adjacent to this highway.

In Illinois, the eastern part of the site is substantially affected by urban and suburban growth with major pockets of residential development interspersed with residual agricultural lands and strips of commercial and light-industrial development. Against this backdrop, the SSC facilities are compatible except where sited in the midst of a substantial area of residential development. The rest of the site is agricultural - vast fields with regularly spaced large-scale farm structures that stand out as the chief visual features of the landscape. In such areas, views extend 2 to 3 mi, fencerows and woodlots being widely separated. As with the other four states mentioned, public sensitivity to the visual impacts of the project can be expected to occur relative to views from residential subdivisions and rural residential areas.

In Colorado, the site is in a relatively unpopulated area, rolling to flat and sparsely vegetated, mostly with croplands and pastures. Ranches and farms prevail but are few in number. Views are open, and appear panoramic, but are subtly enclosed by the gentle roll of the land; they do not extend for more than 1-2 miles. The region is in a broad topographic bowl; views of the Rockies in the distance are largely cut off by the broad rim of that bowl to the west. Within the site, any vertical structure stands out for several miles in most directions, views being unencumbered by tall vegetation. No appreciably sensitive views would be affected at this site.

In Arizona, the semi-arid desert landscape is sparsely vegetated in comparison to the other sites and has great topographic relief because of the Maricopa Mountains enclosed by the collider ring. Unlike the other six sites, the landscape is predominantly unmodified and natural appearing, as evidenced by the extent of the BLM-designated Wilderness Study Areas. Views are distant and panoramic, especially from points close to the base of the mountains at the top of the bajadas (alluvial piedmont). The bajadas slope subtly to broad basin floors, affording open views across the desert from points along their upper reaches. There are a number of highly sensitive views, primarily from recreation trails (jeep) and campsites near several proposed facility sites. Also sensitive are views from a historic trail (the Butterfield Stage Route). Other proposed facility sites are within areas for which the BLM has set stringent visual resource management objectives, indicating this Agency's sensitivity toward visual impacts in such areas.

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CHAPTER 5

ENVIRONMENTAL CONSEQUENCES DURING THE LIFE OF THE PROJECT AND MITIGATIVE MEASURES

CHAPTER 5 ENVIRONMENTAL CONSEQUENCES DURING THE LIFE OF THE PROJECT AND MITIGATIVE MEASURES

TABLES

FIGURES

CHAPTER 5 ENVIRONMENTAL CONSEQUENCES DURING THE LIFE OF THE PROJECT AND MITIGATIVE MEASURES

This chapter identifies and analyzes the expected potential environmental effects of the proposed SSC during preconstruction, construction, and operations at the seven site alternatives. Following selection of a site for the proposed SSC, the DOE will prepare a supplement to this EIS to address in more detail the impacts of constructing and operating the proposed SSC at the selected site and alternatives for mitigating those impacts. The actions that could generate impacts are described in Chapter 3. As described in Chapter 3, mitigation measures applied prior to assessing impacts would be design-controlled elements (those incorporated into SSC conceptual plans) or agency-committed actions (those required by policy, statute, or regulation). Impacts remaining after application of these two levels of mitigation would be residual impacts. In some cases, it may be possible to further mitigate residual impacts through final site design. Mitigation measures that may be incorporated in the final site design are identified in this chapter, where applicable, for each resource affected.

Residual impacts are identified by their duration and magnitude. The duration of an impact describes how long the impact would remain in effect. An irreversible or permanent impact would be an effect that would remain after operations and decommissioning of the SSC.

The magnitude of an impact is the degree of significance or the amount of change to the environmental baseline that would occur. Where possible, the change has been quantified; where that is not practical or possible (e.g., visual and scenic effects), the level of change is described in the more general terms of negligible, measurable, or significant. Not all of these terms are used for all resource values.

Additionally, this chapter identifies cumulative impacts and unavoidable adverse impacts, where applicable. Cumulative impacts are those which may be individually insignificant, but when taken with other similar impacts, cause an incremental change which contributes to a significant effect on the baseline environment. Unavoidable adverse impacts are those which cannot be totally mitigated, although they may be lessened to some extent (i.e., the overall dimensions of the collider tunnel are fixed; however, access areas might be shifted along the tunnel alignment to some extent).

The final section of this chapter discusses natural and depletable resource requirements and conservation potential. The resource consumption requirements needed to construct and operate the SSC are identified (e.g., aggregate needed for concrete; water needed for cooling requirements). The chapter then explores the potential to conserve these resources. This analysis includes both factors imposed by the conceptual site design and those which would vary among the seven proposed sites.

5.1 IDENTIFICATION OF IMPACTS AND MITIGATIVE MEASURES AMONG SITE ALTERNATIVES

Section 5.1 of this chapter presents the potential environmental impacts and possible mitigative measures for the seven site alternatives. Detailed information that augments this impact assessment is provided by resource affected in Appendices 6 through 16.

As noted above, impacts discussed in this section are the residual impacts that would remain after mitigation measures incorporated into project design (design-controlled elements) and agency-committed mitigation measures have been applied.

5.1.1 Earth Resources

5.1.1.1 Topography

SSC project-related changes to topography during construction would be caused by grading in the campus and service areas, cut-and-cover excavations for underground structures, and spoils piles of excavated material. Preconstruction impacts due to site investigations are of a very limited duration and lesser magnitude than the construction period impacts at each site. No operational phase impacts have been identified. The area of disturbance and spoils disposal impacts are detailed in the individual resource areas in this chapter.

The impacts of grading on the campus area would be negligible at six of the seven site alternatives where existing topography is flat or has a low uniform slope. At the North Carolina site, topography is more rolling (incised by streams) than at the other sites; however, the impacts still would be minimal. The need for extensive grading could be mitigated using layouts that conform to the existing topography.

Grading impacts at the service areas at all site alternatives except Arizona would be negligible because of the low surface slopes and the small areas affected. The impact at the Arizona site is expected to be minimal where five service and access areas are located in more mountainous areas that would require regrading for access and construction.

The only cut-and-cover collider tunnel excavations would be for a 6-mi-long, 150- to 250-ft-wide segment of the tunnel at the Arizona site. Temporary diversions would be constructed for dry washes that must be crossed. The dry wash excavations would remain open only long enough to install the tunnel liners and access shaft liners and would then be backfilled and restored to the original topography. At all other sites, collider tunnel excavations would be completely underground.

Cut-and-cover excavations for the booster/injector tunnels might be utilized at all sites except Illinois. Typically, this would involve an excavation 7 to 7.5 mi long, 60 to 150 ft wide. At the Illinois site, the Fermilab Tevatron would be used and no construction would be required.

Temporary diversions would be built at most of the sites to handle flowing streams or surface water runoff where drainages cross the cut-and-cover excavations. As soon as the tunnel liners are installed, the excavations would be backfilled and the original topography restored.

From two to four of the experimental halls might be constructed by cut-and-cover excavation at the Arizona, Colorado, Michigan, Texas, and North Carolina sites. Experimental halls at the North Carolina site are proposed to be constructed by underground excavation; however, if site studies do not show sufficient thickness of unweathered rock, cut-and-cover techniques may be considered. All four halls in Illinois and Tennessee would be underground excavations. The area of surface excavations for the halls typically ranges from 100 by 200 ft up to 600 by 800 ft. During construction, the experimental hall excavations would be backfilled as soon as possible and restored to the original topography.

Near-site spoils piles of excavated material are proposed as options at the Colorado, North Carolina, and Tennessee sites. In Colorado, the spoils would be graded into the existing land contours atop sloping uplands. In North Carolina, spoils would be piled in forested areas, out of local drainages. Spoils in Tennessee may be graded into the heads of dry gullies. The thickness of spoils at all sites would generally be less than 20 ft. Spoils disposal sites would generally range from 5 to 15 acres. Nonimpacting approaches, including sale of spoils as construction material or disposal in existing quarries, are planned in Illinois, Michigan, and Texas. In Arizona, the spoils would be spread as a thin layer (approximately 1 ft thick) over a large area on-site (1 mi^2) or disposed of in existing open-pit mines.

5.1.1.2 Rock and Earthen Materials

Approximately 2.5 to 3.0 million yd^3 of rock and soil material would be excavated at each of the sites for SSC construction. Excavated rock would make up more than 85 percent of this volume (except at the Arizona site, where only about 50 percent of the volume is rock); the remainder would be soil. None of the soils at the seven sites was found to contain significant amounts of deleterious leachable material. Rocks in Michigan (Saginaw and Michigan Formations), Colorado (Pierre Shale), Tennessee (Lebanon, Pierce, and Ridley Formations) and Illinois (Galena - Platteville Dolomite) contain trace to minor amounts of sulfide minerals (e.g., pyrite). However, because of the overall low abundance of sulfide minerals in the rocks from all of these sites, the potential of acid leachate development is minimal. Additionally, dolomite and limestone present in the spoils from Illinois, Tennessee, Texas, and, to a lesser extent, Michigan, would act to prevent development of acidic waters. The Tennessee site has the potential for phosphate contamination from material excavated from the Bigby/Cannon Formation at one shaft location (E7). Impacts from phosphate contamination would be expected to be minimal because of the low concentrations of phosphate minerals (if present) and overall small volumes of rock material to be excavated from this formation. Alternatively, if shaft E7 is relocated, as is being considered to improve the difficult access to this location, the Bigby/Cannon Formation may be avoided altogether.

5.1.1.3 Economic Geologic Resources

Changes that affect local and regional economic geologic resources would occur during SSC preconstruction, construction, and operations (see Table 5.1.1-1).

During SSC operations, some geologic resources at all sites located beneath and adjacent to SSC facilities would not be available for consumption. Sand, gravel, and construction aggregate exist at all sites; limestone for cement manufacture is found near the Illinois, Tennessee, and Texas sites. These resources are not unique and amount to a fraction of a percent of that available in the region. Therefore, the impact of temporarily removing the availability of these resources would be negligible. Construction and operations impacts on quarries are identified at the Colorado, Illinois, Michigan, and North Carolina sites. Small sand and gravel quarries and existing or proposed rock quarries are reported as existing on or near the proposed ring alignment at these sites. Preconstruction analyses would confirm the current status of these operations. Quarries in the area over the collider ring would be purchased to prevent interferences to SSC operations. The impact to regional resource availability caused by the closing of these quarries would be small due to the widespread abundance of these materials throughout the site regions.

Oil and gas production near the Colorado and Michigan sites includes wells along the collider tunnel alignment (three in Colorado; two to four in Michigan). These wells would be located, decommissioned, and plugged to avoid interference with tunnel construction. Additionally, a small number of wells near the ring alignment may need to be shut down to prevent interferences with SSC operations. Impacts of this action on the ability to recover local oil and gas resources may be mitigated by tapping large underground reserves that cover extensive areas with wells drilled outside the site proper. The impact of completely removing a small number of oil and gas wells would be negligible; mineral rights acquired for the SSC from individual operators/owners would be paid for at fair market value. These resources would again be available at the end of operations (considered to be approximately 40 years after construction begins).

The SSC would operate within prescribed tolerances with respect to background vibration. Ambient vibrations must be low enough not to adversely affect the precise targeting of the colliding beams. Geologic resource activities that may cause undesirable vibrations could include rock-blasting, crushing and sizing of rock and gravel, and pumping of oil wells. No mining or extraction activities at any site have been identified as creating vibrations in excess of tolerances. Therefore, impacts to operations from mineral extraction activities are considered negligible at all sites. Permitting of future activities would have to consider the SSC as a sensitive receptor for vibrations.

Table 5.1.1-1

IMPACTS ON AVAILABILITY OF ECONOMIC GEOLOGIC RESOURCES

Specific Impact	AZ	CO	IL	MI	NC	TN	TX
Preconstruction Impacts							
Decommissioning of oil wells on site/loss of wells	None	2-3 wells[1]	None	2-4 wells[1]	None	None	None
Construction Impacts							
Sand, gravel, and cement consumed	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Operations Impacts							
Shutdown of nearby oil wells/loss of well usage	None	<20 wells[2]	None	<10 wells[2]	None	None	None
Potential shutdown of nearby quarries/temporary loss of resource availability	None	None	0-2[3]	0-2[3]	0-2[3]	None	None

* Neg. - Negligible

1 Wells within the ring alignment that are decommissioned during the preconstruction period.

2 Wells near the ring alignment that may need to be shut down during operations to limit vibrations.

3 Quarries near the ring alignment that may need to be shut down during operations to limit vibrations.

Sources:
Arizona Department of Mines and Mineral Resources 1984; Garner 1988; Manhardt 1988; McHugh 1988; Michigan Department of Natural Resources 1987; Michigan Oil and Gas Commission 1988; Peterson et al. 1985; Petroleum Information Corp. 1988; Reid 1988; State of Colorado 1988; U.S. Bureau of Mines; Witcher et al. 1979.

Depending on specific site requirements, materials irretrievably committed in building the SSC would include: 1.3 to 1.8 million tons of high-quality aggregate; 13,000 to 189,000 tons of medium quality aggregate; 38,000 to 63,000 tons of stone bedding; and 99,000 to 149,000 tons of cement. With the exception of Colorado, the sites are either in geologies that include large volumes of the rock materials needed to produce these products or they have existing distribution networks to get these resources elsewhere in the region, or both. Project requirements for construction aggregate represent generally less than 1 percent of locally available reserves in Arizona, Illinois, Michigan, North Carolina, and Tennessee. In Texas, local supplies are more limited, but regional reserves of aggregate (within 90 mi of the site) are considered unlimited. Similarly, project requirements for cement represent a small percentage of commercial resources available either near the site or from nearby states. Impacts caused by irretrievable commitment of resources would be negligible at these sites. The Colorado site has only limited, scattered areas of suitable aggregate in the Denver-Fort Morgan region; some of these aggregate sources have already been built over by the Denver area expansion. Planned projects in the Denver area are expected to deplete the accessible reserves that have currently been permitted by the first decade of the next century. Although the SSC would have less than a 1 percent impact on the aggregate reserve rock material, sources may need to be found beyond the Denver region and transported to the site. At all sites, some portion of the excavated rock may be used to fill part of the demand for aggregate, fill, and landscaping material, thus reducing the impact on off-site reserves.

5.1.2 Water Resources

Four types of impacts on water resources were evaluated. These were: runoff and erosion (including sedimentation impacts on streams), floodplains and flood risk (in accordance with 10 CFR 1022), water quality (both direct impacts of any facility emissions and indirect effects of spoils leachate or soil contamination), and water use (both surface and groundwater).

Impacts to surface water resources caused by the SSC project would be due to changes in the hydrologic regime, flooding characteristics, pollutant loading, or water use. Because these changes would occur primarily during construction and operations, this discussion focuses on these phases.

Groundwater impacts would be associated most commonly with water level declines and/or basin or aquifer overdraft. These impacts would be caused by direct or indirect project water supply withdrawals; but these impacts can also be caused by dewatering and groundwater inflow control activities. Project-related water supply withdrawals would occur during both construction and operations; dewatering and groundwater inflow control would occur primarily during construction.

Subsidence or gradual downward settling of the land surface might result from groundwater supply withdrawals during both construction and operations. Site geologic conditions, primarily stratigraphy and lithology, are a controlling factor on the potential for occurrence of subsidence.

Groundwater recharge reduction might result from soil compaction, construction of impervious surfaces, and modification of drainage patterns within a recharge area. Soil compaction effects would generally be short term and would not extend beyond the construction period. Impervious surfaces (e.g., roads, buildings, parking lots) and the effects of drainage modification would generally remain throughout operations and beyond.

Expansions or other modifications to local public water supply systems with surface water and/or groundwater supply sources may be required as a result of in-migration of project personnel and dependents and indirect population growth associated with project construction and operations. This in-migration might affect both communities in the immediate site vicinity, as well as areas and communities some distance from the site.

Existing water wells on land acquired for SSC project facilities and wells near the planned tunnel alignment might have to be abandoned. This impact would occur during project land acquisition or early during construction. Blasting for tunnel or shaft construction would be expected to potentially affect wells only in the very immediate vicinity of the blast site. Wells within this zone of influence would likely have been abandoned due to location in a fee simple area or at a depth that conflicts with tunnel construction and operations.

Definitions, criteria, and the process for assessing surface water and groundwater resources impact magnitude and significance are detailed in Appendix 7, Sections 7.1.1 and 7.1.2, and 7.2.1 and 7.2.2 respectively. Resource impact assessments for each of the site alternatives are presented in Appendix 7, Sections 7.1.3 (Surface Water) and 7.2.3 (Groundwater).

5.1.2.1 Runoff and Erosion Impacts

Removal of vegetation during site preparation will result in some increased runoff. In addition, runoff increases would result from construction of impervious surfaces such as buildings and parking lots. These increases in runoff are proportional to the acreages disturbed temporarily and permanently as well as the precipitation typical of the area. It is anticipated that 200-1,300 acres would be permanently disturbed; another 250-2,000 would be disturbed temporarily. The number of acres disturbed would be very small in comparison to the subdrainage basins in which they lie. Consequently, overall runoff impacts would be negligible.

During construction, some diversion levees and other runoff-containing measures would be employed to protect construction sites from flooding. In addition, temporary channel diversions could be used for existing perennial streams or rivers where construction activities for roads, railroads, buildings, utilities, and other facilities would cross them. Such drainage pattern modifications could cause impacts to streams from flooding, increased erosion, and sediment deposition. These would be temporary impacts which would only occur during construction. Additional mitigative measures could include effective construction scheduling to minimize drainage or channel diversions, i.e., shorten the duration and extent of diversions by accomplishing construction in smaller steps. Runoff retention is also possible to lessen the impacts from interbasin runoff transfers.

Five of the seven sites would have only a negligible impact from drainage diversions or temporary channel relocations. Modifications would be minimal at these sites. At the Arizona site, there could be a short-term impact from increasing the contributing watershed area to a Southern Pacific Railroad culvert. If a significant flood event occurred while the construction diversion was in place, the railroad embankment and railbed could potentially be damaged. Appropriate mitigation measures would be considered during final design. These measures might include constructing temporary diversions prior to starting excavation and restoring the natural drainage channel as soon as possible as construction progresses.

At the Colorado site, permanent redirection of the channel of Sand Creek (tributary to Beaver Creek) might be necessary to accommodate the location of experimental hall K6. Extensive channel redirection and regrading within the Sand Creek floodplain would be required for protection of Hall K6. The impacts of drainage modifications at the Colorado site should be minimal because the affected stream is a small tributary with only intermittent flow and a low gradient. Increased stream erosion caused by rechannelization could be minimized by maintenance of original channel length, cross section and gradient.

During construction, increased surface erosion would be a continuing impact. Natural vegetation would be removed, and soil surfaces would be disturbed by regrading, excavation, and general construction equipment activity. Potential soil erosion could be increased by this activity. The resulting off-site transport of sediment would be dependent on the local topography and rainfall. Mitigation measures could control the off-site sediment movement to a great extent, using techniques similar to those needed for controlling runoff increases.

At the Colorado site, vegetation-stabilized sand dunes occur in the northeastern part of the proposed SSC ring alignment. Removal of large areas of stabilizing grasses can cause the dunes to remobilize, resulting in blowing sand. Construction practices to avoid or mitigate this impact could include avoiding disturbance of dunes wherever possible and replanting of exposed dune faces with grasses.

Increased surface runoff might increase the potential for channel erosion during construction and operations because of increased volumes and rates of flow. Mitigative measures could include installation of drains and collection ponds and the control of outflow. Mitigative measures used at a site to lower the potential runoff increases would also help control potential channel erosion. Also, for short stream lengths in the vicinity of SSC facilities where increased channel erosion might occur, it would be possible to institute channel protection measures such as lining the stream banks with riprap or installing flow control weirs.

At the Illinois site construction activities potentially could disturb tile drain systems beneath farm fields. Impacts to these systems are expected to be small because of the ability to either make shifts in the locations of excavations to avoid drain tiles, or to relocate drains around construction.

Potential impacts at a site due to altered runoff and increased erosion cannot be quantified at the current level of design. However, standard construction practices and techniques would be employed to reduce runoff and erosion impacts. Although some impacts might be noticed over short sections of drainages in the immediate vicinity of the construction sites, these impacts would be of limited duration (ending with restoration of the construction site). Operations impacts due to increased runoff could be minimized by collection of runoff and controlled outflow.

Potential mitigations to control soil erosion and to reduce off-site sedimentation are the following:

- Schedule construction activities such as to reduce disturbed areas at any point in time.
- Where possible, maintain natural vegetative buffer strips between disturbed areas and surface water bodies.
- Schedule clearing and construction, where practical, to avoid relatively erodible soils during wet seasons.
- Collect runoff from disturbed areas by temporary drainage ditches and divert such runoff to sedimentation basins.
- Use runoff retarding devices such as hay bales to reduce flow velocity and, consequently, erosion.
- Restore disturbed areas to desired topography and establish locally adapted vegetation as soon as possible.

On a regional scale, impacts due to runoff and erosion are expected to be negligible because the area disturbed by the SSC is generally less than 10 percent of the total watershed for each site.

5.1.2.2 Floodplain Impacts

Under Executive Order 11988 "Floodplain Management," Federal agencies must consider the protection of floodplains in decision-making processes. DOE regulation 10 CFR 1022 ("Compliance with Floodplain/Wetlands Environmental Review Requirements") provides the procedures that the DOE follows to assure adequate consideration of floodplains. This FEIS presents the floodplain assessment including the project description, location, analysis of impacts, and suggested mitigations. It is the DOE's policy to "avoid to the extent possible the long- and short-term adverse impacts associated with the...occupancy of floodplains...and avoid direct and indirect support of floodplain...development wherever there is a practicable alternative" (U.S. Department of Energy 10 CFR 1022). Buildings, flood protection measures, bridge abutments, and roadway fills with culverts are all examples of floodplain encroachments.

The proposed layout of the SSC at the seven site alternatives is based on a generic concept provided in the Invitation for Site Proposals (U.S. Department of Energy, DOE/ER-0315). Utilizing this standard design and layout at all sites resulted in certain proposed surface facilities being shown as encroaching on floodplains. The most obvious mitigation of floodplain encroachment is to locate the facility outside the identified or assumed floodplain. This may be allowed in some cases by the design criteria, i.e. service and access shafts can be moved some distance; the interaction halls, however, are less flexible.

To protect any facilities that must be constructed in floodplain areas from flooding, the facility could either be elevated or have levees constructed around it. This would create floodplain encroachment that could raise the flood level in the adjacent channel or direct flood flows into areas not previously reached because of a loss in floodwater conveyance. This assessment identifies cases where these mitigations would be considered further as part of final project design.

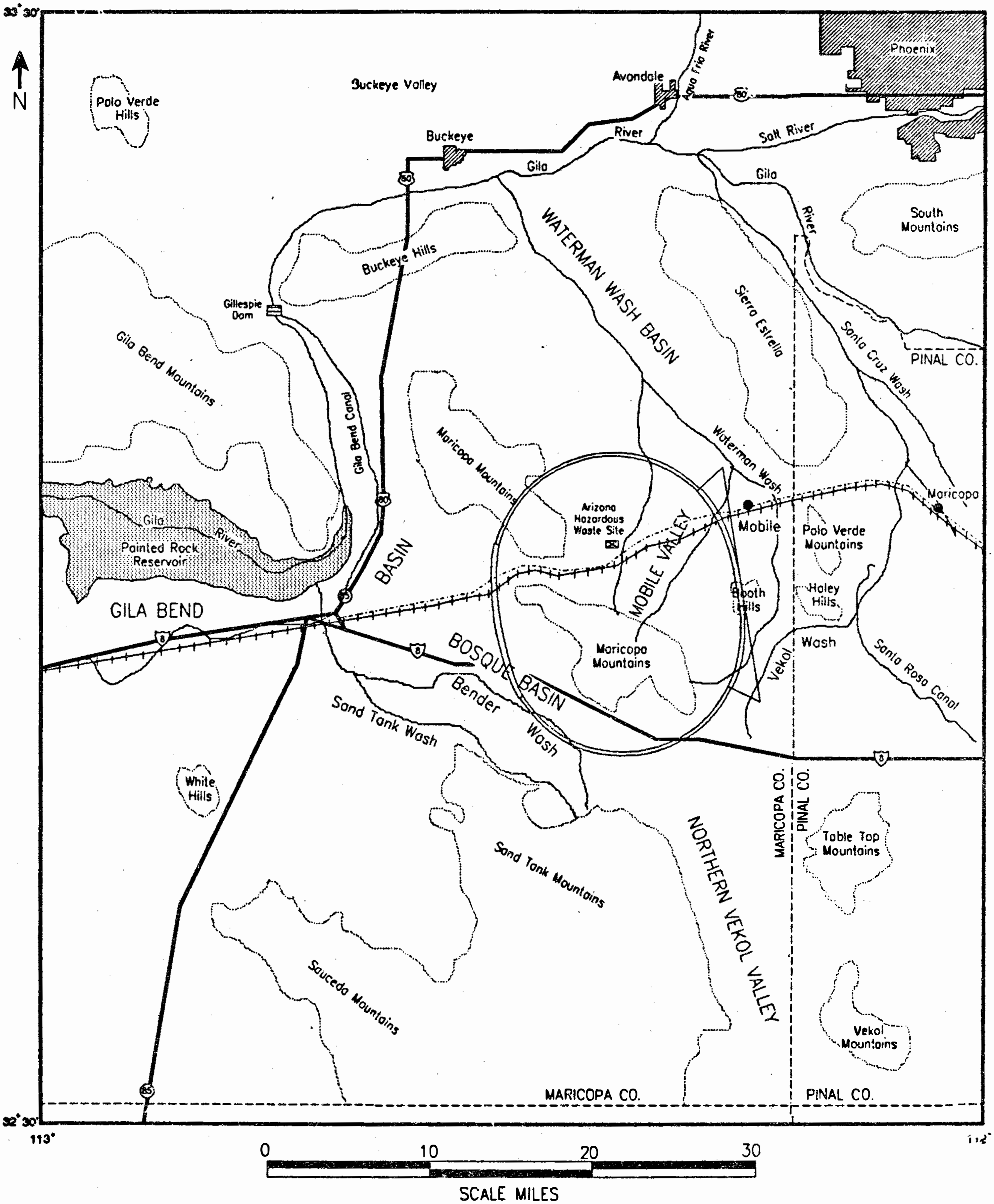
Factors affecting the impacts caused by floodplain encroachment are: width of the floodplain, the extent of the encroachment, and the existing hydrologic regime.

The data used to assess floodplain impacts include: the site engineering assessment from Appendix 1, the utilities and transportation description in Appendix 14, and floodplain maps (Federal Emergency Management Administration (FEMA) Flood Insurance Rate Maps, U.S. Geological Survey (U.S.G.S.) Flood Hazard Area Maps, and other flood maps).

The process of assessing impacts involved identifying the potential location of a facility in or near a 100-yr floodplain according to FEMA rate maps. If no data existed for a 100-yr floodplain, general flood hazard areas were considered. Impact magnitudes were qualitatively assessed based on the proximity of the proposed facility to the stream or floodplain and whether its size would represent a major encroachment

Figure 5.1.2-1

HYDROLOGIC FEATURES - ARIZONA SITE



(more than 25 percent of the floodplain width). Flow regime was considered only if encroachment was likely, and then used as a secondary factor.

A. Arizona

The Arizona site is not situated within or adjacent to any major river system or floodplains (see Figure 5.1.2-1). No FEMA Flood Insurance Rate Maps have been prepared for Maricopa County in the area of the proposed SSC site. This is an indication that flooding in this area has limited damage potential, primarily because there are few man-made structures. The project facilities would be located in areas that experience sheet flows, but would be outside any area considered floodplains. Therefore, there would be no impacts to or encroachments on floodplains.

B. Colorado

At the Colorado site (see Figure 5.1.2-2), there is one FEMA Flood Hazard Boundary Map and some preliminary Flood Insurance Rate Maps available for Morgan County. The Flood Insurance Rate Maps cover only portions of Beaver Creek, Buck Creek, and Shears Draw (Stanton, 1988). The Colorado Water Conservation Board, Flood Control & Flood Plain Management Section recommended the use of the 100-year flood maps produced by URS Corporation (1988) using HEC1 (a hydrologic model from the Army Corps of Engineers) and USGS topographic maps. These maps cover the entire SSC surface footprint and were used in preparing this floodplain assessment of the proposed SSC site in Colorado. During preconstruction analyses, geotechnical and other environmental studies would be performed to verify this assessment as part of final project design.

The Colorado project facilities that would be located partially or entirely within existing floodplains include: J2 and E1 in Badger Creek (Figure 5.1.2-2A); E3 in Beaver Creek at the north ring crossing (Figure 5.1.2-2B); F3 in Shears Draw, a tributary of Beaver Creek (Figure 5.1.2-2C); K3 in Antelope Creek, a tributary of Beaver Creek (Figure 5.1.2-2D); K6 in Sand Creek (Figure 5.1.2-2E); E8, a marginal encroachment on Beaver Creek (Figure 5.1.2-2F); and F8, an encroachment on Wetzel Creek (Figure 5.1.2-2G). The actual placement of surface structures at each of these facilities remains relatively flexible at this time, and would not be determined until a preferred site is selected and site specific designs prepared. Therefore, potential floodplain encroachment is based upon actual land areas and their proximity to floodplains.

Using available floodplain widths, it appears that both encroachments on Beaver Creek (E3, E8) and the encroachment on Shears Draw (F3) and the E1 facility all represent a minor amount of floodplain loss (<15 percent of the floodplain width). If the design criteria permit anticipated flexibility, site-specific design would relocate surface facilities to avoid this loss and therefore negligible impacts to floodplains and flooding would result.

Figure 5.1.2-2

HYDROLOGIC FEATURES - COLORADO SITE

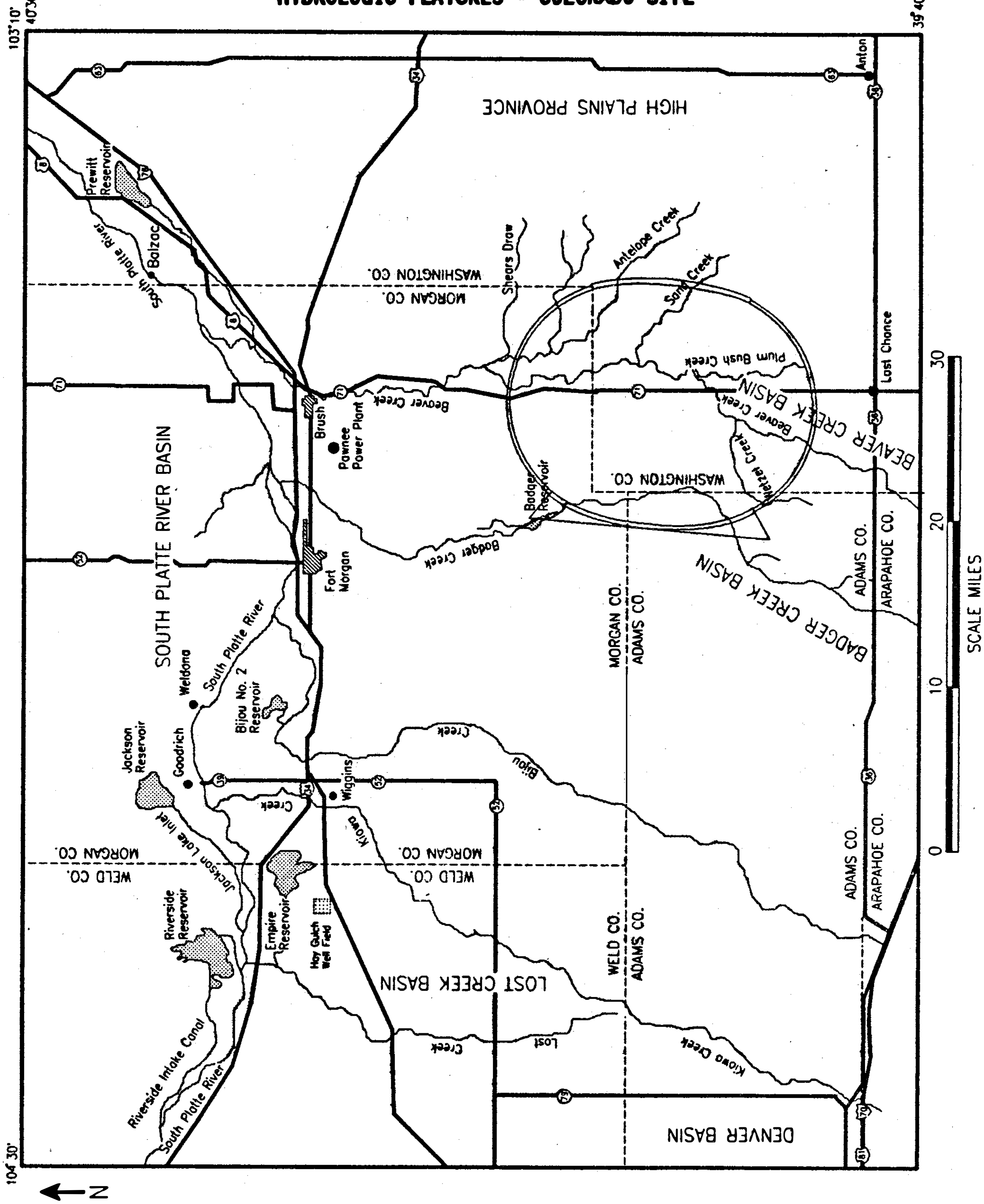
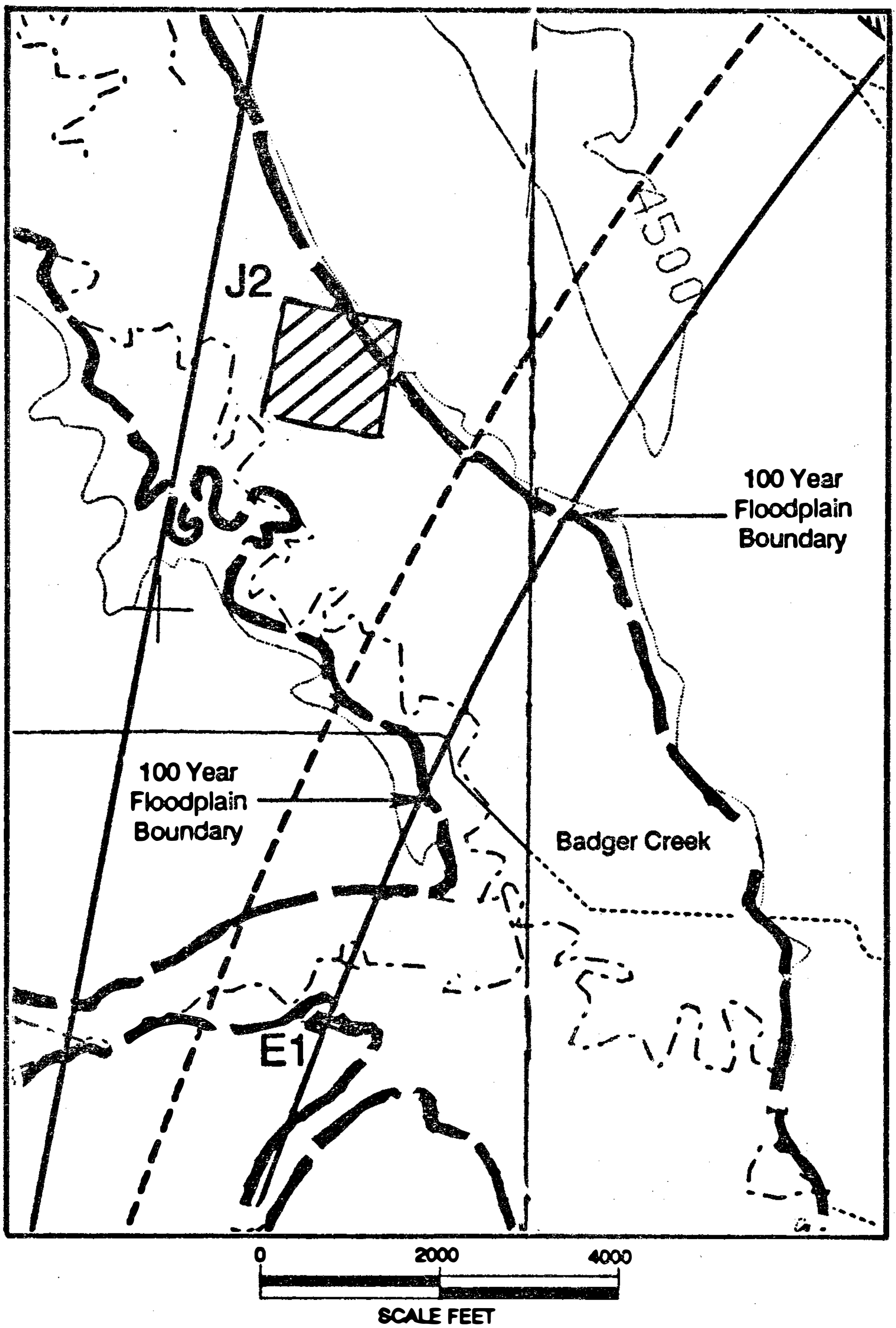


Figure 5.1.2-2A

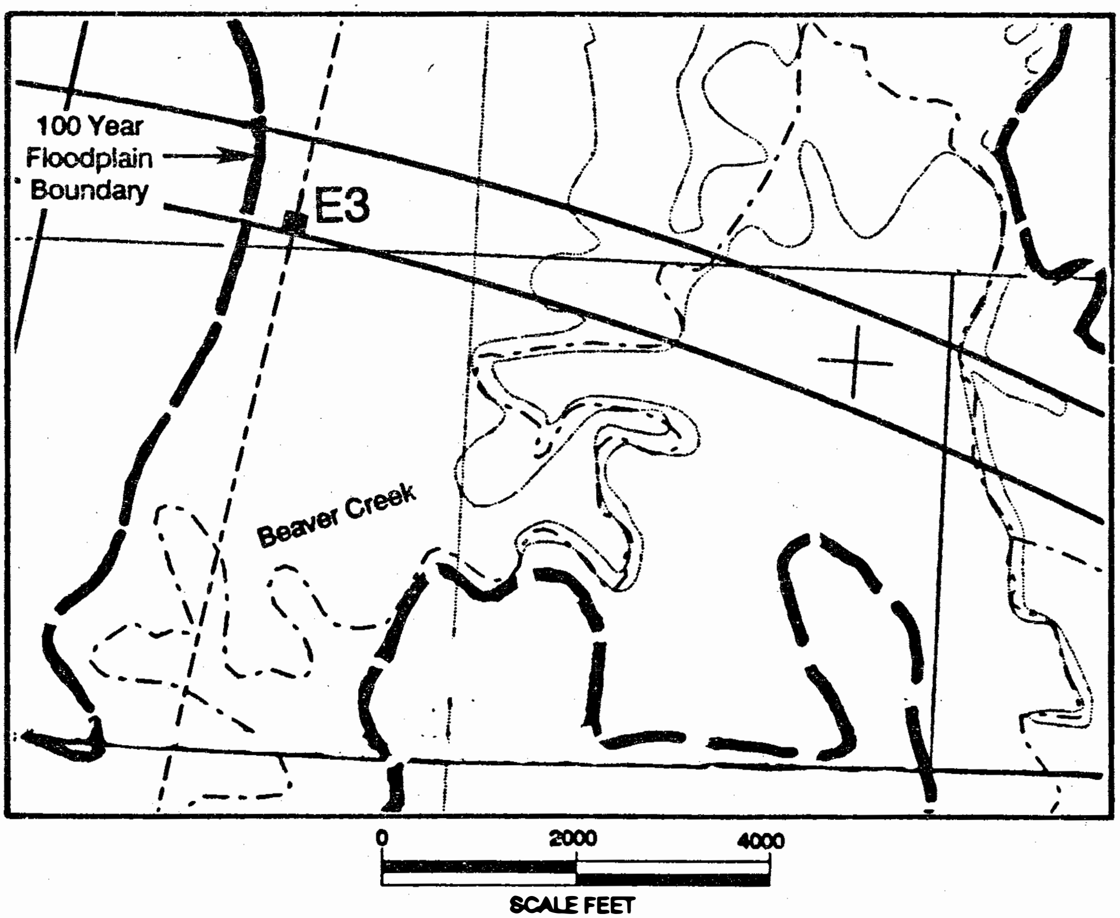
J2/E1 ENCROACHMENT ON BADGER CREEK FLOODPLAIN
COLORADO SITE



Source: URS Corporation, 1988.

Figure 5.1.2-2B

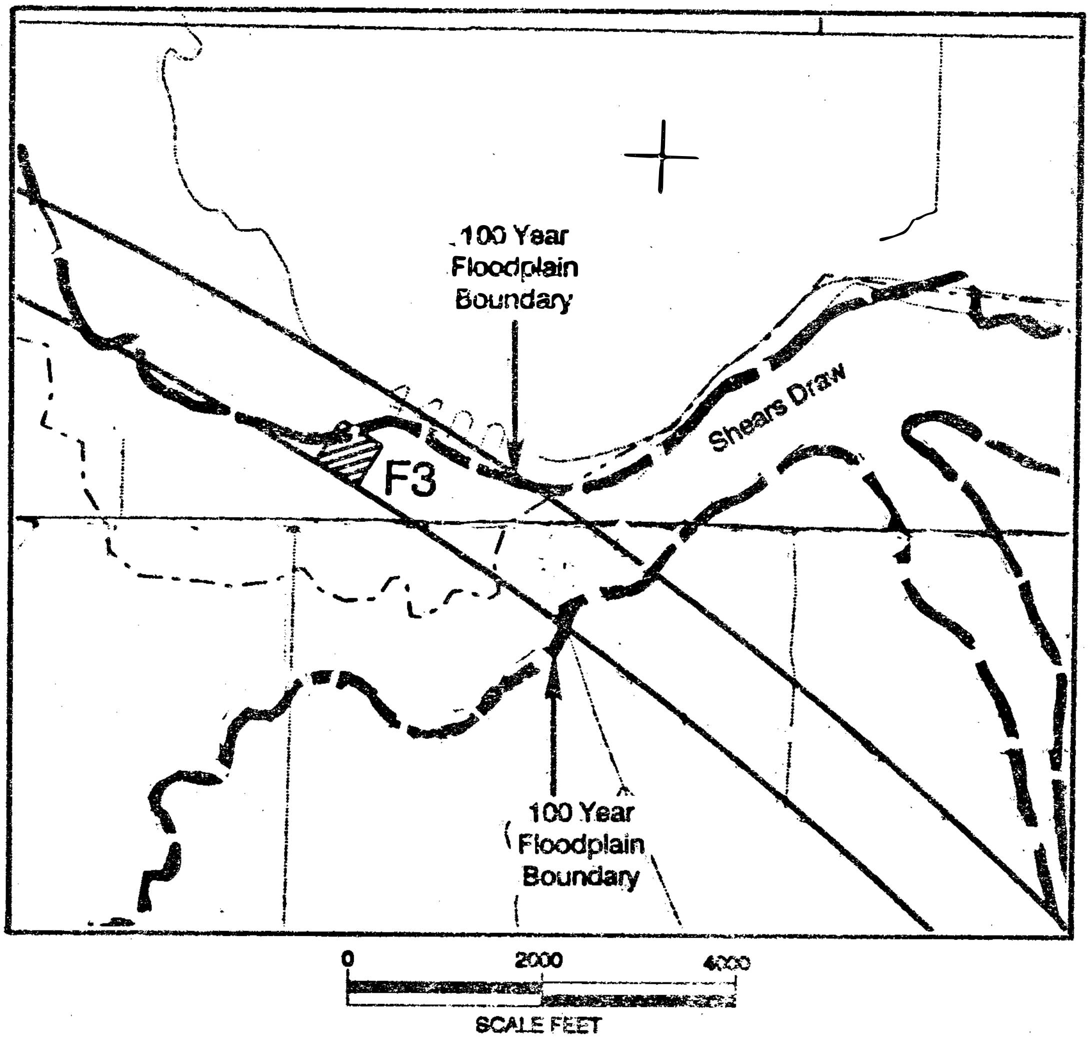
**E3 ENCROACHMENT ON BEAVER CREEK FLOODPLAIN
COLORADO SITE**



Source: URS Corporation, 1988.

Figure 5.1.2-2C

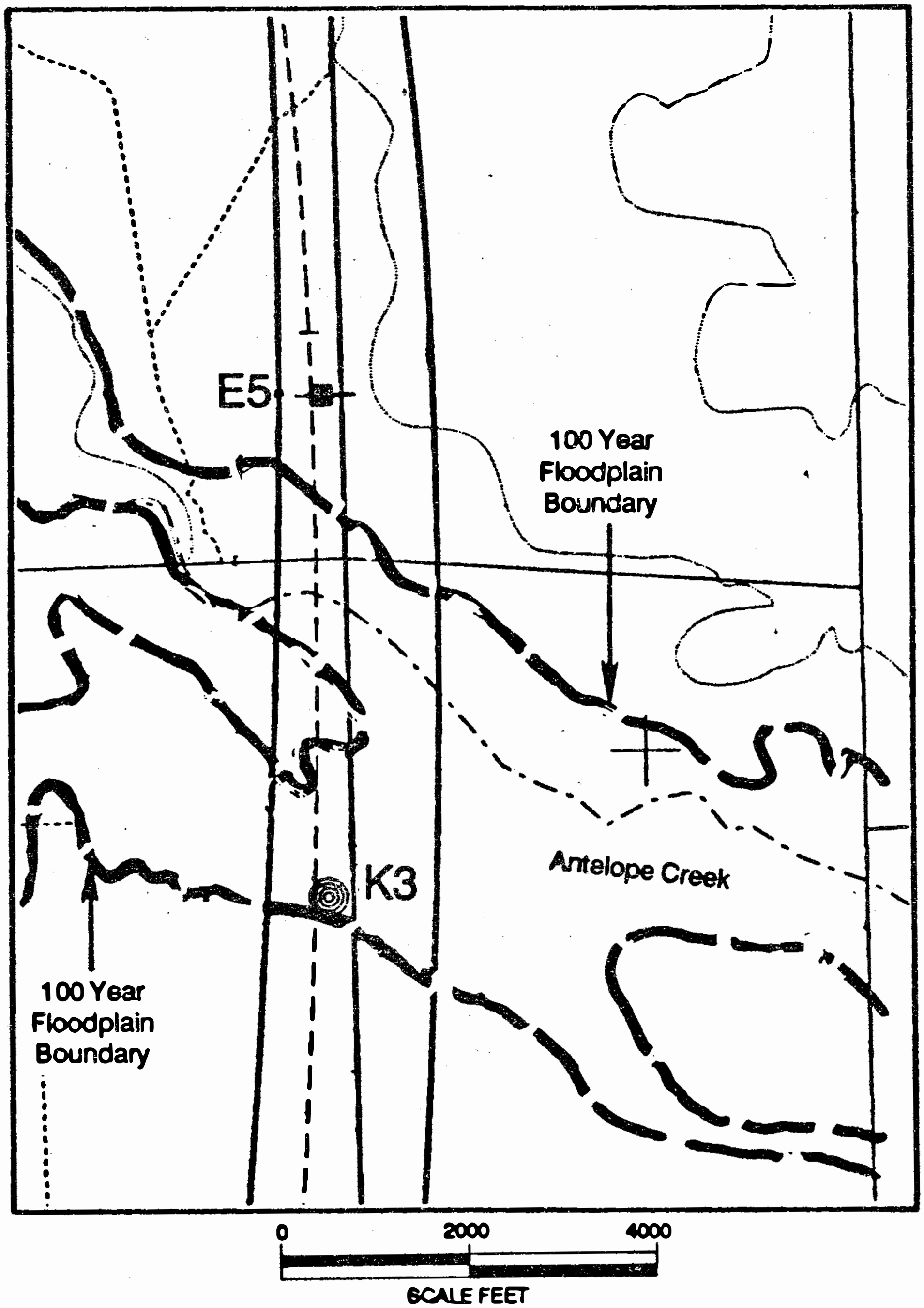
F3 ENCROACHMENT ON SHEARS DRAW FLOODPLAIN
COLORADO SITE



Source: URS Corporation, 1988.

Figure 5.1.2-2D

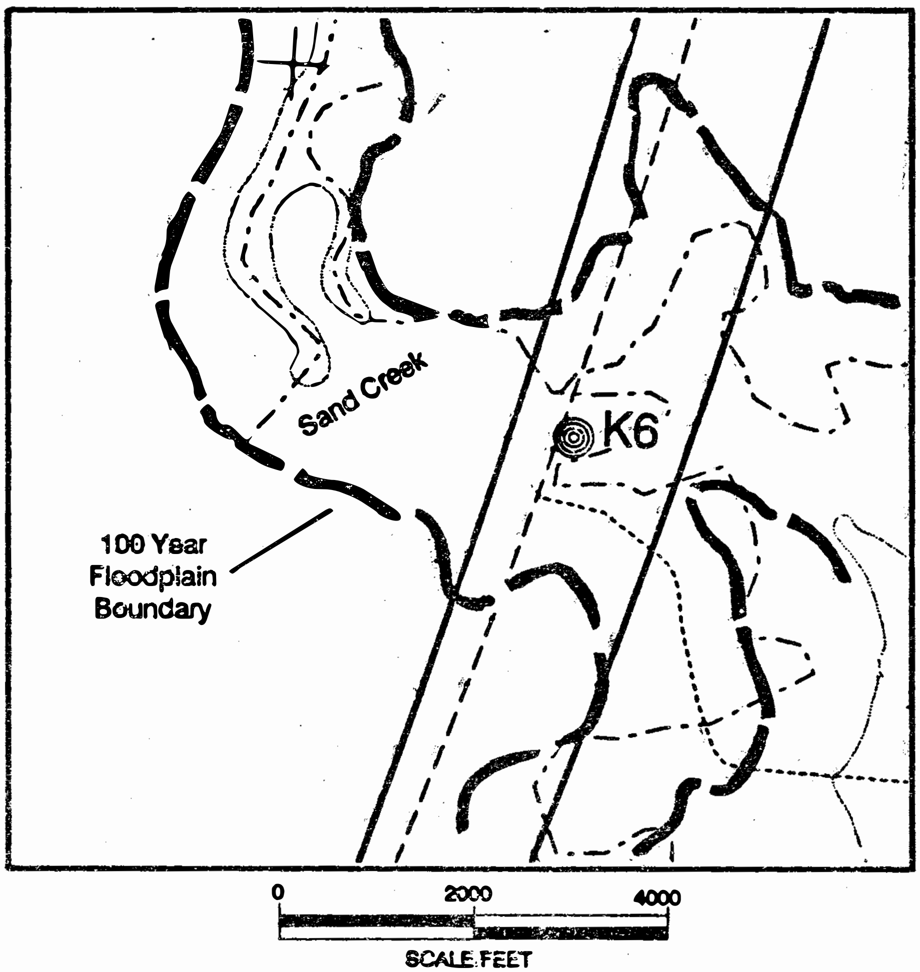
K3 ENCROACHMENT ON ANTELOPE CREEK FLOODPLAIN COLORADO SITE



Source: URS Corporation, 1988.

Figure 5.1.2-2E

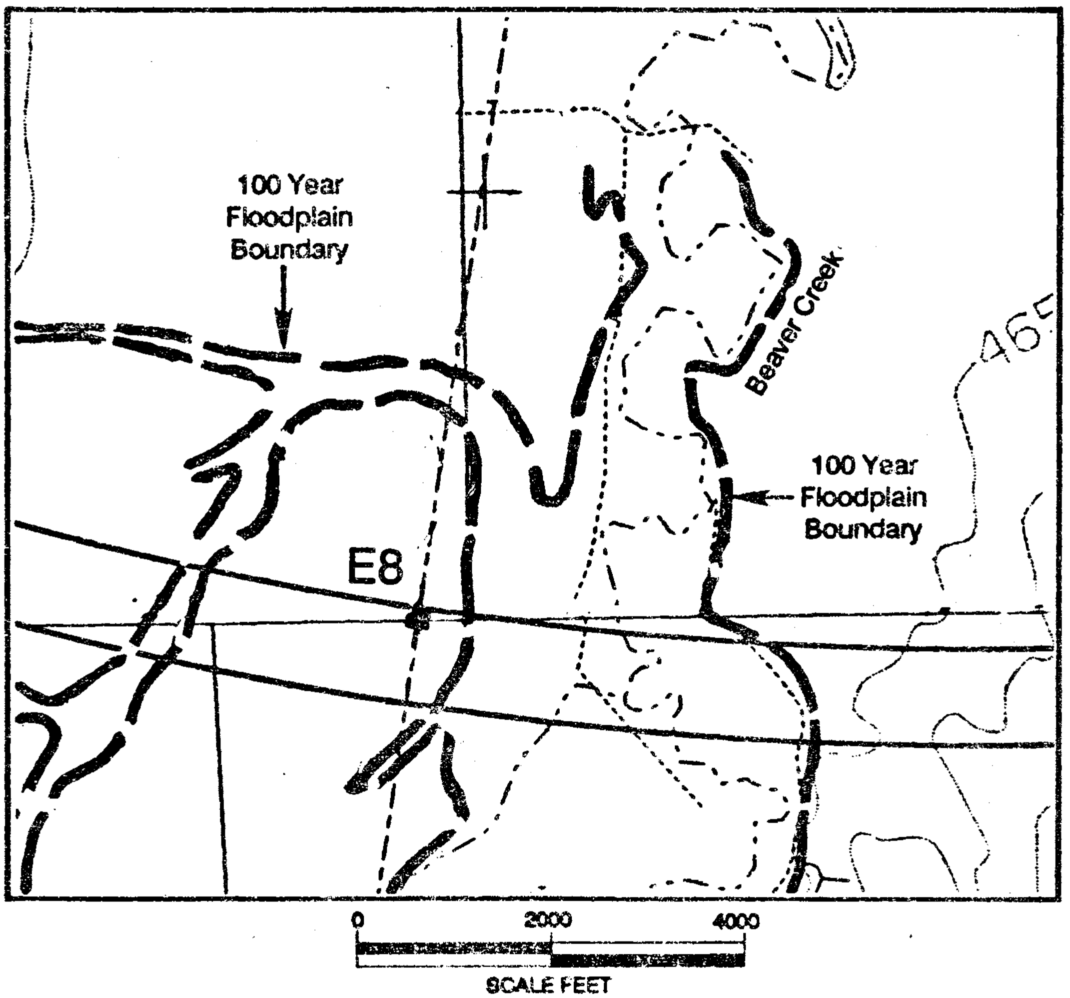
K6 ENCROACHMENT ON SAND CREEK FLOODPLAIN COLORADO SITE



Source: URS Corporation, 1986.

Figure 5.1.2-2F

**E8 ENCROACHMENT ON BEAVER CREEK FLOODPLAIN
COLORADO SITE**



Source: URS Corporation, 1988.

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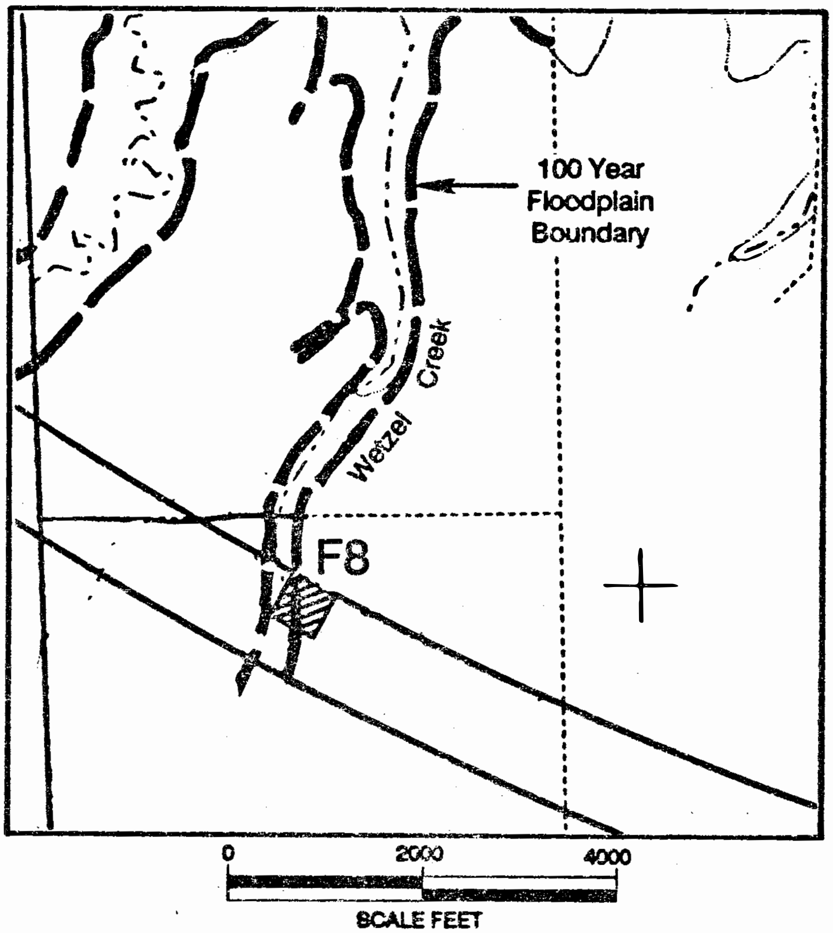
Figure 5.1.2-2G

F8 ENCROACHMENT ON WETZEL CREEK FLOODPLAIN
COLORADO SITE



Source: URS Corporation, 1988.

External beam access area J2 includes 1,200 ft of the 3,000-ft-wide floodplain of Badger Creek. Experimental hall area K3 is placed on 2,600 ft of the Antelope Creek floodplain, which is about 3,700 ft wide. Experimental hall area K6 would occupy about 3,700 ft of the 5,000-ft-wide floodplain of Sand Creek. The current land acquisition boundaries for these facilities occupy from 40 to 75 percent of the identified floodplain width. Watersheds upstream from these facilities range in size from 24 mi^2 (Antelope Creek and K3), 114 mi^2 (Badger Creek and J2) to 229 mi^2 (Sand Creek and K6). Service area F8 (Figure 7-2G) will occupy nearly 100 percent of the floodplain of a small tributary to Wetzel Creek. However, less than 10 acres of watershed lies upstream of the site. Construction of these facilities might affect floodplain hydraulics and could have long-term implications. Mitigation measures such as channel enlargement/improvement, levee construction, and minimizing building locations within the floodplain could help reduce these impacts but may affect the upstream and downstream hydraulics of these channels. These measures would be considered part of final project design. Residual impacts from these three facilities, with mitigation, would probably still exist. However, because the area impacted by any increased flood elevations has few, if any, improved structures, the residual impact should not be significant.

C. Illinois

The Illinois SSC region has been included in the national flood insurance program, and FEMA Flood Insurance Rate Maps have been prepared (Federal Emergency Management Agency 1981a-f, 1982a-f, 1985a-b, 1986a-b, 1987). This includes all of the unincorporated areas of DuPage, Kane, and Kendall Counties and several incorporated communities (see Figure 5.1.2-3). The DOE has initiated informal consultation with the Chicago District Corps of Engineers concerning floodplains. During preconstruction analyses, geotechnical and other environmental studies would be performed to verify the following assessment as part of final project design.

In Illinois, four facilities (F5, K4, J3, and J6) have some potential for floodplain encroachment. At present, these facilities are described by a conceptual design that does not contain specific details on where the buildings and other surface structures would be placed within the area. Surface structures would occupy only a part of the area needed for each facility, and the location of these structures within the area remains flexible in most cases. The four SSC facilities with potential floodplain encroachment would impact only Welch Creek in the far cluster or Kress Creek in the near cluster. Welch Creek would have two of these facilities located near the stream channel; F5 would be within about 200 ft of the floodplain and K4 would lie immediately adjacent to the floodplain. These facilities create a small potential for channel relocation, but almost no change in drainage area. Similarly, two facilities in the Kress Creek watershed would be near or in the stream channel: J3 would be within 1,000 ft of the floodplain and J6 would encroach the entire floodplain.

Figure 5.1.2-3

HYDROLOGIC FEATURES - ILLINOIS SITE

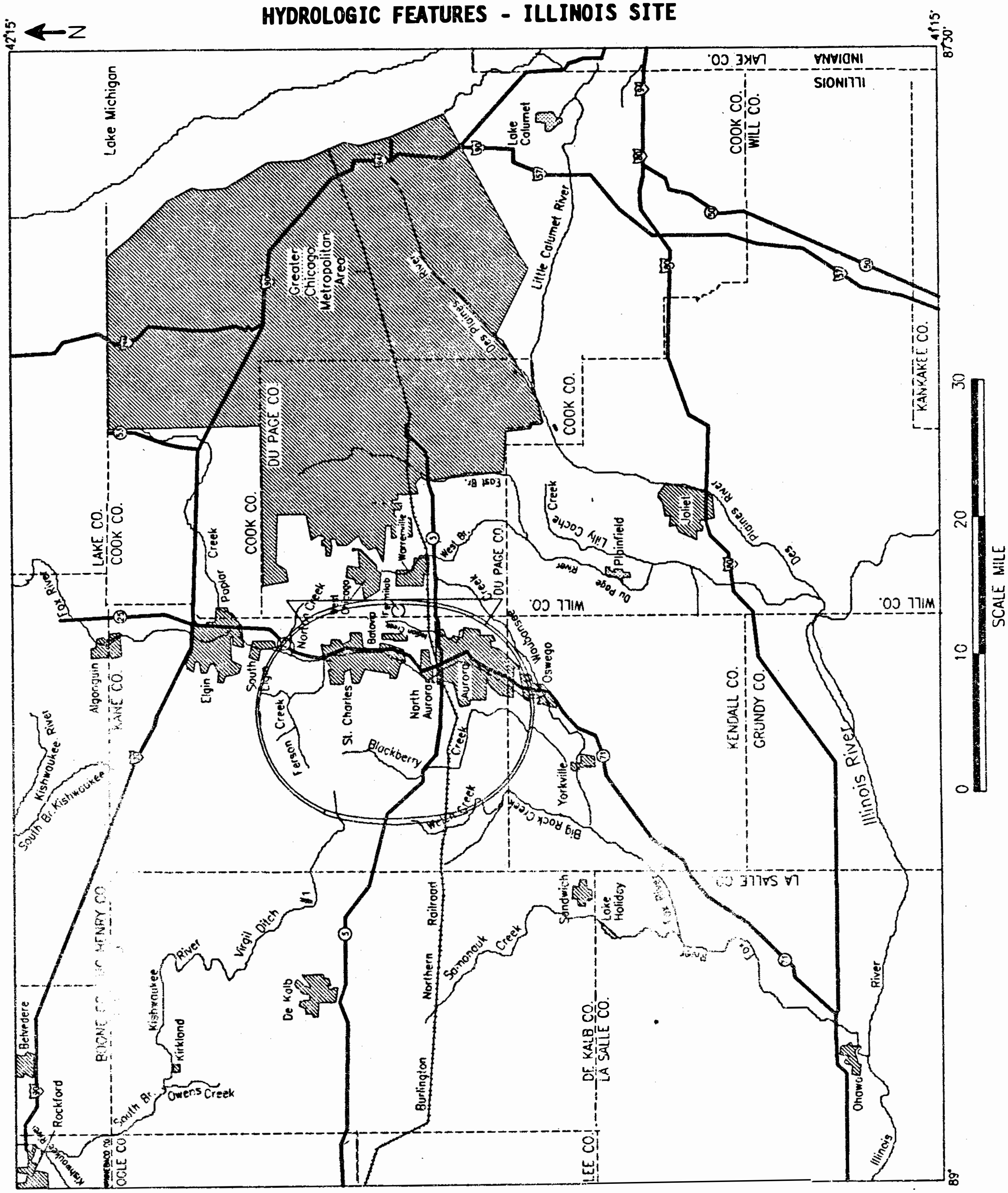
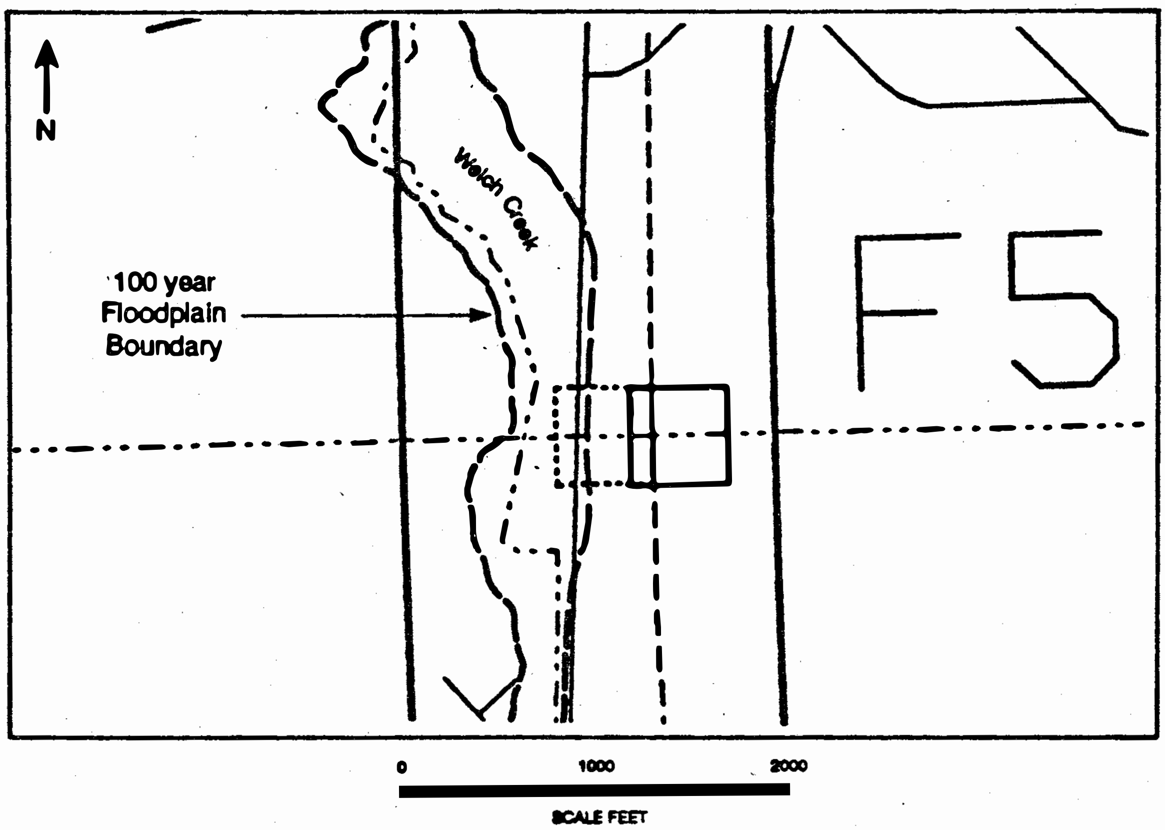


Figure 5.1.2-4

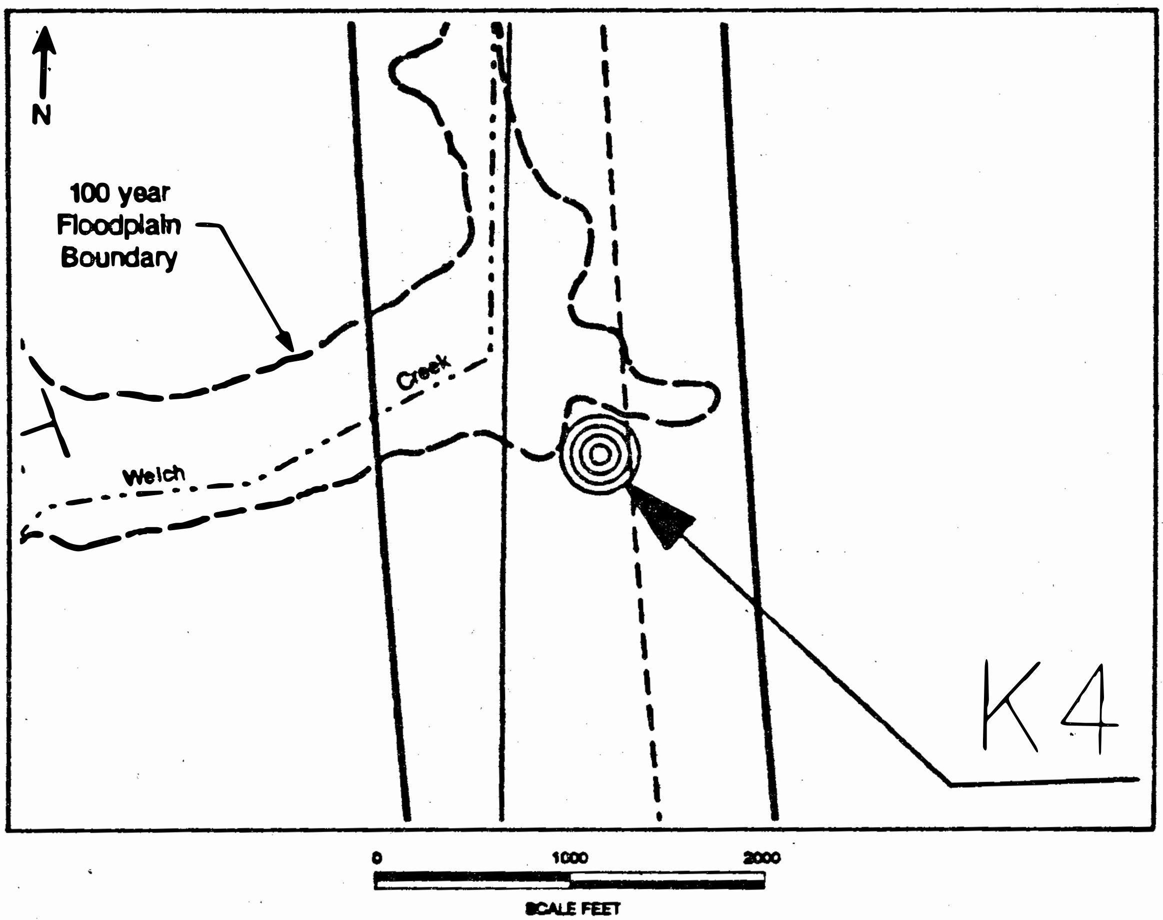
F5 ENCROACHMENT ON WELCH CREEK FLOODPLAIN
ILLINOIS SITE



Source: Federal Emergency Management Agency, 1982B.

Figure 5.1.2-5

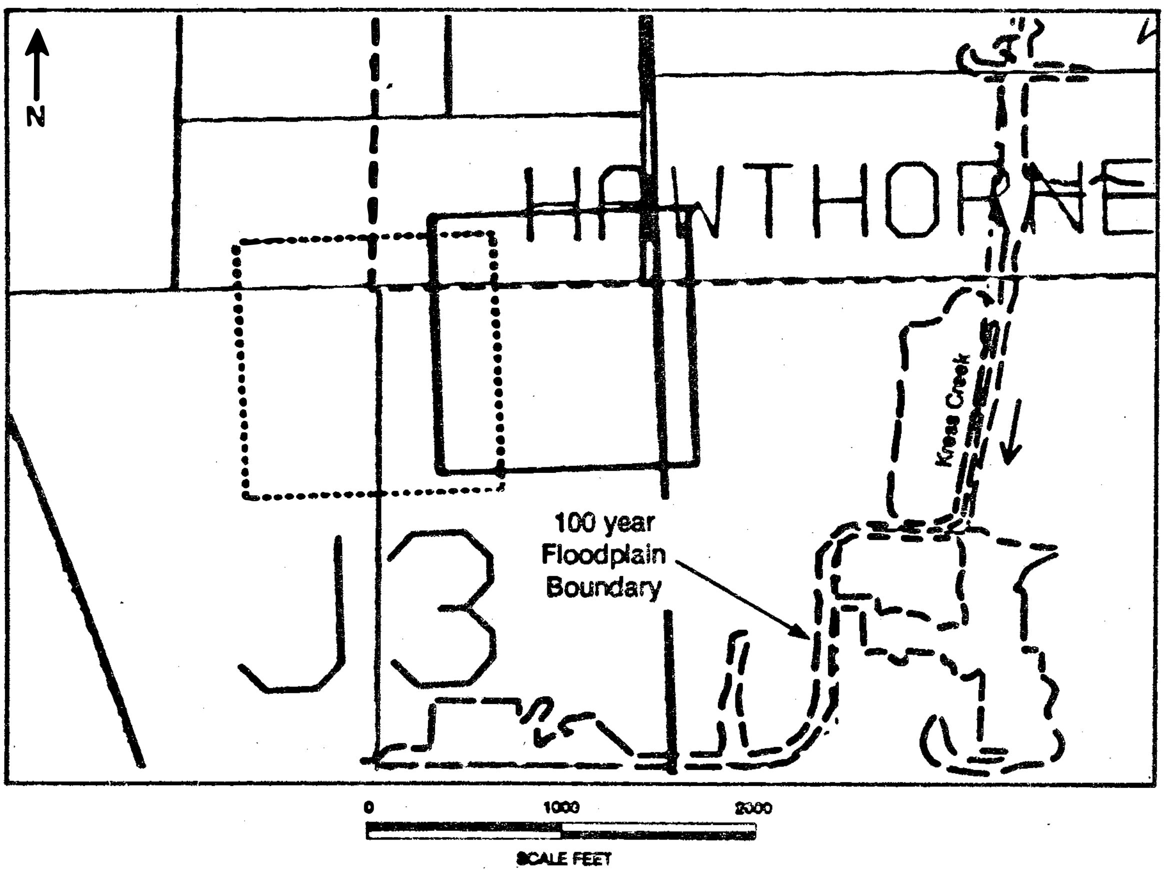
K4 ENCROACHMENT ON WELCH CREEK FLOODPLAIN
ILLINOIS SITE



Source: Federal Emergency Management Agency, 1982B.

Figure 5.1.2-6

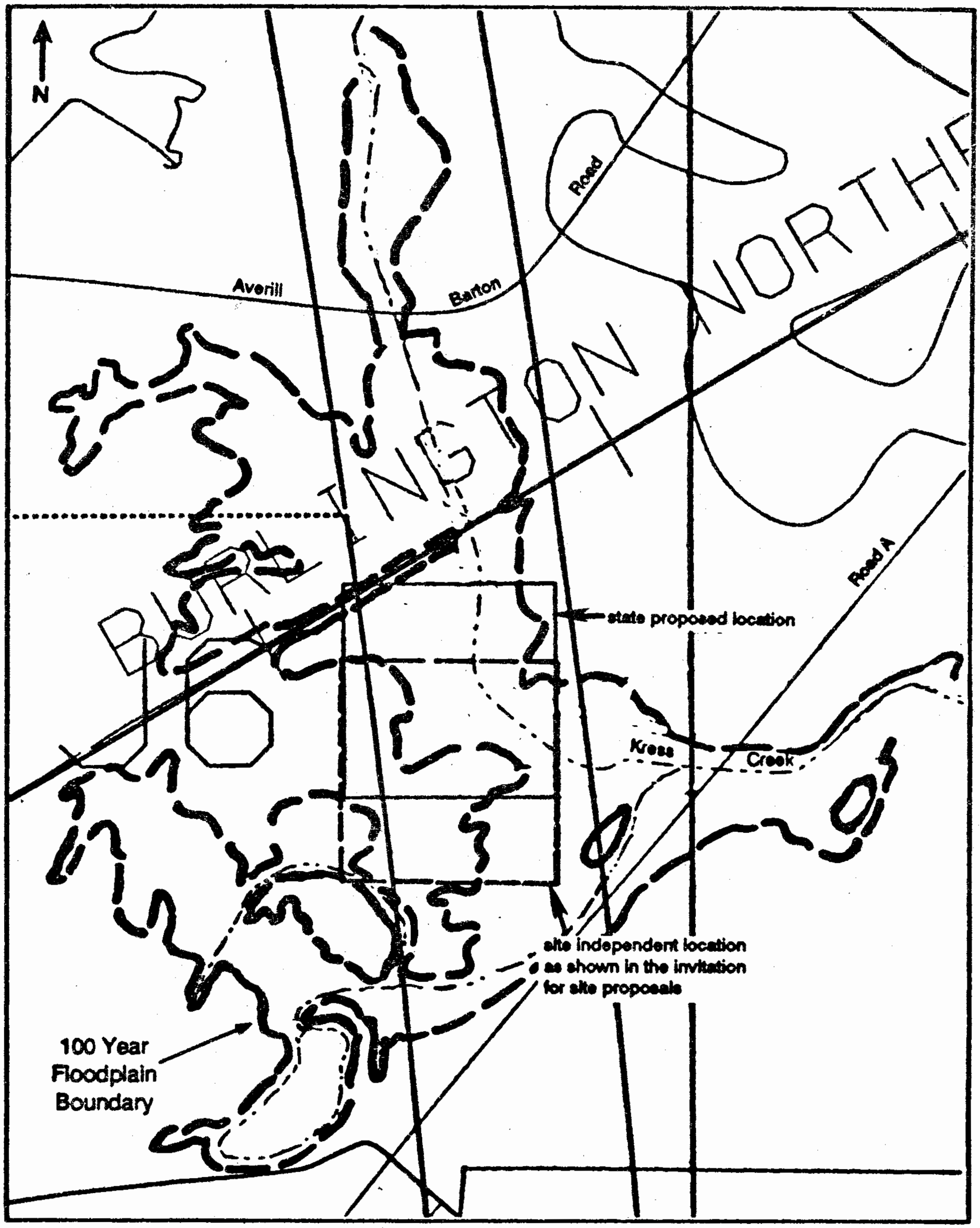
J3 ENCROACHMENT ON KRESS CREEK FLOODPLAIN ILLINOIS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-7

J6 ENCROACHMENT ON KRESS CREEK FLOODPLAIN ILLINOIS SITE



Source: Federal Emergency Management Agency, 1982F.

Facility service area F5 is currently located within about 200 ft of the Welch Creek floodplain, which is about 300 to 600 ft wide (see Figure 5.1.2-4). This facility area lies close enough to the floodplain that further consideration is warranted. However, adjustment in building location could mitigate any potential impact. Impacts to the Welch Creek floodplain from the F5 facility should, therefore, be negligible.

Facility experimental hall K4 lies immediately adjacent to the Welch Creek floodplain, which is about 750 to 1,000 ft wide (see Figure 5.1.2-5). While this is not an encroachment, it is close enough to deserve consideration during final design. Any potential impacts from this particular facility should be easily mitigated by layout of the facility during final project design. As a result, the impact from floodplain encroachment on Welch Creek caused by facility K4 is expected to be negligible.

External beam access area J3 is within 1,000 ft of the floodplain of Kress Creek (see Figure 5.1.2-6). This facility area lies close enough to the floodplain that further consideration is warranted. Very little has been determined about the layout of the J areas, but 40 acres would provide some flexibility in the arrangement of the surface structures. Thus, design mitigation should allow avoiding any impact to the floodplain of Kress Creek from J3.

Facility J6, as currently located, covers the entire width of the floodplain of Kress Creek with its northeast corner (see Figure 5.1.2-7). This is a measurable impact, with some potential for mitigation through design layout or channel diversion. One potential mitigation would be relocating, at design stage, surface structures in flood fringe rather than in floodway (structures located in flood fringe would not significantly raise upstream flood elevation). Other potential mitigations include elevating the structures, diverting the stream, and improving the channel to reduce flood stage. More detailed evaluation of this problem should be made during final site design if the Illinois site is selected.

D. Michigan

In Michigan, very little of the SSC facility location has been mapped for the national flood insurance program. FEMA Flood Insurance Rate Maps have been prepared only for a small portion of the SSC area near the Grand River in Blackman Township where it crosses the ring alignment. Flood Hazard Boundary Maps have also been prepared for other minor parts of Jackson and Ingham Counties, except the unincorporated areas of the counties as a whole. This is an indication that flooding in this area has limited damage potential primarily because there are few man-made structures.

In order to prepare the Michigan floodplain assessment, U.S.G.S. Flood Prone Area Maps (U.S. Department of the Interior 1975a, 1975b, 1975c, and 1975d) of the proposed SSC location were used to determine whether any of the facilities may be in the 100-yr floodplain (Menerey 1988).

Figure 5.1.2-8

HYDROLOGIC FEATURES - MICHIGAN SITE

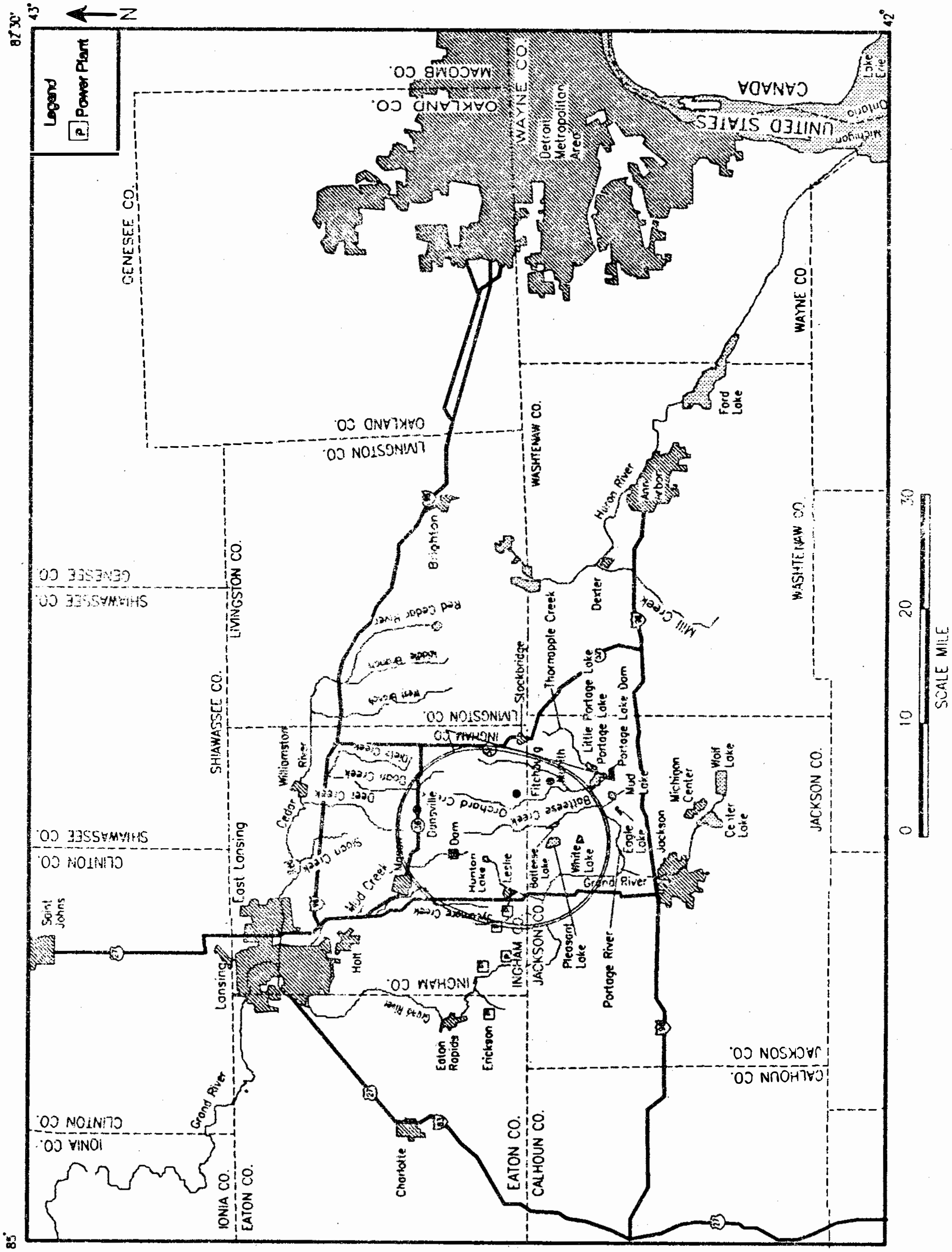


Figure 5.1.2-8A

CAMPUS AREA ENCROACHMENT ON THORNAPPLE CREEK FLOODPLAIN
MICHIGAN SITE

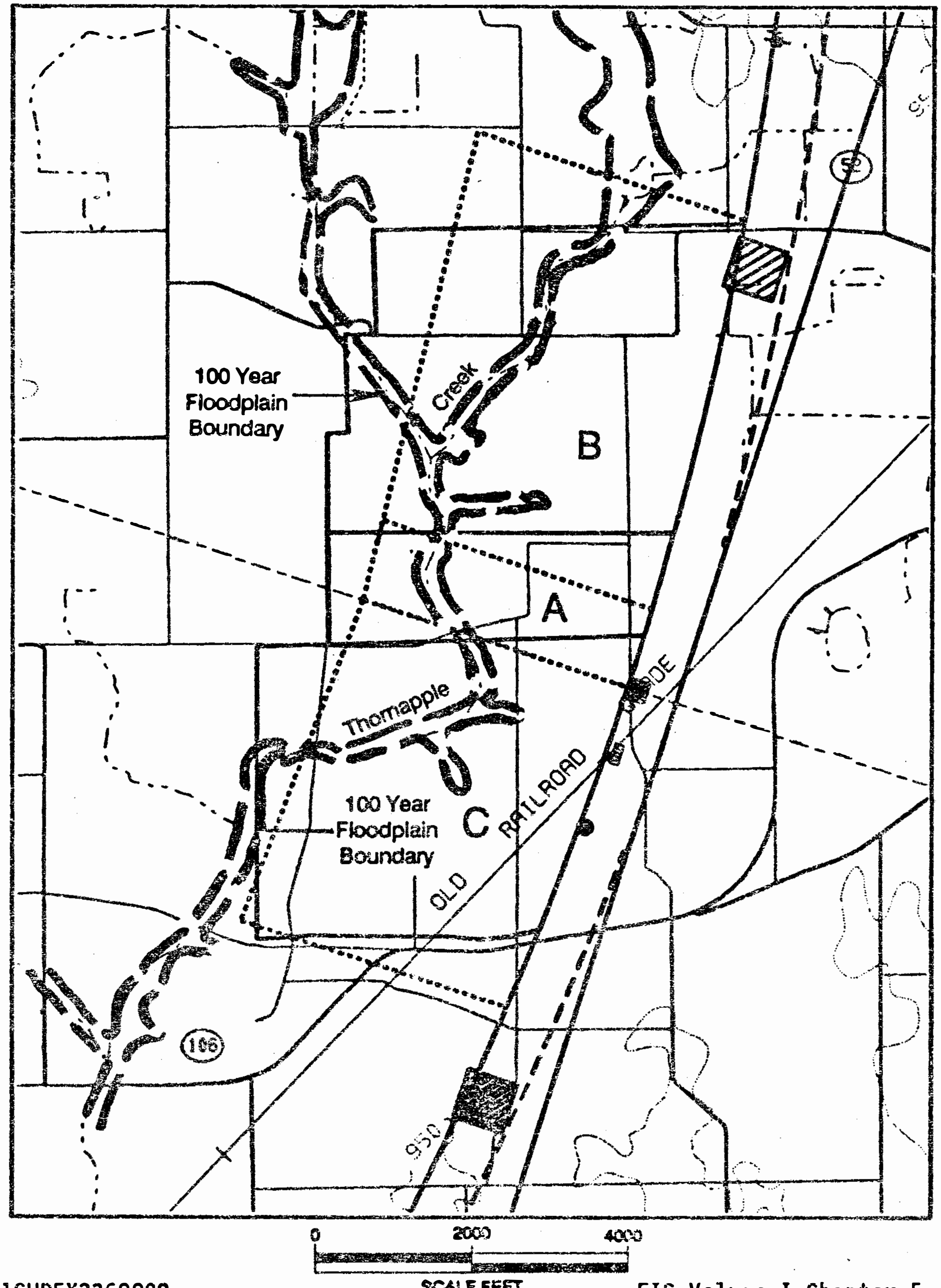
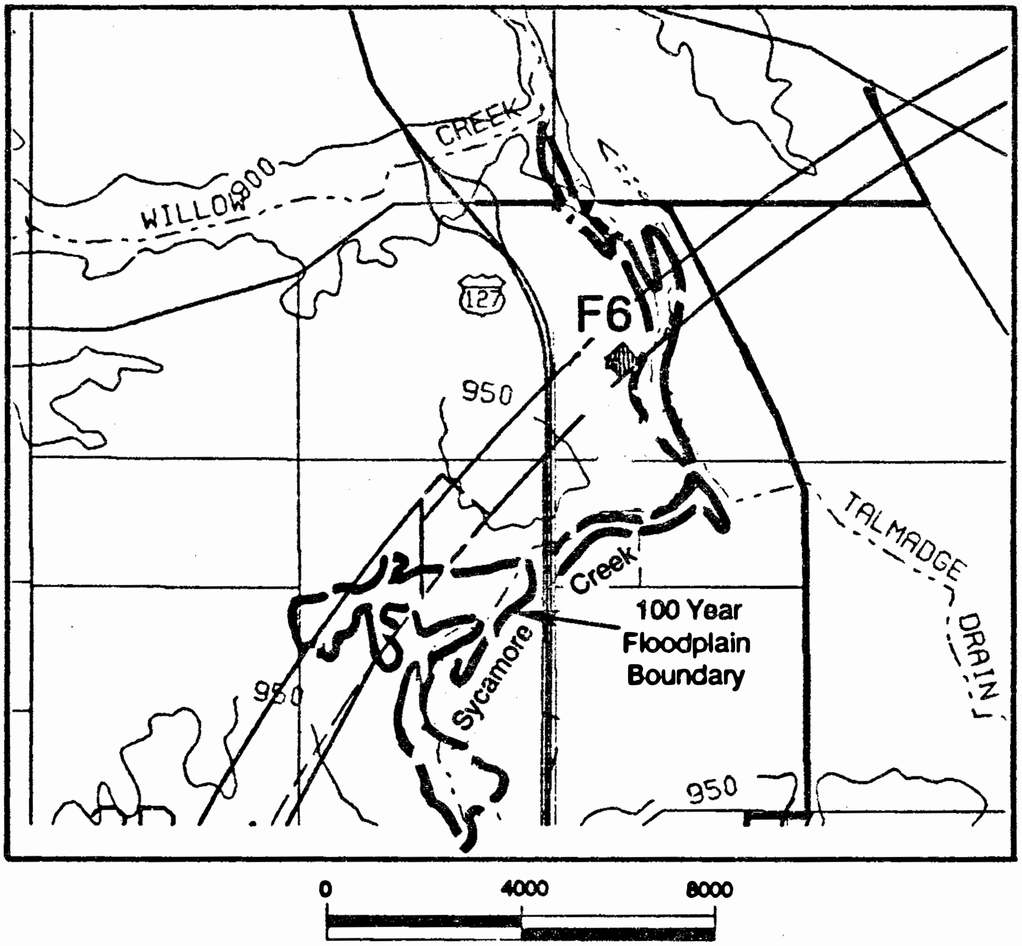


Figure 5.1.2-8B

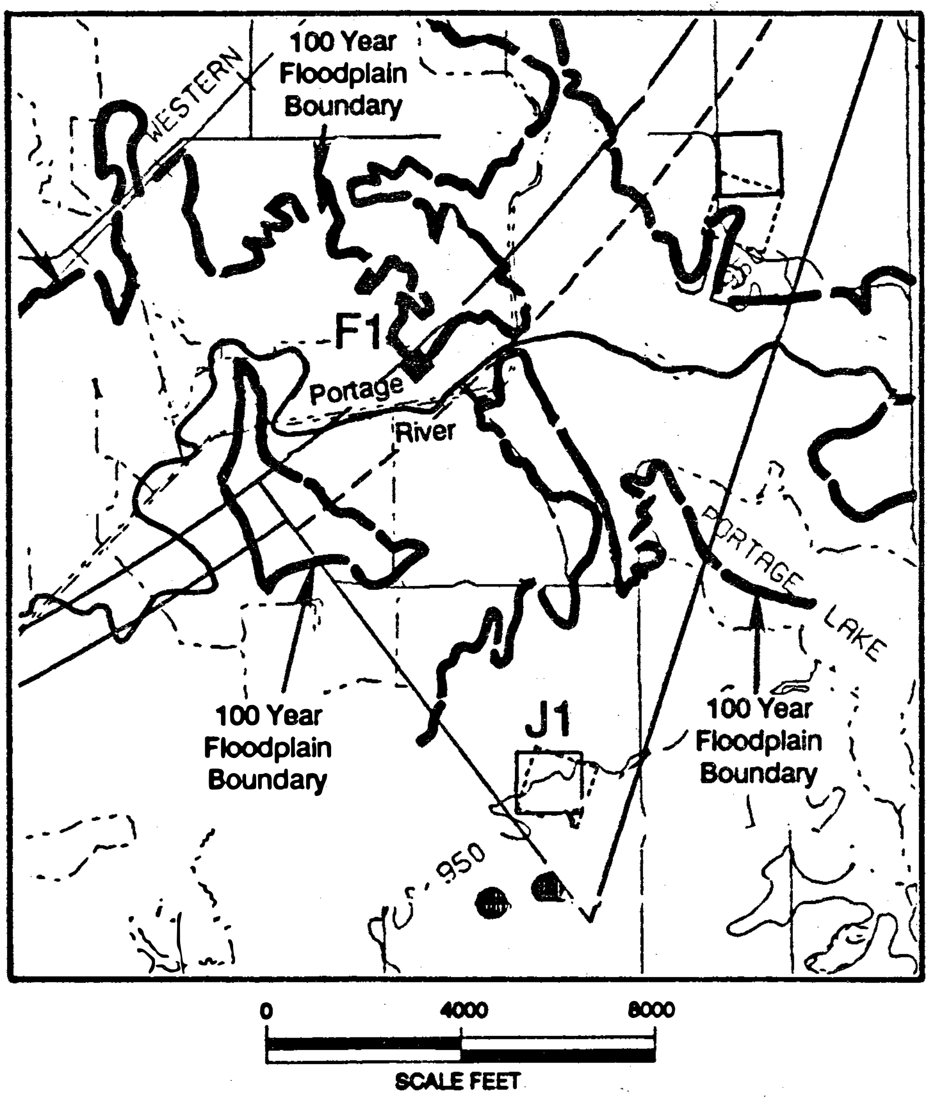
**F1 ENCROACHMENT ON PORTAGE RIVER FLOODPLAIN
MICHIGAN SITE**



Source: Menerey, Michigan Department of Natural Resources, 1988.

Figure 5.1.2-8C

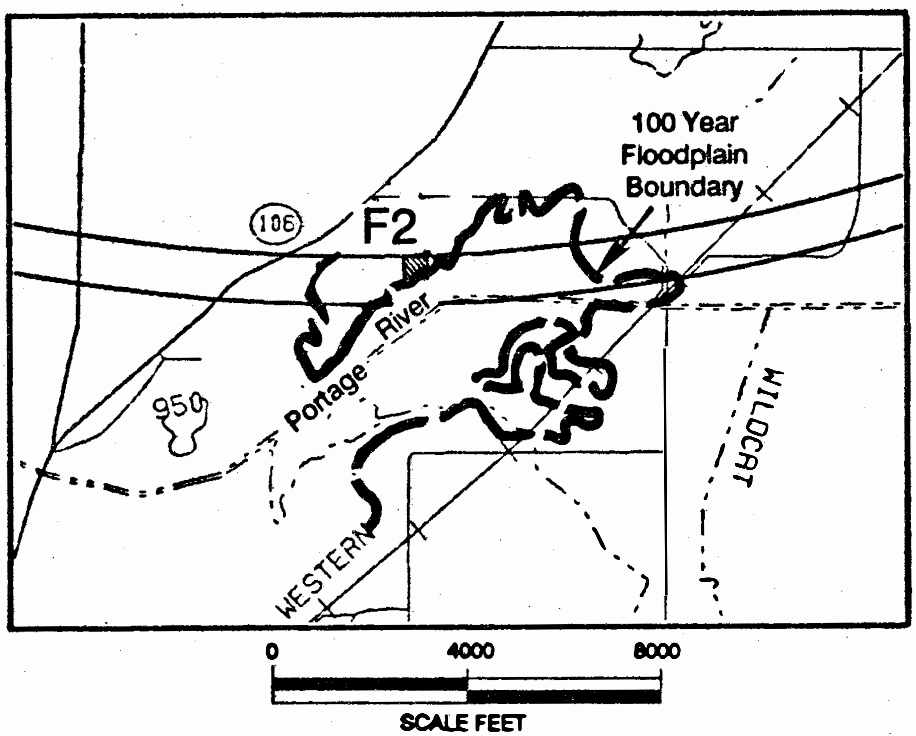
F2 ENCROACHMENT ON PORTAGE RIVER FLOODPLAIN
MICHIGAN SITE



Source: Menerey, Michigan Department of Natural Resources, 1988.

Figure 5.1.2-8D

F6 ENCROACHMENT ON SYCAMORE CREEK FLOODPLAIN MICHIGAN SITE



Source: Menerey, Michigan Department of Natural Resources, 1988.

Temporary floodplain encroachment, because of construction activities, would likely occur on Thornapple Creek where it passes through the injector and booster areas, and to a lesser extent in the campus area (see Figures 5.1.2-8 and 5.1.2-8A). The cut-and-fill construction of the injector and booster tunnels would cross Thornapple Creek twice and come very close to the channel in a third location. All three locations probably would encroach on the floodplain temporarily, especially where the tunnel alignment crosses the creek. Although the creek is a small one (less than a 10-mi² drainage area), this impact could be measurable. Three service areas, F1 (Figure 5.1.2-8B), F2 (Figure 5.1.2-8C), and F6 (Figure 5.1.2-8D) all may, depending upon final design, encroach on floodplains. F1 and F2 could encroach upon the Portage River floodplain, which has an upstream watershed of 80 mi². Even without mitigation, the encroachment impacts are likely to be minor. The F6 area could have marginal encroachment upon the Sycamore Creek floodplain, which has an upstream watershed of 18 mi², however the impacts are expected to be minor. Mitigation by relocating these facilities to minimize the floodplain encroachment is the best initial strategy. Protection from or confinement of the additional flood elevation by levees or berms is another reasonable alternative. Either alternative could effectively reduce the impact. No other potential floodplain encroachments exist at the other SSC surface facilities and, therefore, no additional floodplain encroachment impacts would be expected.

E. <u>North Carolina</u>

In North Carolina, all three counties in which the SSC facility would be located are included in the national flood insurance program (see Figure 5.1.2-9). However, only Durham County is mapped to the detail of the Flood Insurance Rate Maps (FEMA 1979b). Granville and Person Counties are only shown on Flood Hazard Boundary Maps (FEMA 1970, 1978). The lack of complete coverage of this area by Flood Insurance Rate Maps indicates that flooding in this area has limited damage potential primarily because there are few man-made structures. The area is rural with little development in the form of houses or other buildings. During preconstruction analyses, geotechnical and other environmental studies would be performed to verify these data as part of final project design.

In preparing this floodplain assessment, the available FEMA maps were used to determine whether any of the proposed facilities may be in the 100-yr floodplain (FEMA 1978a, 1978b, 1979).

Temporary floodplain encroachment is inevitable from construction and operations activities in area B, the injector complex and from future activities in area C (Figure 5.1.2-9A). Other areas with potential floodplain involvement include: access area E2 (Figure 5.1.2-9B); beam access area J6 (Figure 5.1.2-9C); experimental hall K6 (Figure 5.1.2-9D); beam access area J5 (Figure 5.1.2-9E); and beam access area J2 (Figure 5.1.2-9F). Beam access area J6 and experimental hall K6 both show potential encroachment exceeding 90 percent of the floodplain. The upstream watershed in both cases, however, is small (J6 - 3 mi²; K6 - 1.3 mi²), therefore mitigation activities such as channel relocation, diking, or facility location adjustment should reduce or eliminate any

Figure 5.1.2-9

HYDROLOGIC FEATURES - NORTH CAROLINA SITE

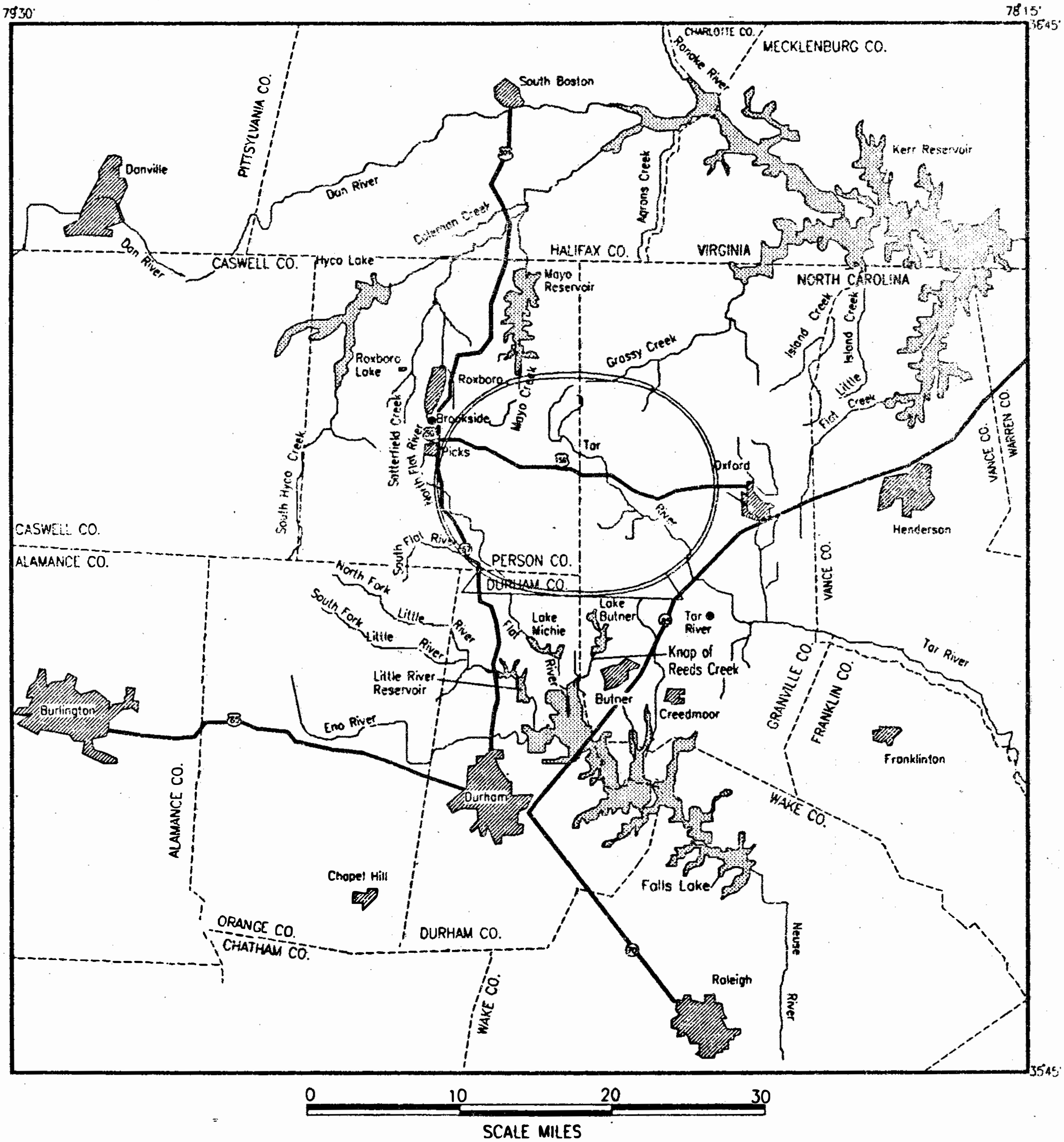
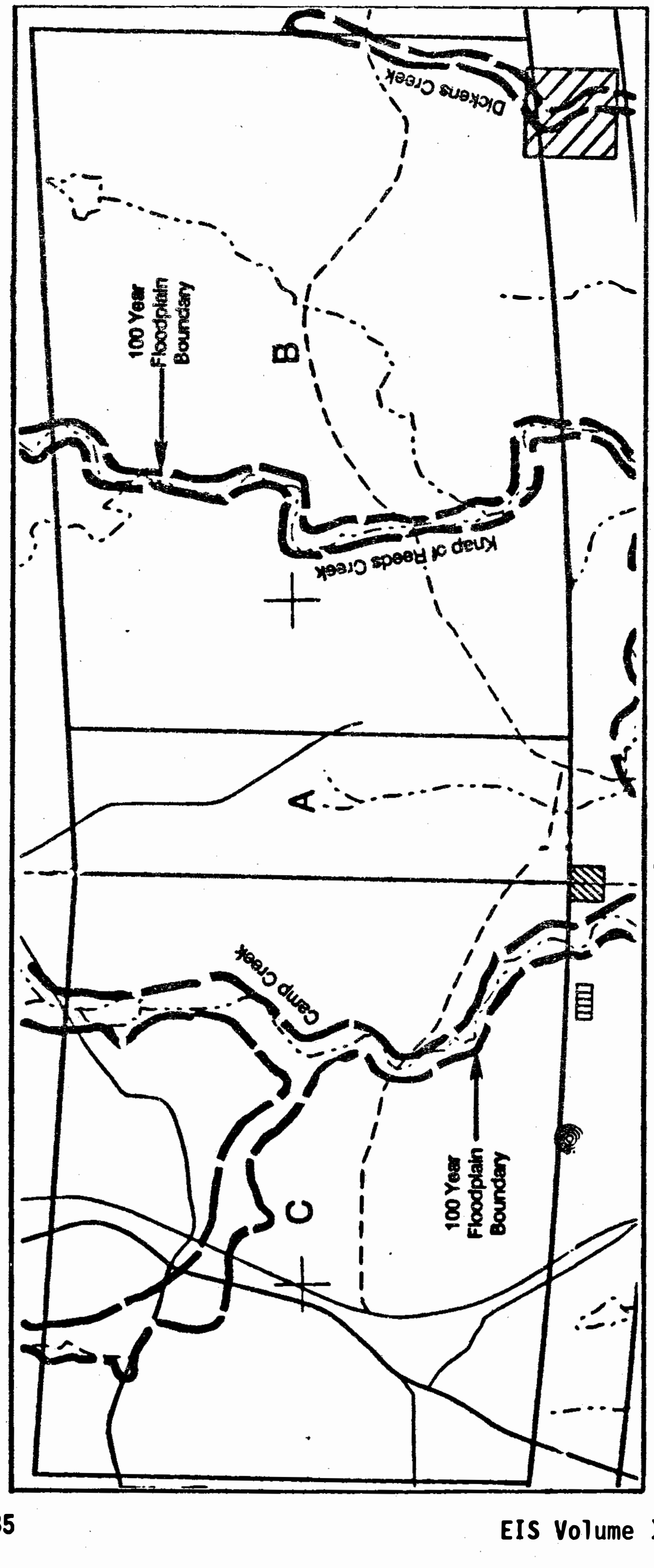


Figure 5.1.2-9A

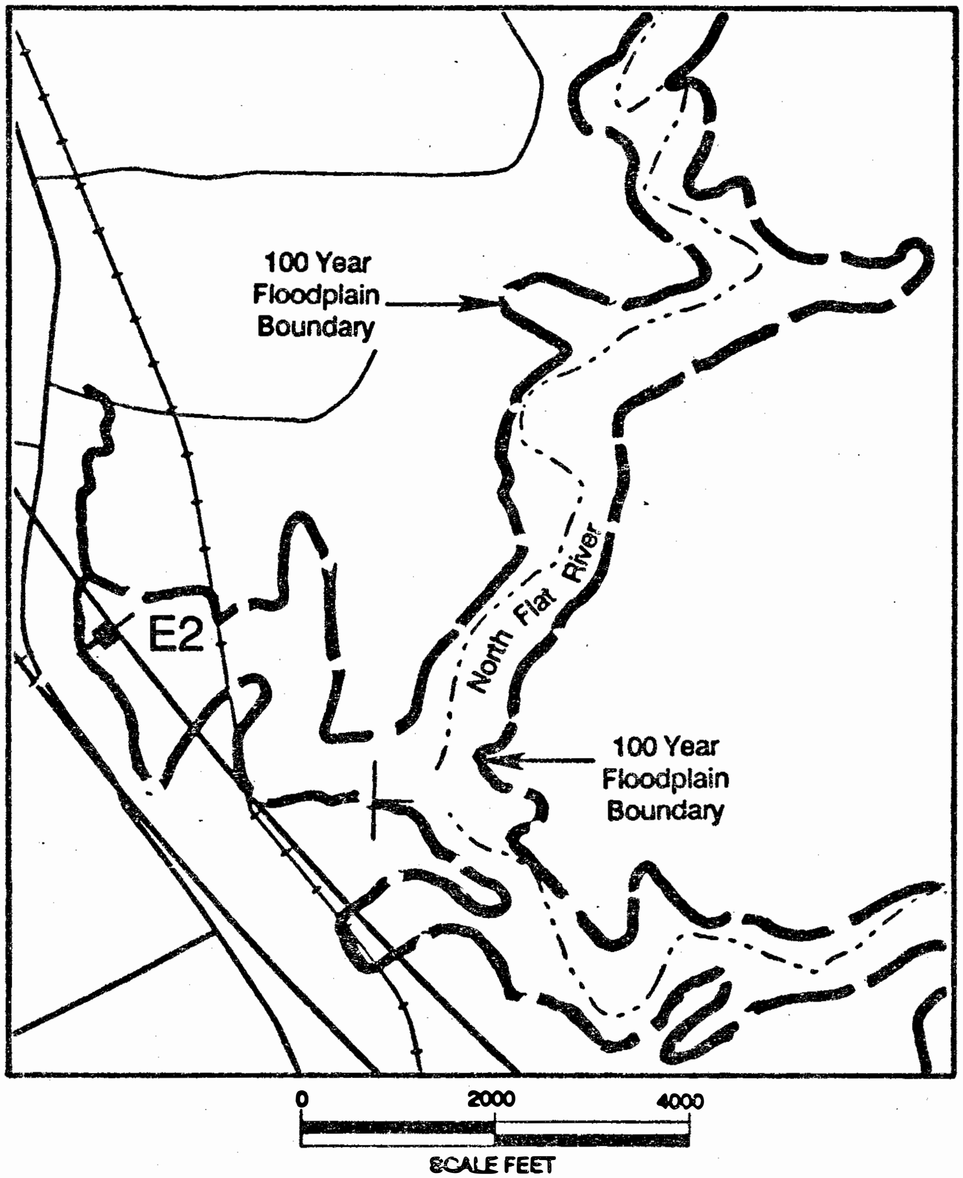
AREA C AND B ENCROACHMENTS ON CAMP CREEK, KNAP OF REEDS CREEK, AND DICKENS CREEK FLOODPLAINS NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1978a and 1979.

Figure 5.1.2-9B

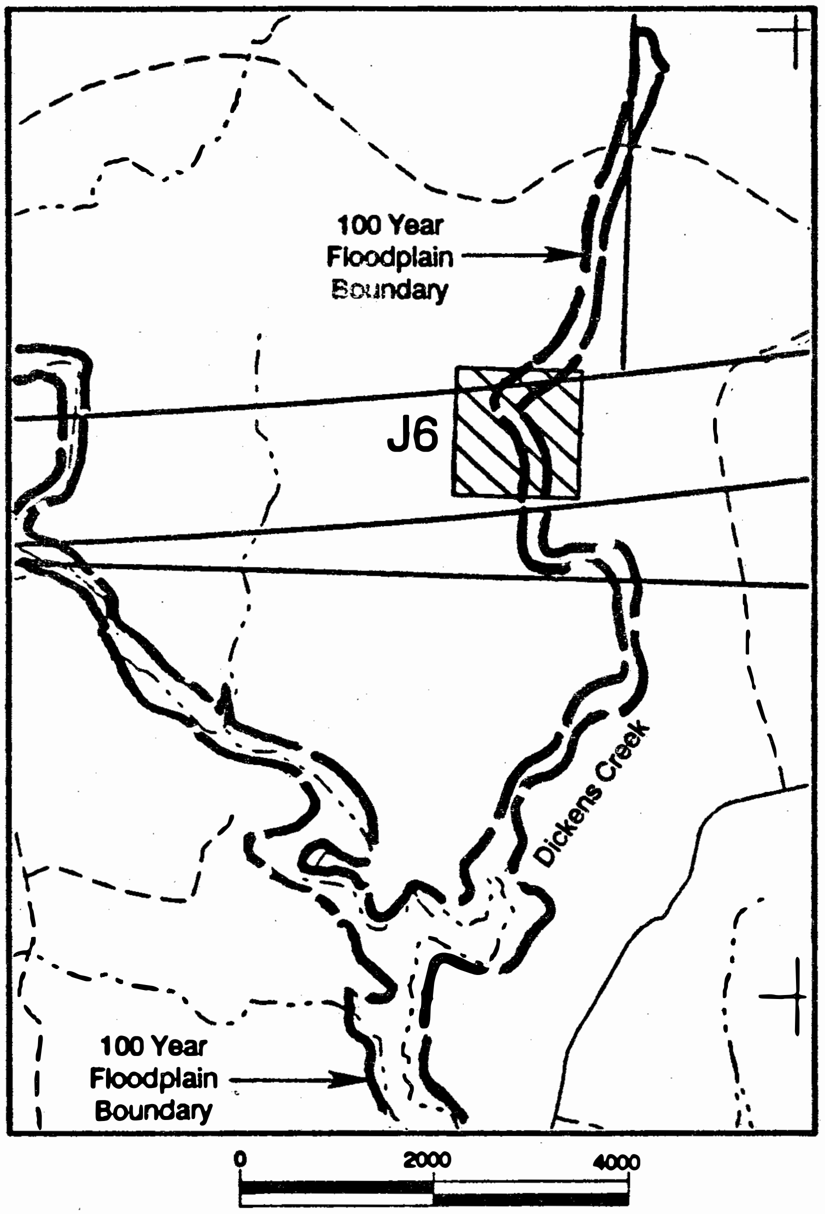
E2 ENCROACHMENT ON NORTH FLAT RIVER FLOODPLAIN NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1978b.

Figure 5.1.2-9C

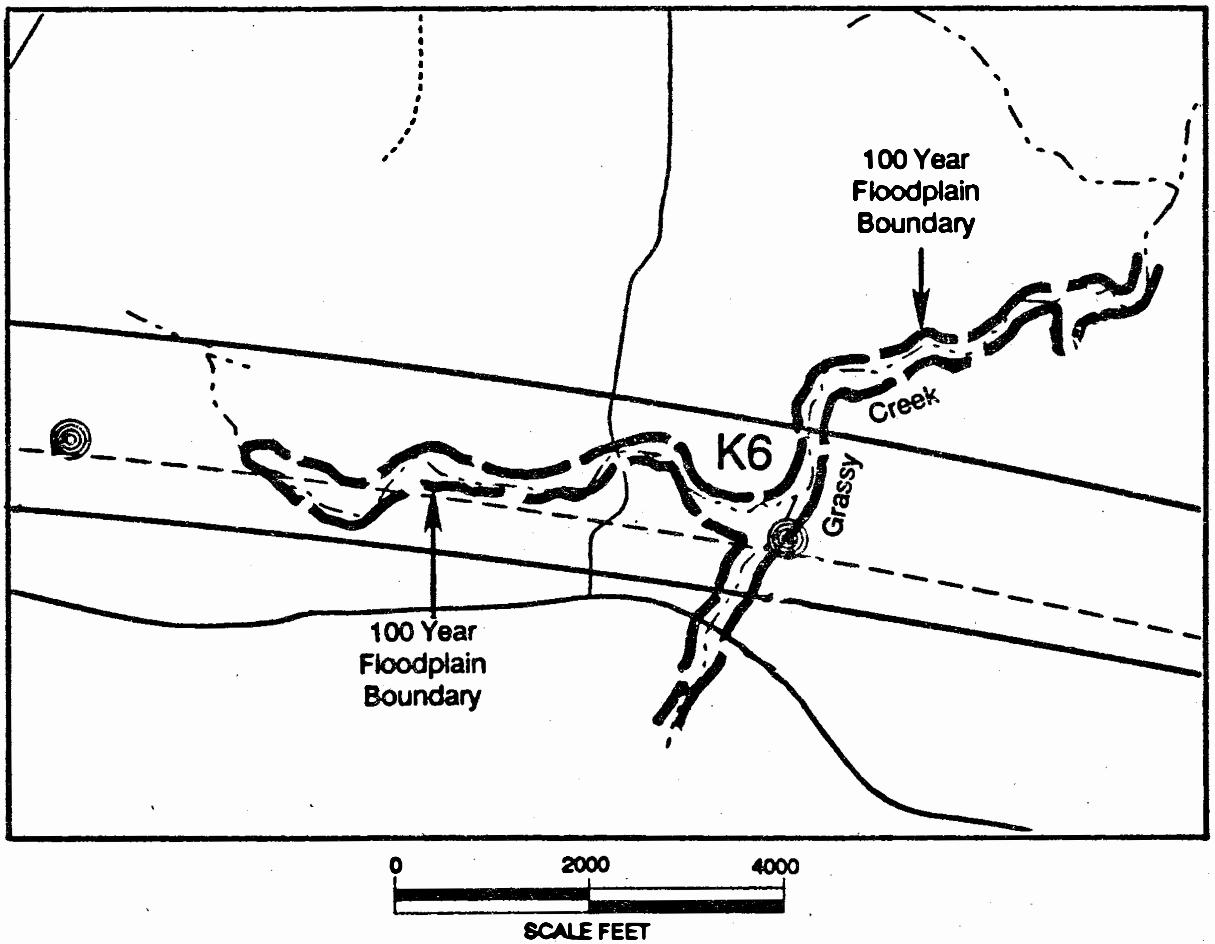
J6 ENCROACHMENT ON DICKENS CREEK FLOODPLAIN
NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1978a.

Figure 5.1.2-9D

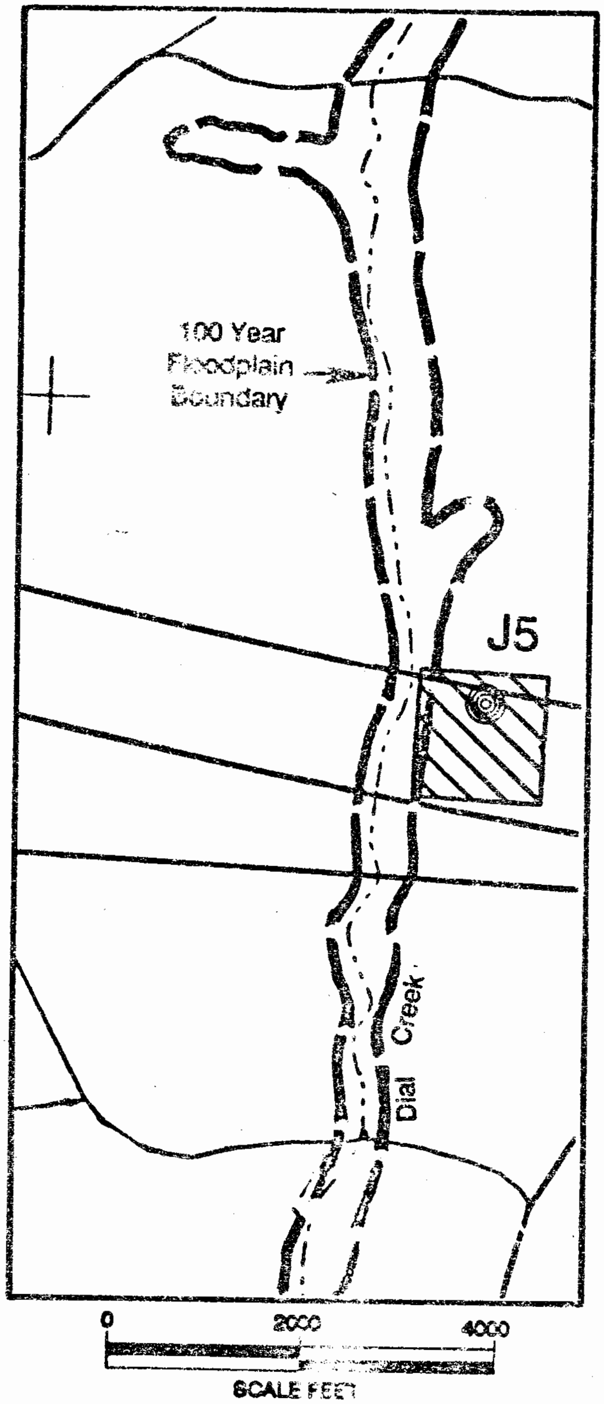
K6 ENCROACHMENT ON GRASSY CREEK FLOODPLAIN
NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1978a.

Figure 5.1.2-9E

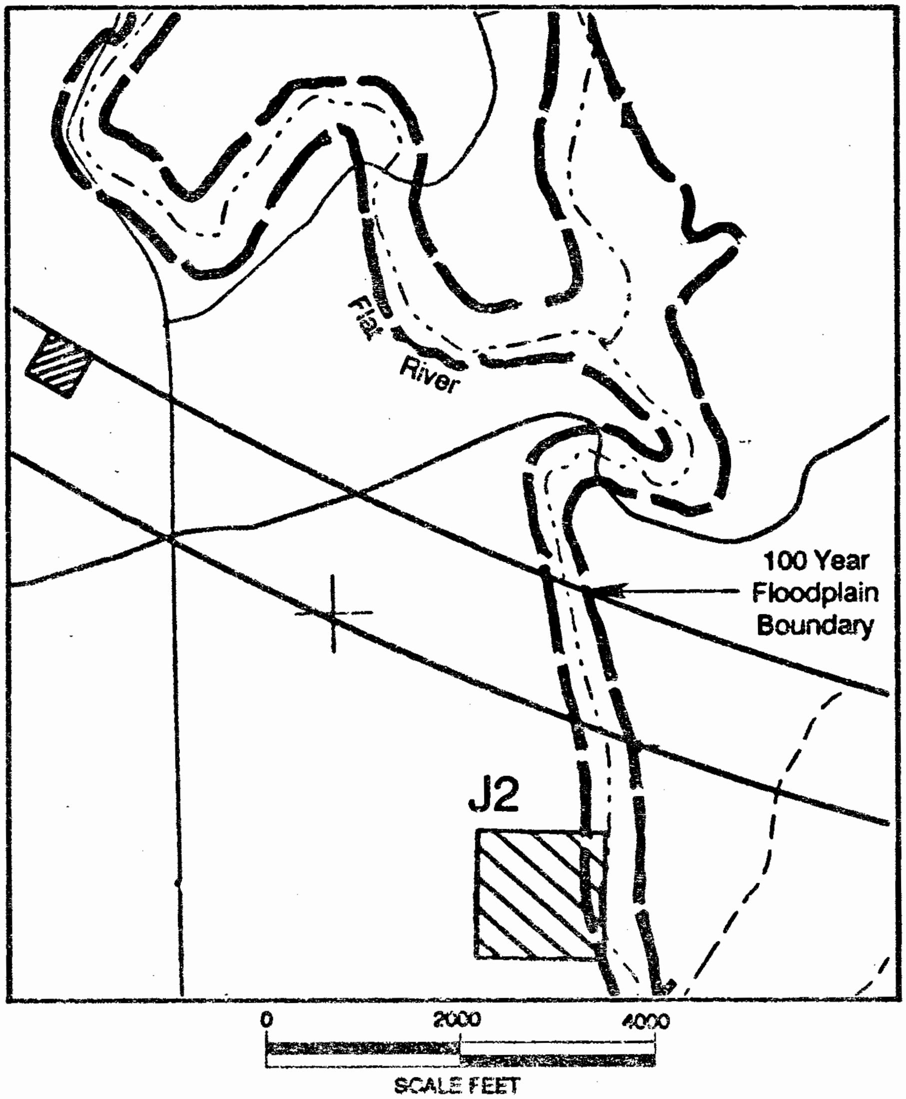
J5 ENCROACHMENT ON DIAL CREEK FLOODPLAIN
NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1979.

Figure 5.1.2-9F

J2 ENCROACHMENT ON FLAT RIVER FLOODPLAIN NORTH CAROLINA SITE



Source: Federal Emergency Management Agency, 1979.

upstream flooding impacts. Beam access area J2 has a large upstream watershed area (141 mi^2), but along with beam access area J5 and access area E3, these areas only show minor encroachment into the floodplain and are not likely to create upstream flooding. Because the existing floodplain mapping of these locations with the Flood Hazard Boundary Maps is not detailed enough to make any measurements of floodplain encroachment, no actual numbers are given. These encroachments all could have the potential to produce impacts to the local flooding of their adjacent streams if the encroachment is great enough. Encroachment on the floodplain of Knap of Reeds Creek from the injector and booster complex (Area B) can be mitigated with levee or berm construction during cut-and-fill operations. The residual floodplain encroachment impacts here would then be negligible. Encroachments at the other locations may be avoided through adjustments of the final facility location. If this is not possible, mitigation with levees is also an alternative.

Construction of new roads to provide access to the SSC facility would be extensive for the campus area. A total of 25.3 mi of new four- to six-lane roadways would be constructed to provide easier access to the campus area. These roadways would cross the Flat River, Dial Creek, and Camp Creek, as presently located. To make the desired connections to other existing roads and the campus, these stream crossings cannot be avoided. An additional 12.3 mi of new, two-lane paved access roads would be built for the other facilities around the ring. Most of these roads are in short stretches of less than 1 mi, one of which may cross Grassy Creek to connect with experimental hall K6. This stream crossing may not be necessary, depending on the final road location. A total of 1.3 mi of new one-lane gravel roads would be built to provide access to the intermediate access areas (E1 through E9). None of these short roads are expected to cross any identified stream channels.

In general, floodplain encroachments only impact upstream flooding by constricting the floodplain, causing backwater effects. This is more of a problem on larger streams with shallower slopes than smaller or steeper streams. Only two of these potential encroachments are on streams with watersheds greater than 20 mi^2: the South Flat River (at E2), and the Flat River (at a new four-lane highway crossing). Both of these have watersheds of less than 150 mi^2, and regional impacts from floodplain encroachment on these streams would be negligible.

F. <u>Tennessee</u>

In Tennessee, all four counties that would include parts of the SSC facility have FEMA maps available (see Figure 5.1.2-10). However, only Williamson County is shown on the more detailed Flood Insurance Rate Maps (FEMA 1981). Bedford, Marshall, and Rutherford Counties are shown only on Flood Hazard Boundary Maps (FEMA 1978b, 1979a, and 1980). The lack of more detailed coverage in this area is an indication that flooding in this area has limited damage potential primarily because there are few man-made structures. Indicative of this is the rural nature of the Tennessee site location with scattered houses and few other buildings. During preconstruction analyses, geotechnical and other environmental studies would be performed to verify this assessment as part of final project design.

The available FEMA maps (FEMA 1977, 1981, 1984a, 1984b, 1988a, 1988b) mentioned above were used in preparing this floodplain assessment to determine whether any of the proposed facilities may be in the 100-yr floodplain.

Temporary encroachment is likely on the Armstrong Branch from construction of the campus facilities or from the placement of buildings or other structures. Service area F1 covers about 100 ft of a 300-ft-wide floodplain. Actual placement of surface structures in the campus area and in the service areas remains relatively flexible at this time and would not be determined until site-specific designs are prepared. Potential encroachment is based on the actual land areas and their location on or near floodplains. Other SSC facilities are located near to floodplain areas, and depending upon final design, could also affect upstream flooding. These include: service area F10 (Figure 5.1.2-10A), and beam zone access areas J2 (Figure 5.1.2-10B), and J4 (Figure 5.1.2-10C).

In the campus area, the new four-lane highway providing site access would cross Armstrong Branch causing potential encroachment. Both this encroachment and the access road encroachment at E6 can be mitigated relatively easily because both streams are small (watershed areas <6 mi^2) and their floodplains only 200 to 300 ft wide. With proper design of the bridge or culvert and possible channel improvements, this impact can be reduced to negligible levels at both sites.

Intermediate access area E6, depending upon final design, may encroach upon the Spring Creek floodplain by blocking up to 50 percent of the floodplain cross section at that point (Figure 5.1.2-10D). This encroachment can be mitigated because of the small watershed area upstream (less than 25 mi^2) and with channel relocation, diking, or adjustment of facility design, this impact should be negligible.

Intermediate access area E1-PI is located wholly within the Stones River floodplain (Figure 5.1.2-10E). At its narrowest point adjacent to the facility, the floodplain is approximately 2,500 ft wide with an upstream watershed of less than 8 mi^2; the 200 ft width of the facility is not likely to create upstream flooding impacts, and final design and facility placement and mitigation are likely to reduce the overall impact of the facility on floodplain encroachment.

The F1 encroachment (Figure 5.1.2-10F) has both a new channel crossing and a possible facility placement in the floodplain. The channel is Christmas Creek, which has a small watershed draining an area of <5 mi^2, so mitigating the impact at the crossing should not be difficult. Pending final design, the impact on the floodplain and local flooding should be negligible.

Figure 5.1.2-10

HYDROLOGIC FEATURES - TENNESSEE SITE

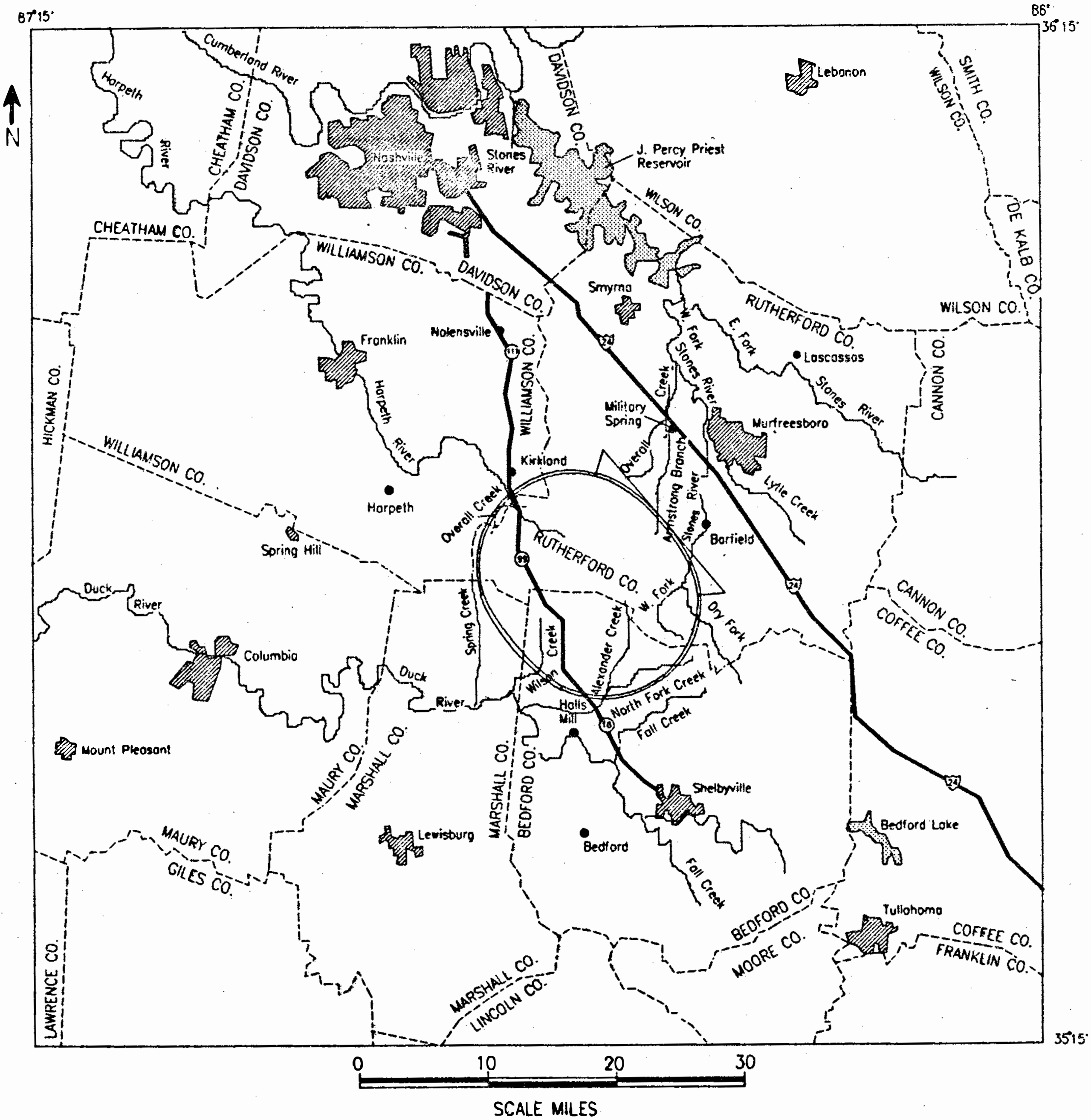
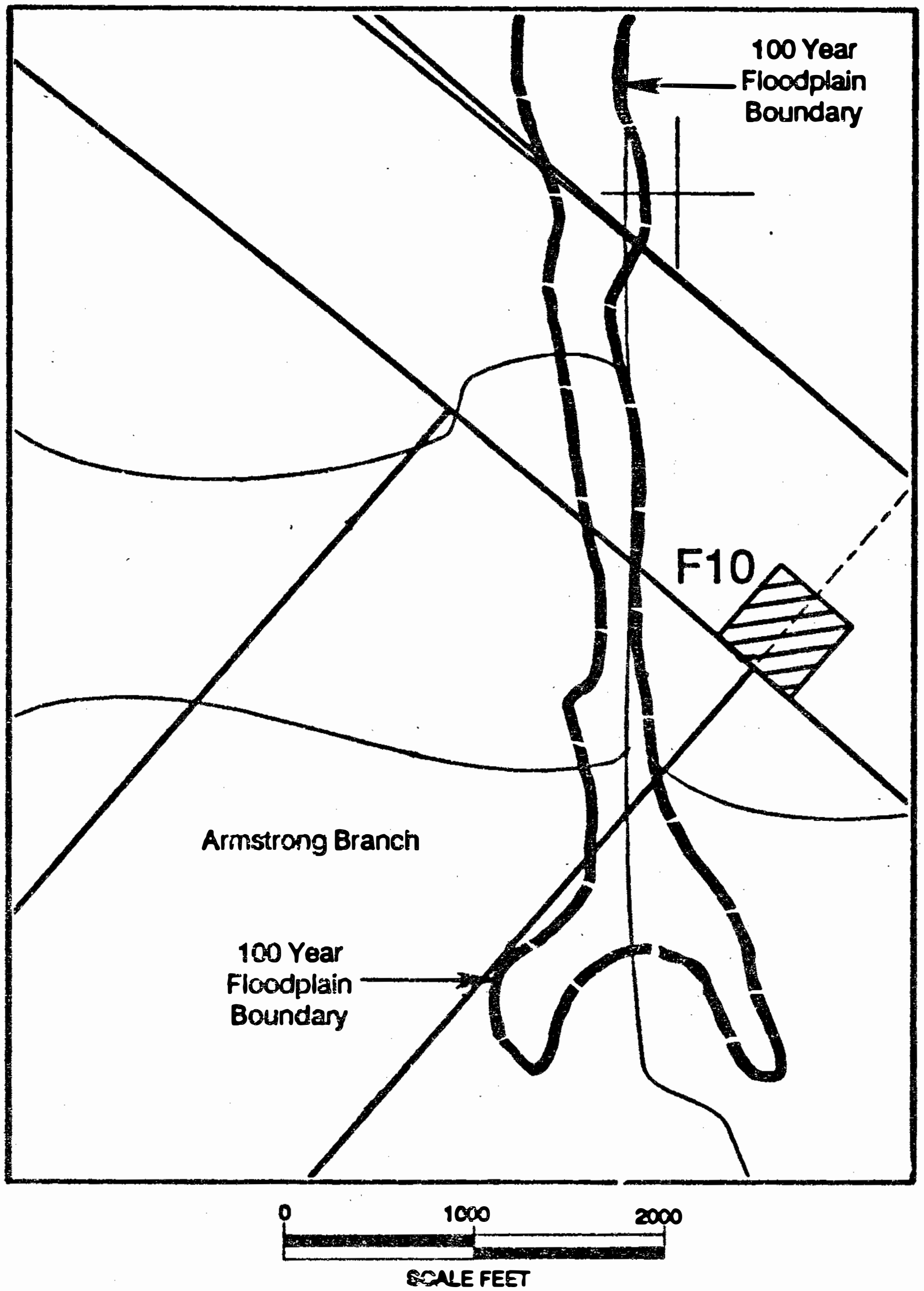


Figure 5.1.2-10A

**CAMPUS AREA ENCROACHMENT ON ARMSTRONG BRANCH FLOODPLAIN
TENNESSEE SITE**



Source: Federal Emergency Management Agency, 1984A.

Figure 5.1.2-10B

MARGINAL J2 ENCROACHMENT ON LYTLE CREEK FLOODPLAIN
TENNESSEE SITE

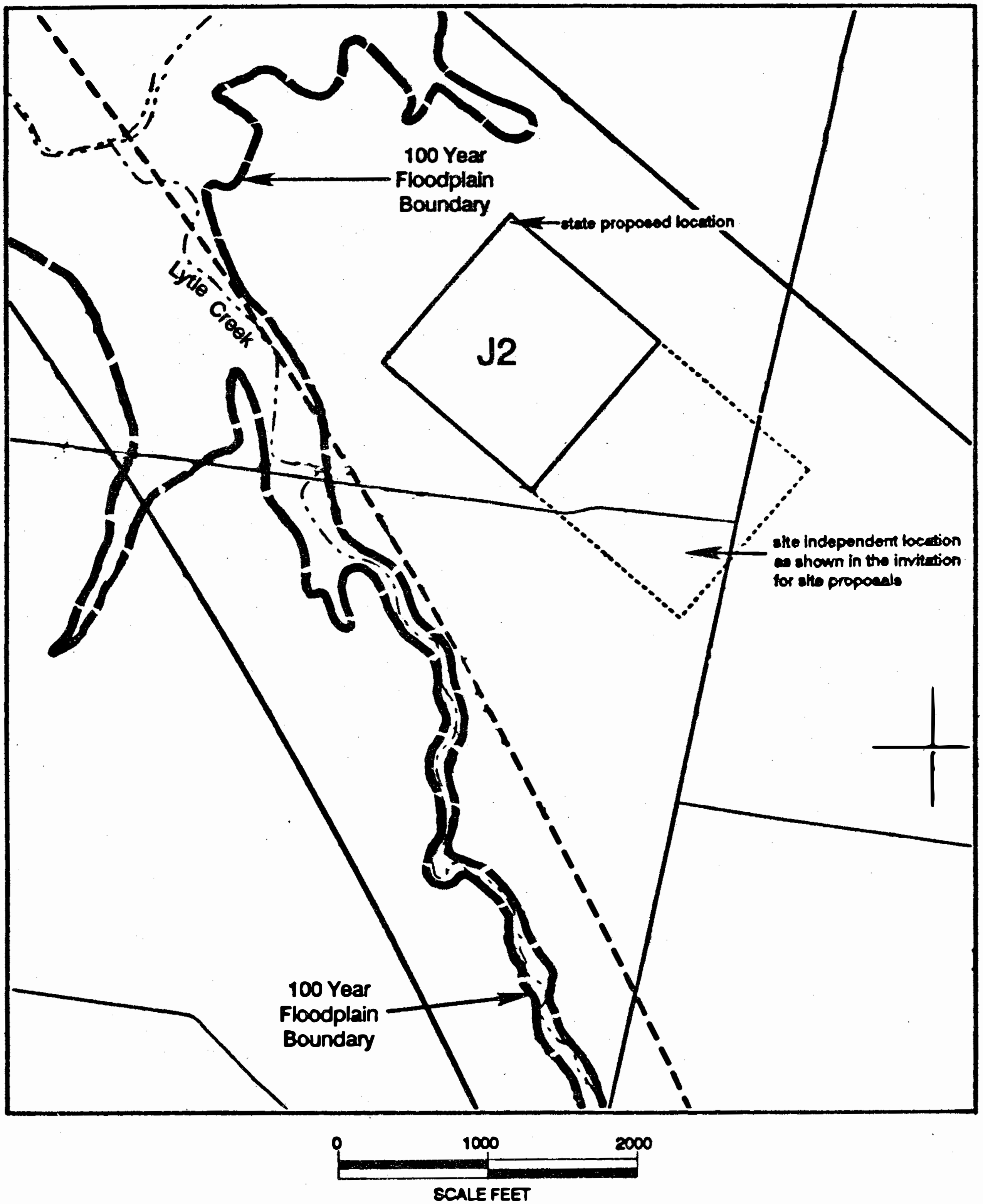
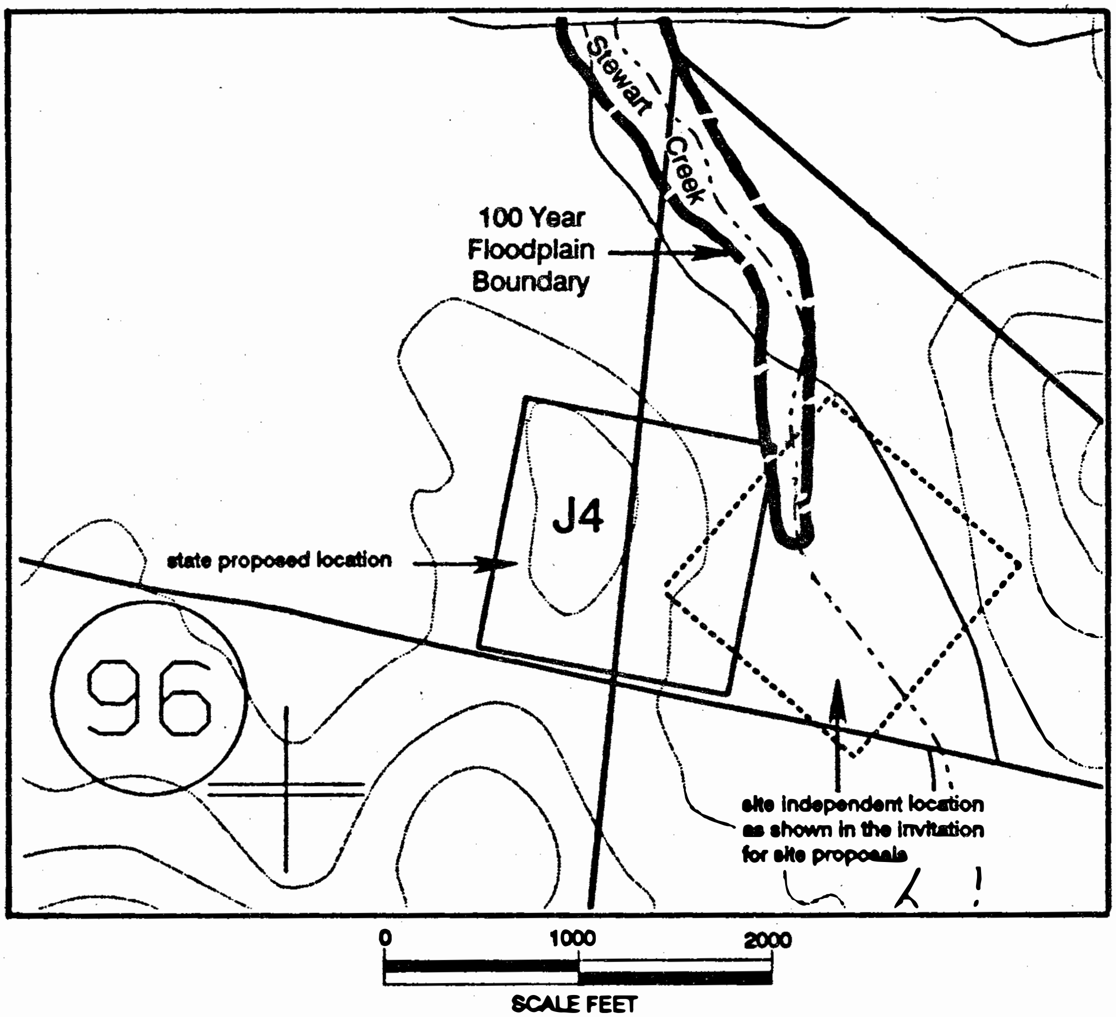


Figure 5.1.2-10C

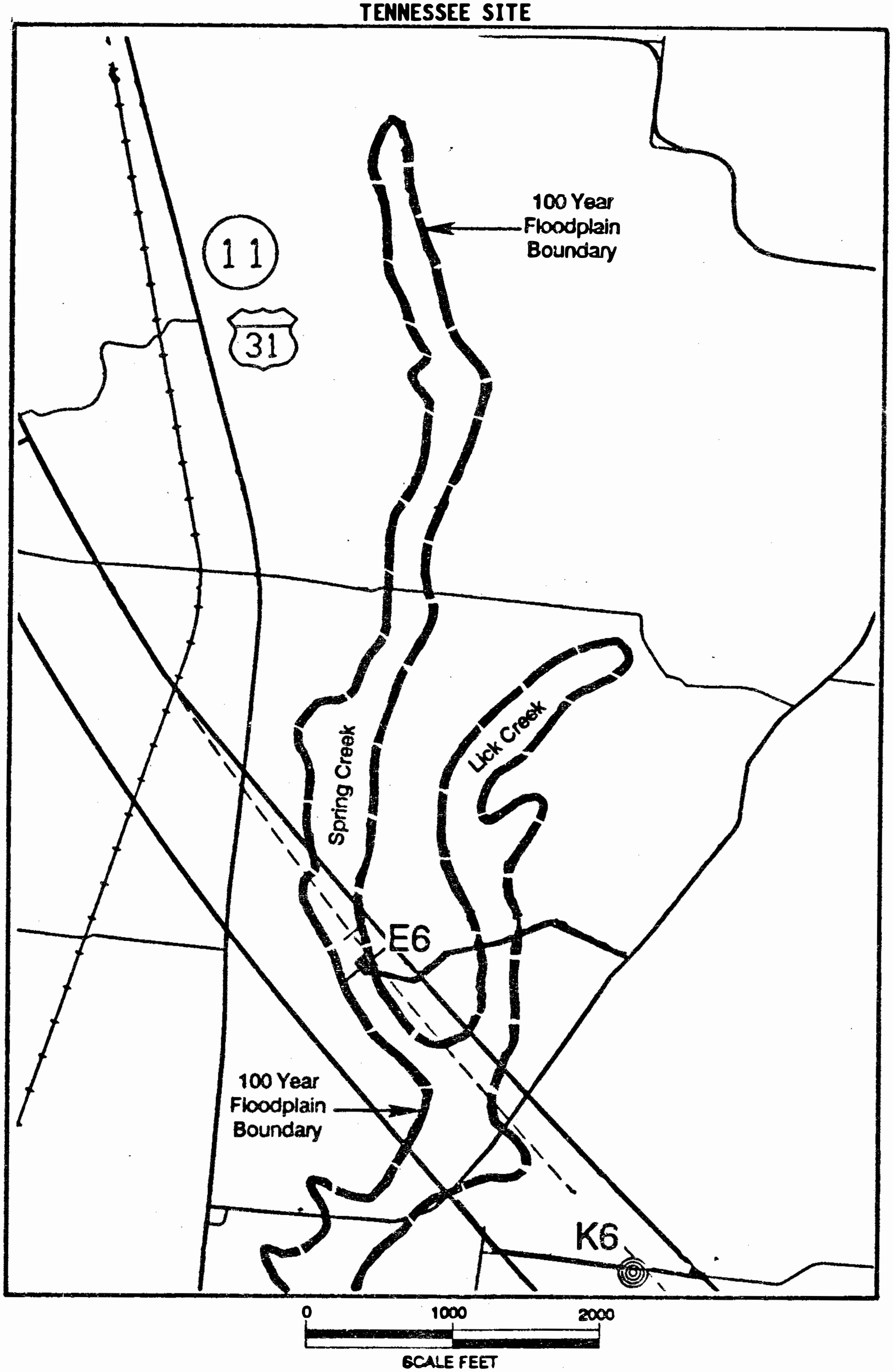
J4 ENCROACHMENT ON STEWART CREEK FLOODPLAIN
TENNESSEE SITE



Source: Federal Emergency Management Agency, 1988A.

Figure 5.1.2-10D

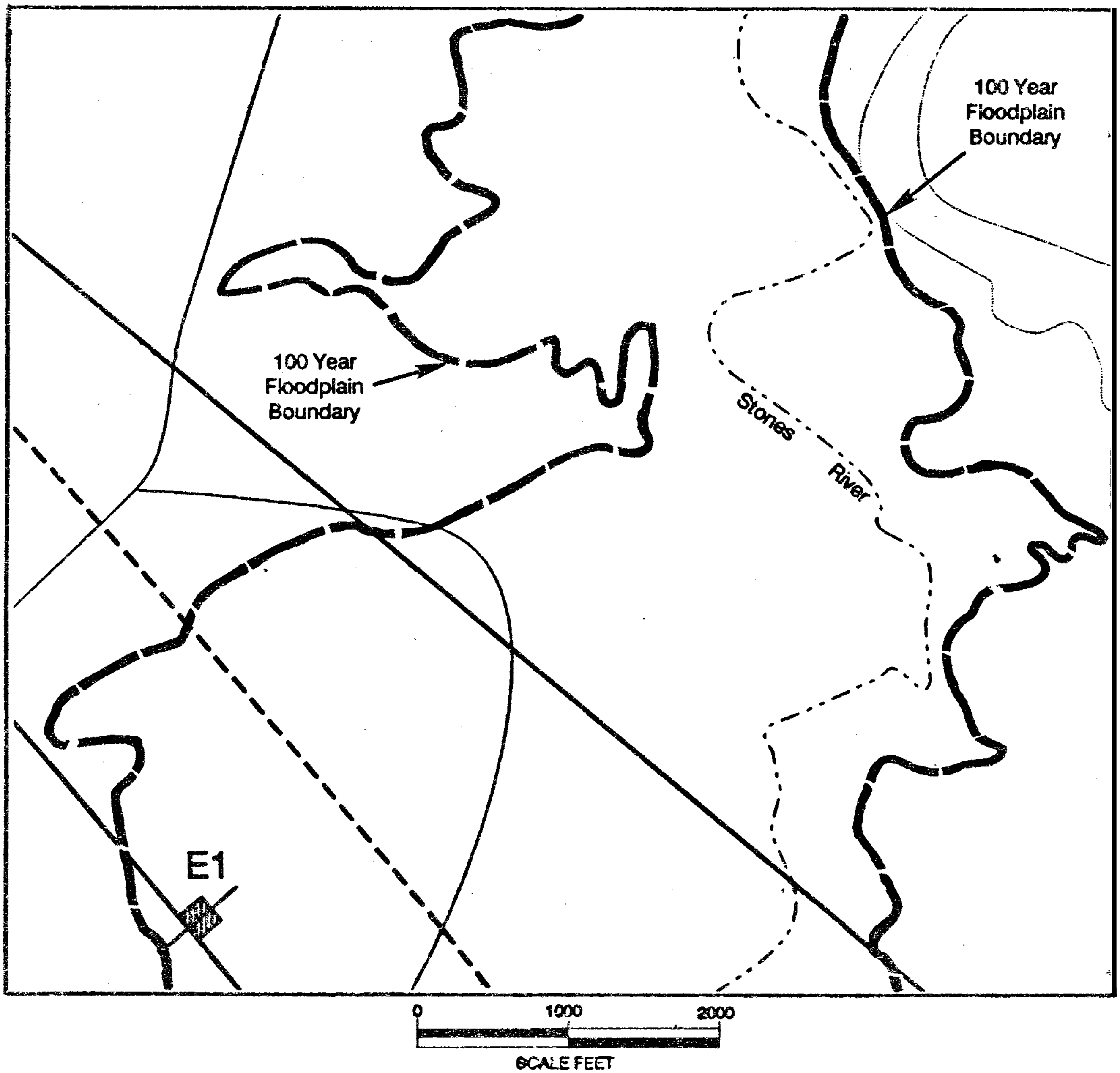
**E6 ENCROACHMENT ON SPRING CREEK FLOODPLAIN
TENNESSEE SITE**



Source: Federal Emergency Management Agency, 1988A.

Figure 5.1.2-10E

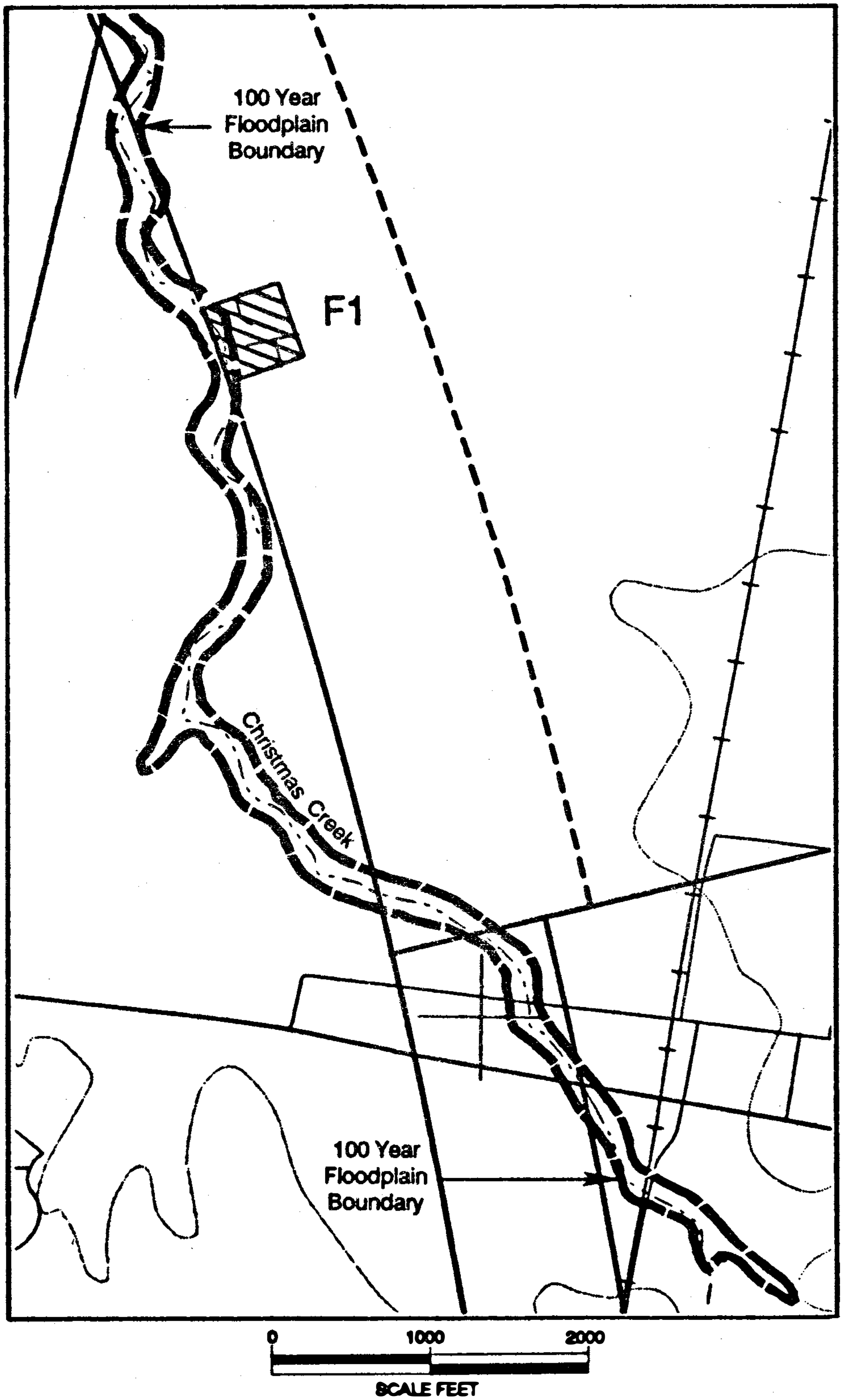
**E1 ENCROACHMENT ON STONES RIVER FLOODPLAIN
TENNESSEE SITE**



Source: Federal Emergency Management Agency, 1984A.

Figure 5.1.2-10F

F1 ENCROACHMENT ON CHRISTMAS CREEK FLOODPLAIN
TENNESSEE SITE



Source: Federal Emergency Management Agency, 1984A.

G. Texas

In Texas, the single county containing the SSC facility is included in the national flood insurance program (see Figure 5.1.2-11). Ellis County is shown on the Flood Insurance Rate Maps, including the entire ring and surface facilities (FEMA 1987). In spite of the generally rural nature of the area, it has been included in the full flood insurance program at this mapping level. These maps have been used in preparing this floodplain assessment to determine whether any of the proposed facilities may be in the 100-yr floodplain. During preconstruction analysis, geotechnical and other environmental studies would be performed to verify this assessment as part of final project design.

Project facilities that would be located partially or entirely within existing floodplains include: J2 in South Prong Creek (Figure 5.1.2-12), J3 in Baker Branch (Figure 5.1.2-13), J4 in Chambers Creek (Figure 5.1.2-14), and J6 in a tributary to Chambers Creek (Figure 5.1.2-15). Two intermediate access areas, E1 and E9, are located in floodplains: E1 in South Prong Creek (Figure 5.1.2-15A); E9 (Figure 5.1.2-15B) in the Mill Branch of Chambers Creek. Actual surface structure locations within the facility boundaries, and in some cases the boundaries themselves, remain relatively flexible at this time. The final locations of facilities (which would not be determined until site-specific design) would be sited to exclude floodplain encroachment if possible. If required, mitigation measures such as the construction of levees would be evaluated during final site design.

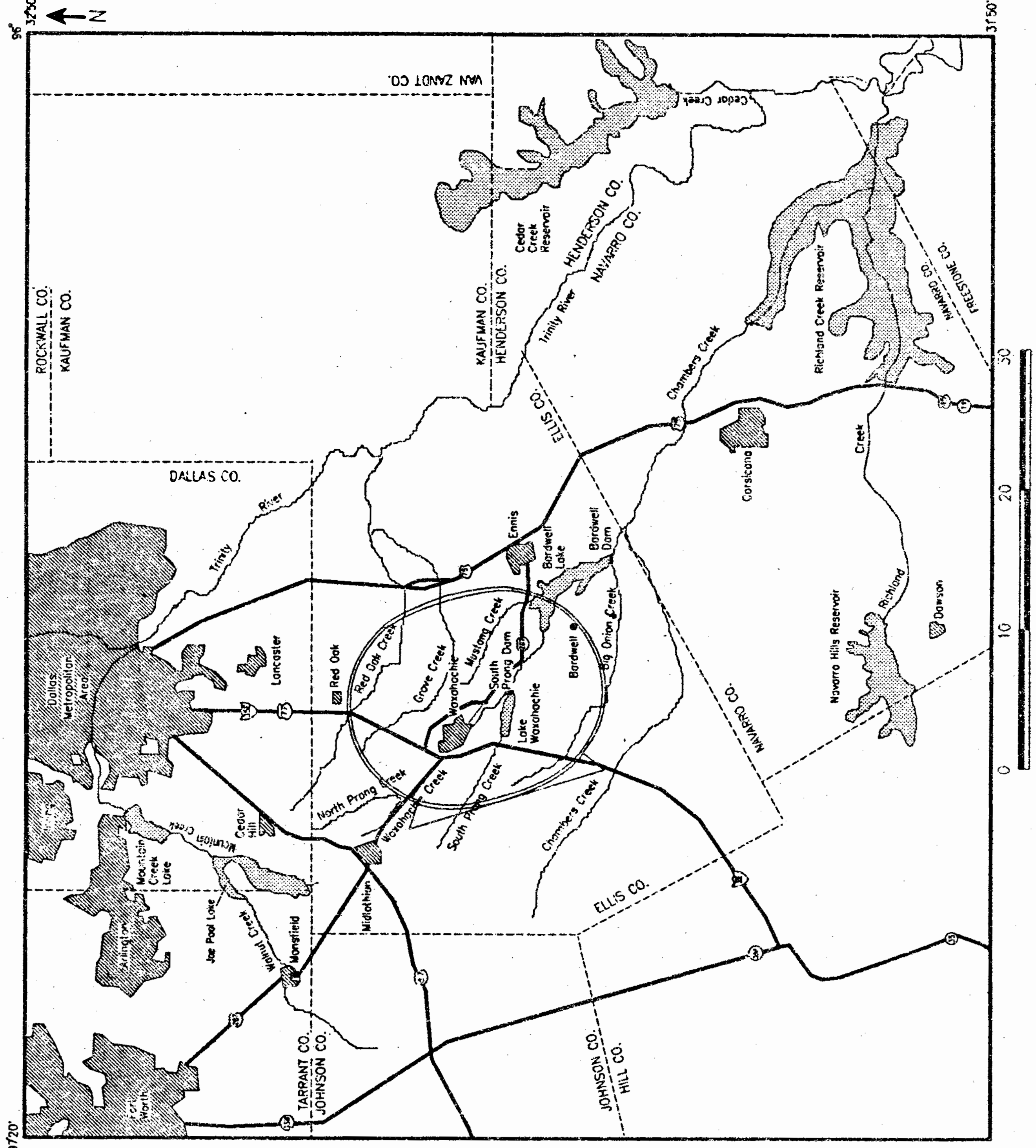
External beam access area J2 is located with its southeast corner crossing South Prong Creek. The floodplain at this location is approximately 250 to 300 ft wide and the encroachment would completely span this distance (see Figure 5.1.2-12). This impact could be mitigated through design layout options or channel diversion. Since the stream is small at this location (<10 mi² watershed) and the area very rural, the impact on the floodplain and local flooding should be negligible.

External beam access area J3 is situated on Baker Branch, a tributary to Chambers Creek (see Figure 5.1.2-13). As currently located, it completely covers the floodplain which is 200 to 300 ft wide in this location. This impact could be mitigated through design layout options. Channel diversion or leveeing could help mitigate flooding problems, since the channel is small (<5 mi² watershed area) and the area rural.

External beam access area J4 is presently located in the floodplain of Chambers Creek, a watershed of 107 mi². The floodplain is about 500 to 750 ft wide at this location and the facility would cross the entire width of this floodplain (see Figure 5.1.2-14). Because this is a larger stream, providing mitigation could be more difficult. However, this impact could be mitigated through design layout options and/or channel diversion.

Figure 5.1.2-11

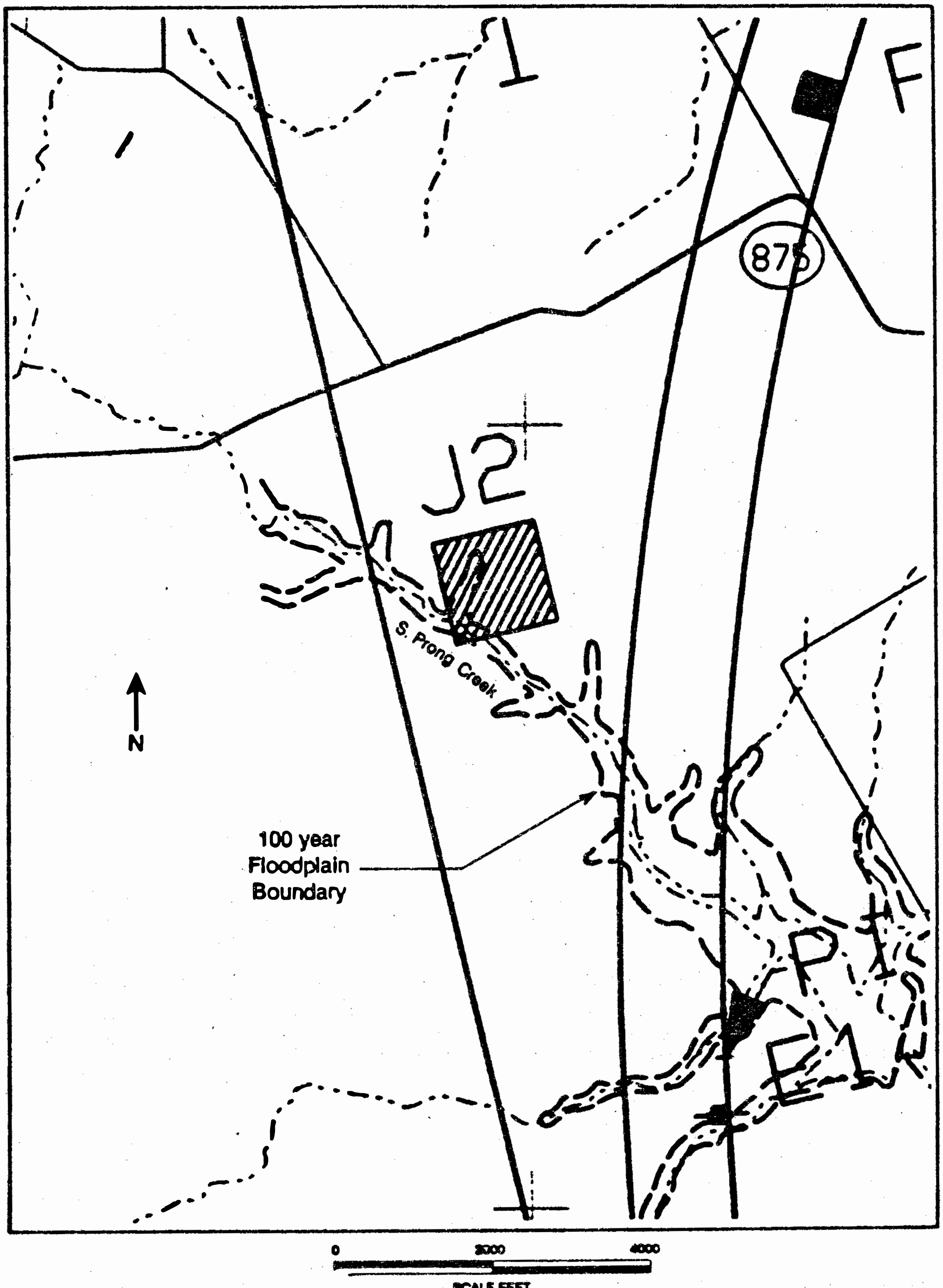
HYDROLOGIC FEATURES - TEXAS SITE



225-775 0 - 88 - 11 (1)

Figure 5.1.2-12

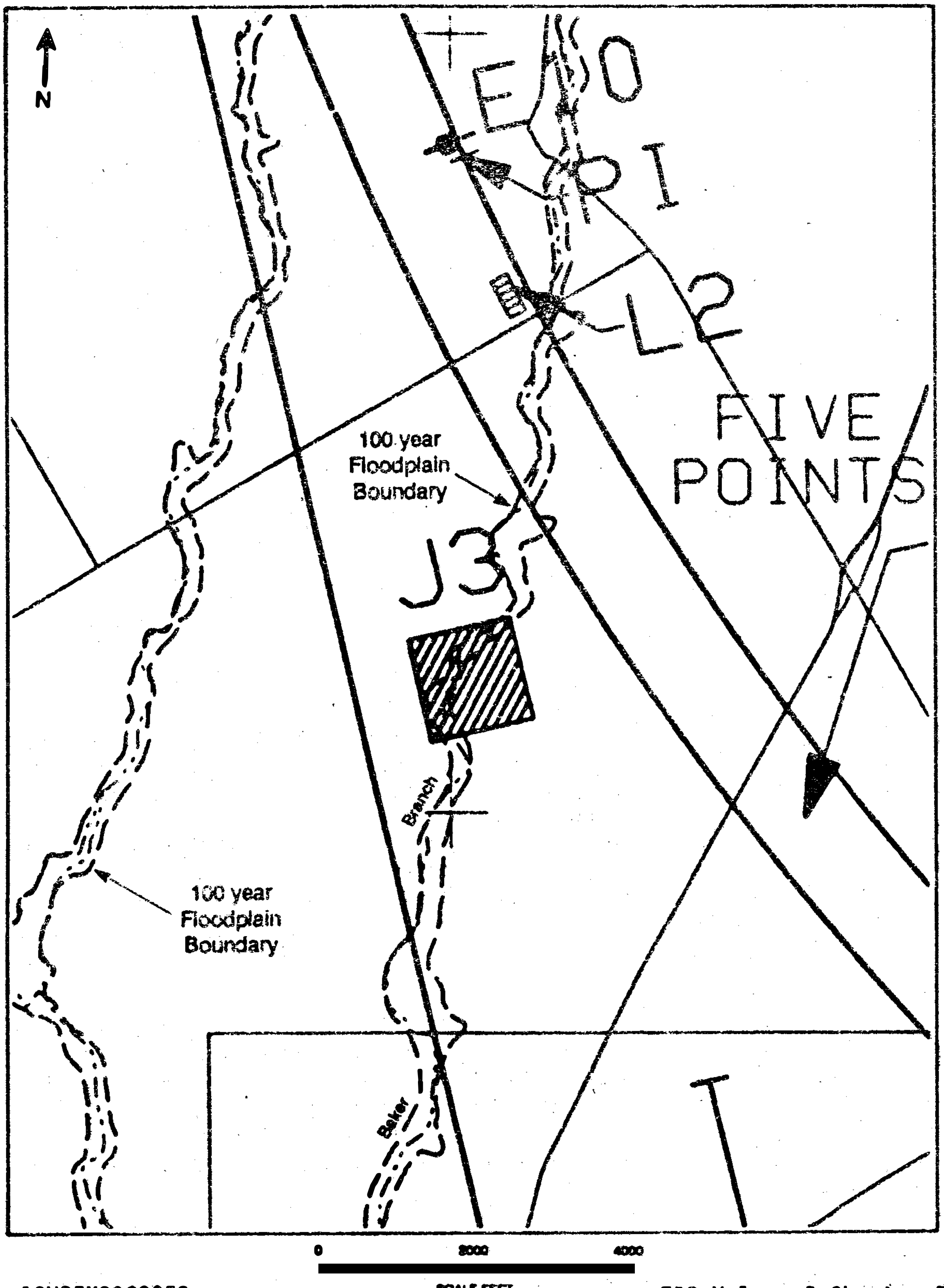
J2 ENCROACHMENT ON SOUTH PRONG CREEK FLOODPLAIN
TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-13

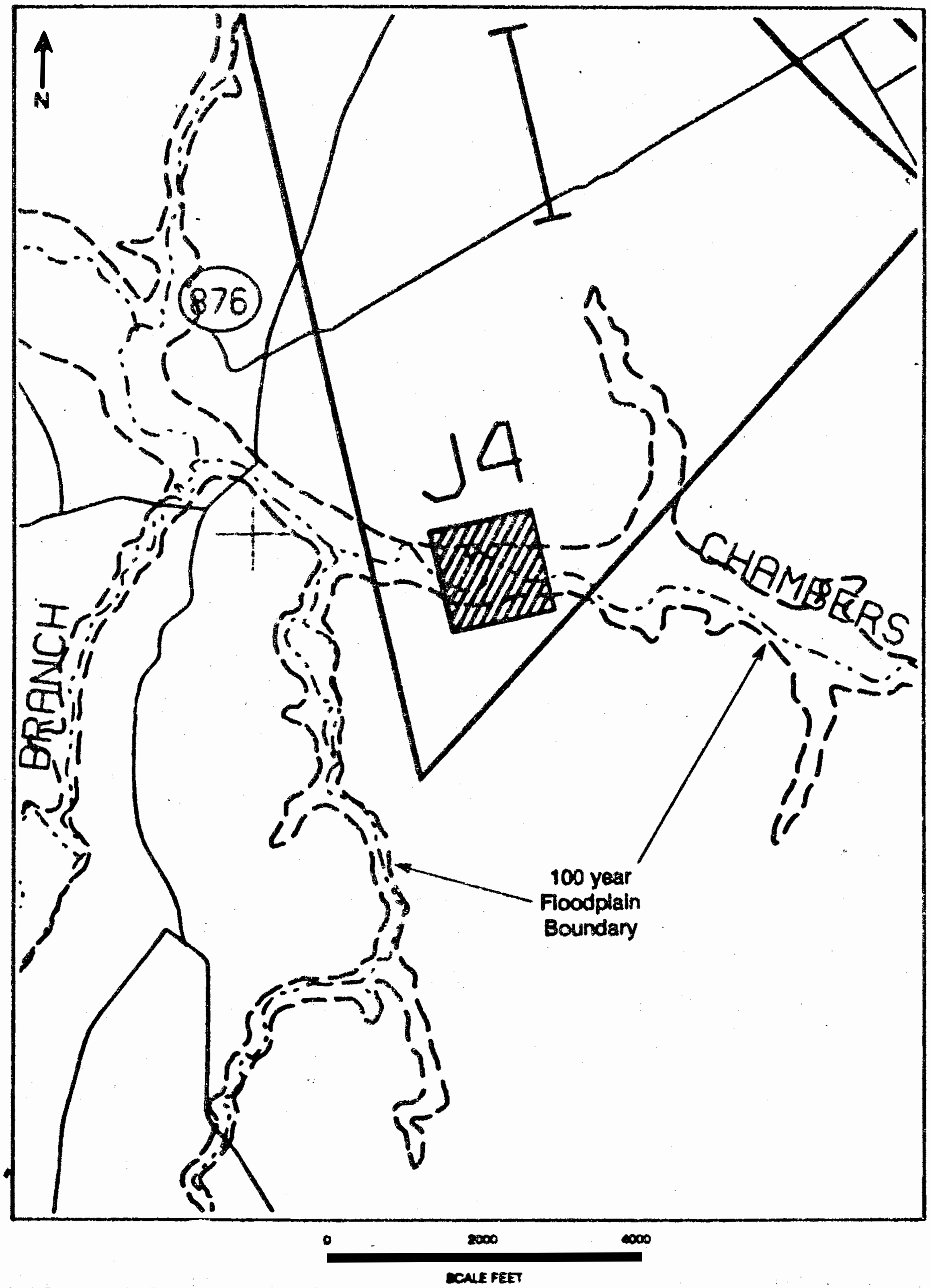
J3 ENCROACHMENT ON BAKER BRANCH FLOODPLAIN
TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-14

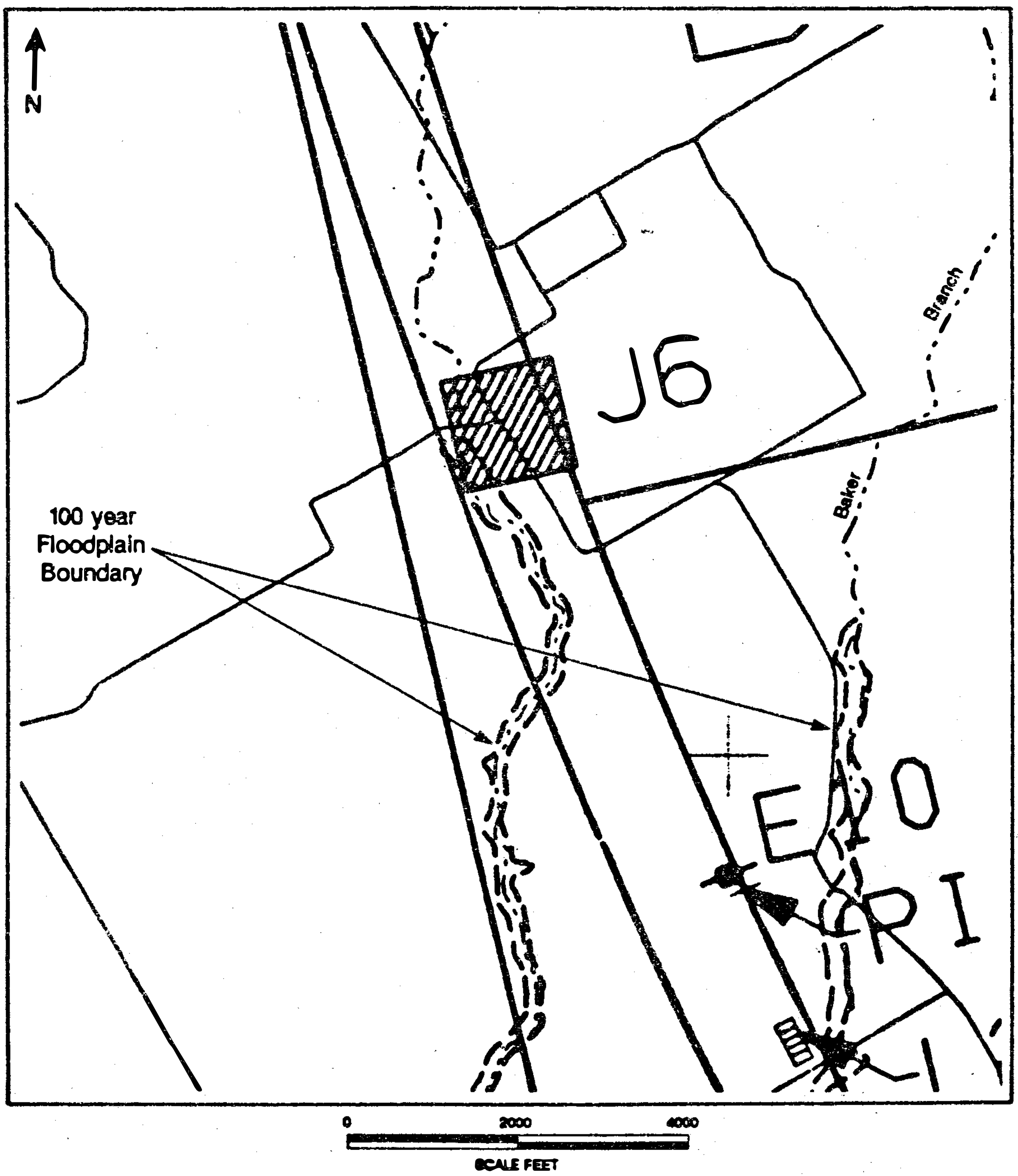
J4 ENCROACHMENT ON CHAMBERS CREEK FLOODPLAIN
TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-15

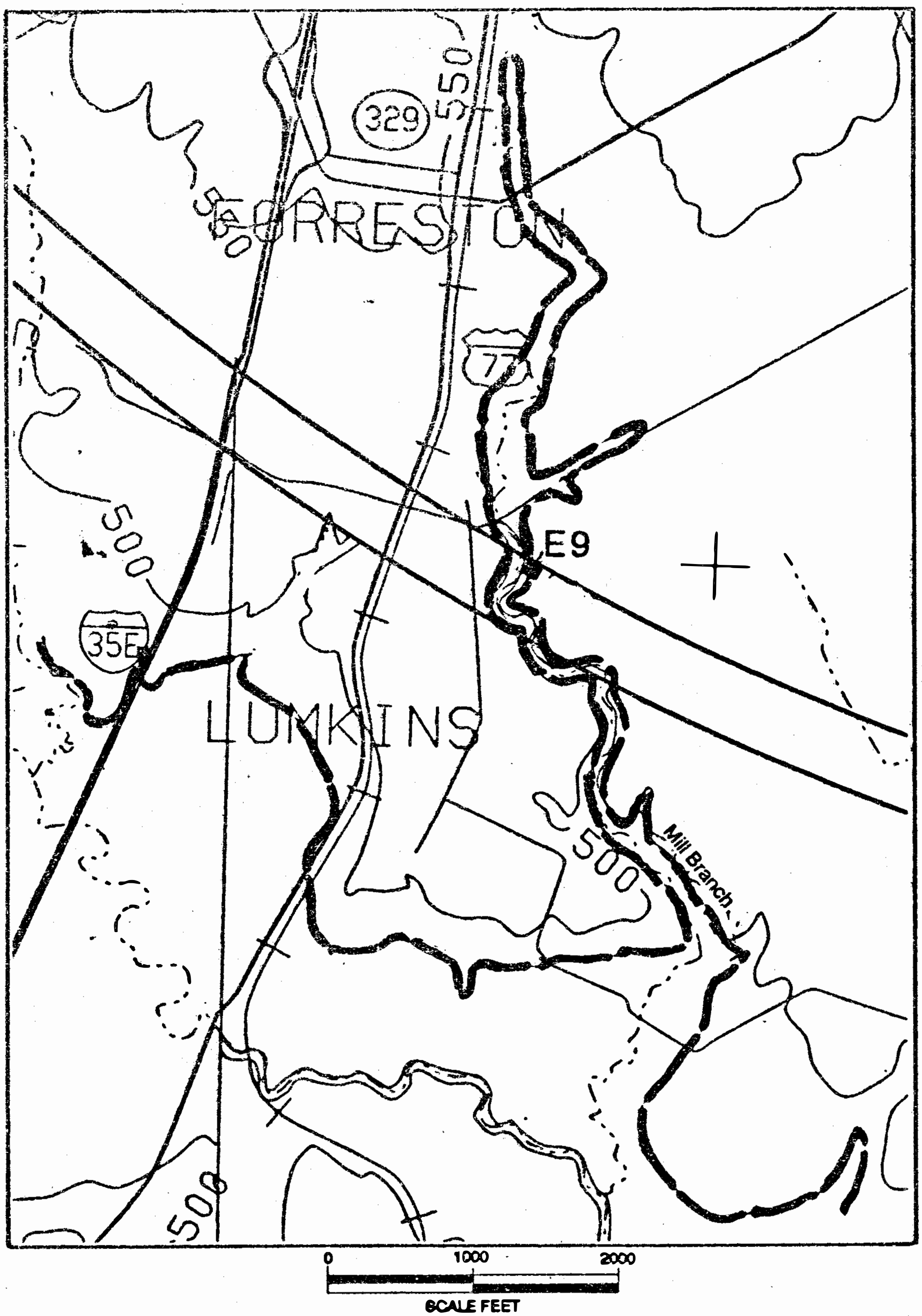
J6 ENCROACHMENT ON UNNAMED TRIBUTARY TO CHAMBERS CREEK FLOODPLAIN TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-15A

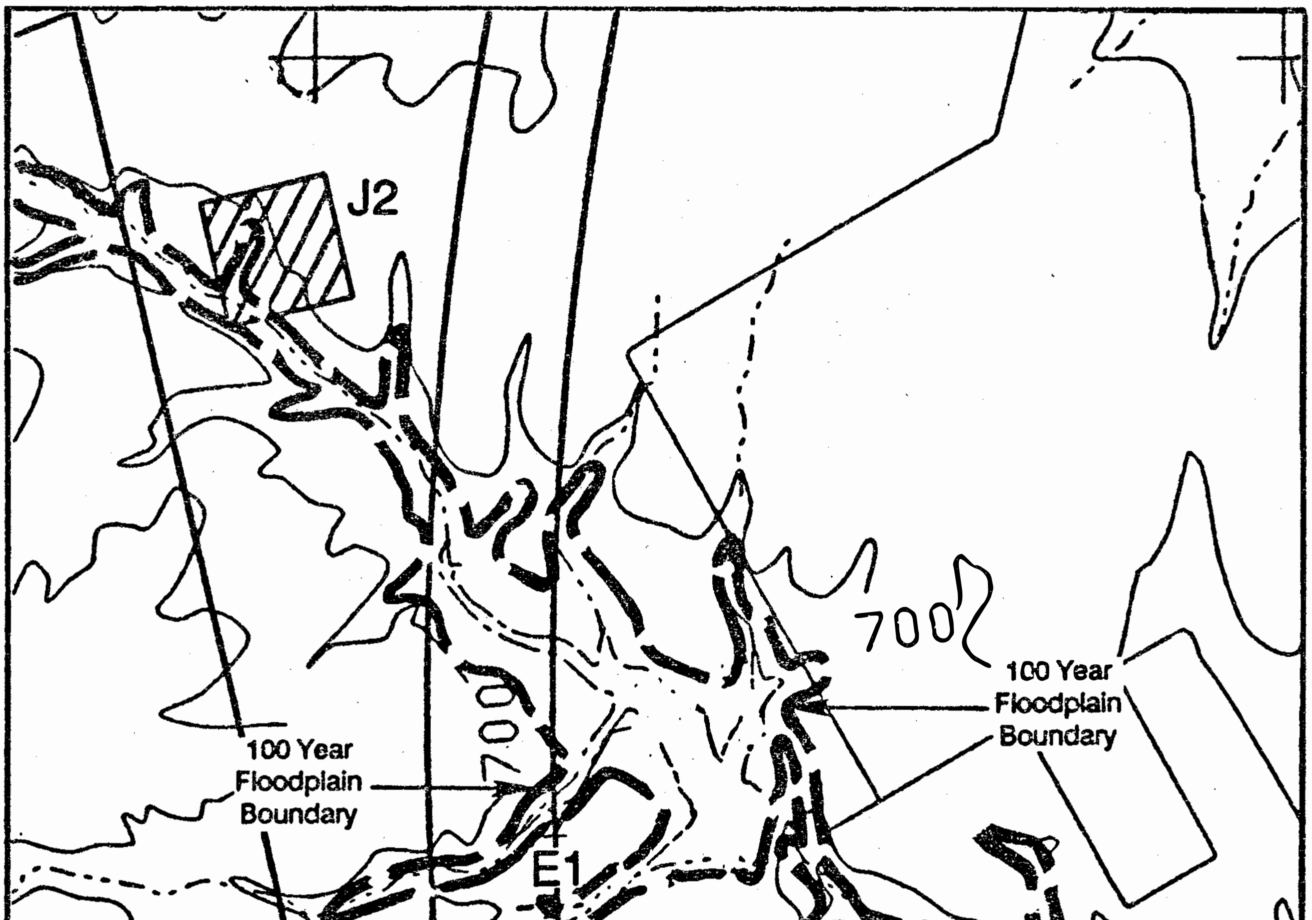
E9 ENCROACHMENT ON SOUTH PRONG CREEK FLOODPLAIN
TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

Figure 5.1.2-15B

E1 ENCROACHMENT ON MILL BRANCH OF THE CHAMBERS CREEK FLOODPLAIN
TEXAS SITE



Source: Federal Emergency Management Agency, 1987.

External beam access area J6 is presently located in the floodplain of an unnamed tributary to Chambers Creek. The southeast corner of this facility completely crosses the floodplain (Figure 5.1.2-15). However, this is the upstream limit of the mapped floodplain on a watershed less than 3 mi^2 in area. For this reason, mitigation through design layout and berms or levees should reduce the impacts from encroachment to negligible levels.

Intermediate access area E1 is located in a tributary of the South Prong Creek. The encroachment should not create flooding impacts as the upstream watershed is very small (less than 0.1 mi^2) and the encroachment only covers a small portion of the floodplain (Figure 5.1.2-15A). Intermediate access area E9 is located in the Mill Branch of Chambers Creek (Figure 5.1.2-15B). As the encroachment is small and the upstream watershed is less than 0.8 mi^2, flooding impacts are expected to be negligible. In addition, final placement and mitigation is expected to further minimize any flooding impacts.

Two access roads, one to service area F3 and the other to access area E8, would cross the stream channels of Red Oak Creek (about 1,000 ft wide) and Big Onion Creek (about 1,500 ft wide). Mitigation of these encroachments would require careful design of the bridge or culvert used and the amount of roadway embankment.

5.1.2.3 Water Quality

The deterioration of local surface water quality is a net result of the additional loads of pollutants put into these waters by proposed SSC activities. During construction, pollutant loads could come from increased surface erosion, increased channel erosion, and any waste or spilled materials that may be improperly handled. During operations, pollutant loads could come from materials washed off surfaces such as parking lots and roads, from channel erosion, or other sources. Wastewater effluent loads due to increasing populations associated with the SSC would be another source of pollutant loads.

Groundwater quality changes, other than effects from radiologic and hazardous materials (see Section 5.1.6), may result from SSC construction and operations. Groundwater quality could be affected by the same types of activities that have potential for impacting surface water. Impacts to groundwater could occur at those sites where there is a direct hydraulic connection between surface water bodies and underlying shallow aquifers (Colorado, Illinois, Michigan, North Carolina, Tennessee and Texas). Also, materials used in subsurface construction (e.g., concrete or metallic liners) could interact with groundwater, changing its quality.

SSC construction and operations at all sites would be carried out to minimize pollutant releases to groundwater and surface water. A variety of mitigation measures and operations procedures are available to reduce the potential for water quality deterioration. The potential for increased siltation and turbidity in streams due to construction-related surface and channel erosion has been discussed in Section 5.1.2.1. The likelihood of pollutant spills due to improper handling could be reduced by a vigorous program of employee training and inspection. If necessary, facilities could be designed and constructed to treat channel storm water runoff prior to release into natural drainages.

At most sites where hydraulic connections exist between surface and groundwater, only minimal, short term impacts to surface water quality are expected. The affected area of surface water represents only a small portion of the recharge zone for underlying aquifers. Also, the filtration effect of the rock and soil through which groundwater recharge would move would significantly reduce the amount of particulate contaminants (e.g. silt) present. Filtration and dilution of recharge from surface waters would reduce any impacts to groundwater to negligible levels at all except the Tennessee site. At the Tennessee site, the shallow karst aquifer is very susceptible to contamination from surface sources because of the solution openings which commonly extend to the surface. At the Arizona site, lack of surface water and the great depth to the water table would effectively limit transport of contaminants into the groundwater. At the Colorado and Texas sites, shallow alluvial aquifers may be disturbed by surface construction. However, these aquifers are generally small and discontinuous around the SSC site. There are no deep groundwater supplies at the Colorado site. In Texas, deep groundwater supplies are generally isolated from surface activities by impermeable rocks. Physical disturbance of aquifers by the introduction of concrete or steel liners in shafts and tunnels will affect only total dissolved solids (TDS) and common ions such as sulfate, sodium, calcium, iron, etc.; as a result, any changes in groundwater quality would be localized and would not require any change in the potential use of the water.

5.1.2.4 Water Use

SSC construction and operations would cause an increase in water use. The primary demand would be for water directly at the site; a secondary demand would be for domestic water to supply the needs of project personnel (initially construction personnel and, subsequently, operations personnel) who relocate to the SSC site vicinity. Each state has proposed a specific plan to supply these needs. Three states, North Carolina, Tennessee, and Texas, have proposed the use of surface water as the primary water supply. Minor groundwater use for primary and/or secondary water demands would occur in all three states. Four states, Arizona, Colorado, Illinois, and Michigan have proposed groundwater as the primary project water supply source. Arizona, Colorado, and Michigan would probably impact a surface water source through a secondary water demand on a domestic system. This evaluation takes into account all primary and secondary water demands on supply systems for both construction and operations.

Colorado has limited surface water in the site area. The proposed method of water supply is from wells of the Morgan County Quality Water District. The potable water wells are located in the Hay Gulch nontributary aquifer. Additional water demand will be met by the district's other wells and, if necessary for direct supply or augmentation, by the purchase and conversion of existing senior agricultural water rights. As a backup source, transfer of surface water from the Colorado River Basin to the Big Thompson River (the Colorado-Big Thompson, or CBT Project) and diversion to a distributary system could be used to augment recharge for the primary groundwater supply for the SSC facility. Existing water rights would be purchased and there would be no increase in transfer of Colorado River water for the project. The amount of water needed for this recharge for the construction period is less than 0.1 percent of the annual transfer of Big Thompson River water. Water use during operations would require less than 1 percent of the annual transfer amount to be used for recharge.

Illinois has no identifiable impacts on surface water use due to the proposed SSC. While Illinois has significant amounts of surface water, very little of it is used for water supply, and no additional surface water use by the SSC facility beyond the current level now used by Fermilab has been proposed. Increased surface water use (Lake Michigan, Fox River) by local municipalities could lessen groundwater use impacts related to the project.

Michigan's water use would be all groundwater except for domestic water supply for the population increase in Ann Arbor which would use surface water (primary) and groundwater. The increased surface water use in Colorado and Michigan due to the SSC project would be negligible.

North Carolina, Tennessee, and Texas all propose surface water as the major supply for direct SSC project needs (with minor contribution of groundwater at remote facilities). These states would also supply some or all off-site domestic water needs with surface water. In Texas, direct and indirect project water use for both construction and operations would represent a small percentage of current excess capacity in the region. Therefore, impacts to current water use would be negligible. In North Carolina, the proposed water supply for the SSC project is Lake Butner for the campus, injector complex, and the near cluster half of the ring, and Mayo Reservoir for the far cluster half of the ring. Current off-site water supply requirements for SSC construction are projected as ranging from 300 to 1,855 acre-ft/yr. Lake Butner has a current safe yield of about 10,000 acre-ft/yr and an available excess of 7,540 acre-ft/yr. Mayo Reservoir has a current safe yield of over 22,000 acre-ft/yr and an available excess of 13,800 acre-ft/yr. The total peak yearly SSC direct construction period demand is 88 acre-ft in 1992 or less than 2 percent of the available excess of either of these supply sources.

The estimated peak off-site domestic water use also occurs in 1992. For assessment purposes, it is assumed that the additional demand for water in Durham County would be met by the city of Durham's water supply reservoirs Lake Michie and the recently completed Little River Reservoir; the additional demand in Granville and Person Counties would be met by Kerr Reservoir and Lake Isaac Walton, respectively. The Little River Reservoir has a safe yield of 24,000 acre-ft/yr. Together with Lake Michie, the two reservoirs now provide Durham a combined safe yield of 47,500 acre-ft/yr and an available excess of about 21,700 acre-ft/yr. Therefore, the estimated peak domestic use in Durham County (565 acre-ft/yr) would be less than 3 percent of the excess. The current available excess from Kerr Reservoir is about 3,500 acre-ft/yr. The estimated peak domestic use increase in Granville County (110 acre-ft/yr) would be less than 4 percent of this excess. In Person County, the estimated peak domestic use increase (50 acre-ft/yr) would be less than 2 percent of the current available excess water in Lake Isaac Walton, currently about 4,700 acre-ft/yr. For all counties, the impacts from the combined effects of direct SSC construction use of water and off-site increases in domestic water use would be expected to be negligible.

The expected operations water use of the SSC facility would be 460 acre-ft/yr from Mayo Reservoir and 1,715 acre-ft/yr from Lake Butner. This is less than 4 percent of the available excess water from Mayo Reservoir, and 23 percent of the available excess of Lake Butner. These increased water use impacts are measurable and unavoidable. However, because they are well within the existing systems' capacities and available excess water, they are not considered as significant impacts.

It is assumed that, during operations, the additional demand for water in Durham County would be met by the city of Durham's water supply reservoirs Lake Michie and the Little River Reservoir; the additional demand in Granville and Person Counties would be met by Kerr Reservoir and Lake Isaac Walton, respectively. The domestic water use projected for Durham County beginning in 1996 is 415 to 550 acre-ft/yr, or up to 3 percent of the combined excess of Lake Michie and Little River Reservoir. Granville County is expected to have domestic water use increase of 80 to 105 acre-ft/yr, up to 3 percent of the currently available excess water from Kerr Reservoir. Water use in Person County during operations is projected to be 35 to 45 acre-ft/yr, or up to 1 percent of the currently available excess.

These water use increases constitute a measurable regional impact to the water supply systems of the area. However, these increases would probably not require any changes to the existing systems, unless the available excess water declines dramatically.

In Tennessee, most of the proposed water supply is surface water from a number of small to moderately-sized systems. The combined primary and secondary water use for both construction and operations represents a small percentage (generally less than 10 percent) of the total available excess supply capacity of these systems. Even if the smaller systems provide all on-site and off-site water, sufficient excess capacity exists. Therefore, the expected impacts are negligible.

At all site alternatives, localized groundwater level declines related to direct or indirect project water use and/or project construction activities, such as dewatering for groundwater flow control, are anticipated. Such declines would be in the range of a few feet to a few tens of feet, would be localized and would last only during construction. On a regional scale, groundwater level declines would be negligible at all sites during construction because of the limited water volumes required.

Operations impacts to groundwater resources would be greater at site alternatives where overdraft of groundwater resources is presently a regional issue or where proposed increased groundwater use would initiate or worsen a local overdraft condition. An increased public water supply requirement would occur for communities in the general vicinity of all the proposed site alternatives. During operations, on-site project water use would be significantly greater than during construction and an impact on local water levels and aquifer overdraft would be anticipated in Illinois, Michigan, and Texas.

At the Illinois site, the water level/overdraft impacts from indirect project water use by in-migrants and secondarily induced population growth during construction and continuing through operations would be measurable at the regional level and potentially long-term. Given the present pattern of water use in the Illinois site vicinity, it must be assumed that most of the projected increase, ranging from 125 to over 820 acre-ft/yr, would be derived from municipal groundwater pumping. Increased pumping would occur primarily from the deep sandstone or Cambrian-Ordovician aquifer. There would be a decrease in long-term groundwater availability essentially equivalent to the amount pumped from the overdrafted aquifers. The wide distribution of use suggests that water level declines near individual wells or well fields would be small and very localized. A reduction in reliance on groundwater from the deep bedrock aquifer by municipalities in the region is the only practical mitigation for the impact. Plans exist for about 30 municipalities in DuPage County to begin to import and use surface water from Lake Michigan in the 1992-2000 time frame. Other local surface water sources, such as the Fox River, may also be used to replace some amount of municipal deep groundwater use. Municipalities, especially those in the immediate SSC site vicinity, could also diversify groundwater pumpage and develop the glacial and shallow bedrock aquifers which are not overdrafted within the SSC site. This latter change would not conflict with the present and future domestic groundwater withdrawals from the shallow aquifers. Even if it is assumed that these potential mitigations do not occur in a timely manner, the impact, however, would not be significant because of the wide areal distribution of the increased groundwater use (very limited local effect). The major aquifers are already locally or regionally overdrafted and the project-related water use would be a small and very distributed increment to the existing condition.

In Michigan, water level/overdraft impacts from indirect project water use during construction and continuing through operations would be measurable at the regional level and long-term. The increased use would be distributed over a ten-county area within which recent (1984) municipal groundwater use was about 100,000 acre-ft. However, it is assumed that a significant portion of the projected use would occur in the communities of Lansing and Jackson, the two largest communities near the site. These two communities are also the only areas where localized groundwater overdraft is documented by areal declines in water levels (see Appendix 5). Increased groundwater withdrawals related to indirect project use would slightly increase any existing areal water level declines in the vicinity of any other potentially affected communities; however, data for evaluation is limited. There are no easily developed alternative supply sources or plans for development for either of the communities most affected. Consequently, it is assumed that the impact cannot be effectively mitigated within the time frame of the project. The impact would not be significant because the incremental use related to the project is very small in relation to present use in the two most affected communities (maximum of 100 to 250 acre-ft/yr versus 1984 usage of about 11,000 and 38,000 acre-ft for the Jackson and Lansing areas, respectively). Groundwater recharge in the project vicinity is estimated to be approximately 100 acre-ft/yr/mi^2.

In Texas, most of the water for both SSC construction and operations, for both on-site and indirect off-site needs, will come from surface water sources. During the SSC operations, the period of maximum water use, about 20 percent will be supplied from groundwater. This use represents slightly less than one percent of the 1985 total groundwater use in Dallas, Ellis, and Tarrant counties, the principal counties to be impacted by the water needs of the project. Nevertheless, groundwater level/ overdraft impacts from direct and indirect operations water withdrawals would be measurable at the regional level and long-term. The Woodbine and Twin Mountains aquifers are confined aquifers with relatively low transmissivities. The Woodbine and Twin Mountains aquifers are also presently overdrafted regionally as evidenced by declining water levels. Because the present overdrafting would be increased by project-related water withdrawals and because the aquifers are the major supply aquifers in the area, the impact is considered to be measurable. There is no effective mitigation for the water level/ overdraft impact. The impact is not viewed as significant since the regional overdraft condition exists and project water requirements would increase the apparent level of overdraft only slightly.

At the Arizona site, water level/overdraft impacts from direct project water withdrawals would be measurable and long-term at the regional level. The total projected on-site water use for operations would be derived from a well field in northern Vekol Valley. The required withdrawals are equivalent to a continuous pumping rate of 1,350 gal/min or 450 gal/min/well if three wells are used. This level of pumping should result in long-term drawdowns of several tens of feet at distances of approximately 1 mi from the wells. One well used for watering livestock in the BLM South Vekol Allotment would be in the affected area.

Overdrafting of the groundwater basin may be indicated because annual total withdrawals (SSC and other users) of 2,225 acre-ft would exceed the estimated annual recharge (1,200 acre-ft) to the northern Vekol

Valley groundwater basin. Estimated annual recharge values are approximate and the difference between 1,200 acre-ft/yr and 2,200 acre-ft/yr may not be sufficient to promote regional water level declines. It is estimated that from 2 to 3.1 million acre-ft of groundwater is in storage in the northern Vekol Valley groundwater basin, and if pumpage were to exceed recharge by 1,000 acre-ft/yr for the life of the project, only 30,000 acre-ft of groundwater would be withdrawn from storage in Vekol Valley. This represents less than 1 percent of the groundwater in storage. Although the State of Arizona has historically allowed overdrafting of groundwater basins and will continue to allow overdrafting until the year 2025, the impact of groundwater withdrawals for operations water use in Arizona would be measurable. The impact is not viewed as significant since the SSC water requirements would be less than 1 percent of the groundwater in storage.

A potential mitigation for water level and overdraft impacts is importation and use of CAP water for all or a portion of operations industrial water requirements. This would result, however, in other impacts from pipeline construction and limiting other uses of CAP water.

Only a negligible impact is projected in Colorado, North Carolina, and Tennessee because of limited competition for the available groundwater resources or a very limited project groundwater use or purchase of existing use rather than additional groundwater development.

5.1.3 Air Quality

The assessment of air quality impacts in the DEIS was intended as a worst-case analysis. This resulted in the DEIS evaluation that there would be some violations of ambient air quality standards (AAQS). These projected violations were raised as a major concern by commenters on the DEIS. The DOE is committed to complying with all AAQS in the construction and operations of the SSC. Therefore, the Final EIS (FEIS) analysis has been revised to include more efficient mitigation measures to bring the emissions from the SSC within standards. The FEIS also discusses the availability of additional mitigation measures that are available to the DOE to further reduce emissions. Additional changes in the FEIS resulted from comments received on the DEIS and further refinements in analyses.

SSC impacts on air quality were assessed through: 1) identification of air pollutant emissions associated with SSC preconstruction, construction, and operations, 2) quantification of the emissions, 3) determination of the location of the emissions, and 4) a quantitative comparison between the emissions estimates and the ambient conditions. Standard emission control equipment and methods are included. Ground-level concentrations are determined from established air dispersion modeling techniques, added to background concentrations, and compared to the National or State Ambient Air Quality Standards (AAQS).

Construction and operations of the SSC would result in increased emissions of total suspended particulates (TSP), fine particulate matter having an equivalent aerodynamic diameter of 10 microns or less (PM_{10}), oxides of nitrogen (NO_x), carbon monoxide (CO), hydrocarbons (HC), and sulfur dioxide (SO_2). Other conventional air pollutants such as ozone would not be directly emitted. Additional background information on air quality is provided in Appendix 8. Assessments associated with airborne emissions of radiological, hazardous, or toxic materials are discussed in Section 5.1.6.

The several individual facilities that comprise the SSC were evaluated for regional impacts as one source and for local impacts as individual sources, i.e., each service area. While the SSC encompasses a 53-mi ring and has several surface facilities, it does not qualify as a major source of air pollutants under Prevention of Significant Deterioration (PSD) programs. As discussed with the air quality regulatory agencies within each of the seven states, and supported by a review of their regulations, no PSD permit would be needed for the SSC project, nor would it be subject to Part D New Source Review (NSR) for major sources. General NSR would apply (40 CFR 51.160-164).

While a PSD permit would not be required, the substantial emissions during SSC construction may affect the host State's management of its Clean Air Act program. For example, construction emissions, other than from mobile sources, would count against allowable increases (i.e., consume "PSD increment" if these emissions significantly impact a baseline area). An exclusion from increment consumption may be available for TSP from construction activities upon written request to the EPA administrator. EPA is expected to promulgate final rules for a PSD program for NO_x by Fall late 1988 (proposed rules 53 FR 3698, February 8, 1988). This program may require that NO_2 from mobile sources also consume PSD increment.

5.1.3.1 <u>SSC Pollutant Emissions</u>

A. <u>Preconstruction</u>

The limited on-site activities of preconstruction (including land surveying for design and acquisition purposes, borehole drilling for geotechnical investigations, and environmental surveys) would temporarily emit very small amounts of pollutants. These emissions, including those associated with vehicles to transport the equipment and workers, are much less than for construction and, in general, would be completed prior to construction. Resultant impacts to the ambient air quality, even locally, would be negligible.

B. <u>Construction</u>

During construction, air pollutant emissions would be associated with construction equipment used for tunneling, spoils handling, building, and road and infrastructure development.

The emission estimates developed are categorized in two ways: 1) the exhaust pipe emissions resulting from the combustion of fuels in the various types of construction equipment and commuter traffic; and 2) the dust emissions resulting from earth and rock handling activities and traffic over unpaved and paved construction sites and roads. Because of the size of the project, construction activities would be spread out over a large area and are not contiguous throughout the whole 53-mi ring.

Total emissions were calculated for each location subactivity such as the collider ring construction, campus construction, or injector construction, and were based on an estimate of numbers, use and types of equipment, fuel requirements, spoils generation rates, etc. Because the construction of the SSC would cover a 6- to 7-yr period, a ratio of peak year activity to total activity was determined for each identified activity on the project construction schedule (see Appendix 1). The peak year emissions were then summed, producing a worst-case peak year emission rate. Actual peak year emissions would be less because the peak year for each activity would not coincide.

Table 5.1.3-1 compares the construction emissions inventories occurring in the potential host counties for the seven sites. On an absolute basis, the pollutant emissions would be significant when compared to the limits in the PSD regulations (40 CFR 52.21). It should be noted, however, that when calculating emission levels that would trigger the requirement for PSD permits, neither exhaust pipe emissions from mobile construction equipment or commuter traffic are included. The state air pollution control agency responsible for managing PSD increments would have to consider these emissions. The differences among the emission inventories for the seven sites are due largely to the following:

- The injector area at the Illinois site is already available (Fermilab).
- The Arizona site includes 11 percent of the collider ring as cut-and-cover construction; all other sites propose a 100 percent tunneled collider ring.
- The amount of off-site road development varies and is highest in Colorado.
- Commute distances for construction workers vary.
- Local factors affecting dust generation, such as wind speed, surface soil silt content, rain days per year, surface soil moisture, and volume of spoils generated, differ on a site-specific basis.

Table 5.1.3-1 also compares the SSC construction emissions to those currently existing in counties (Chapter 4) potentially hosting the SSC. The increases in Table 5.1.3-1 are considered negligible because of their low values and temporary nature.

Table 5.1.3-1

COMPARISON OF CONSTRUCTION EMISSIONS TO EXISTING CONDITIONS IN POTENTIAL HOST AREAS

Pollutant	AZ Emission Rate Ton/pk-yr[1]	AZ Relative[2,3] Increase %	CO Emission Rate Ton/pk-yr[1]	CO Relative Increase %	IL Emission Rate Ton/pk-yr[1]	IL Relative Increase %	MI Emission Rate Ton/pk-yr[1]	MI Relative Increase %	NC Emission Rate Ton/pk-yr[1]	NC Relative Increase %	TN Emission Rate Ton/pk-yr[1]	TN Relative Increase %	TX Emission Rate Ton/pk-yr[1]	TX Relative Increase %
CO	1,240	0.5	1,260	1.2	600	0.3	640	0.5	750	1.3	720	1.5	710	2.9
HC	120	0.1	130	0.5	70	0.1	70	0.2	80	0.4	80	0.3	80	1.4
NO_x	770	0.8	620	1.2	410	1.2	490	2.2	480	0.6	450	4.2	520	1.9
SO_2	80	0.5	60	0.2	40	0.8	50	0.3	50	<0.1	50	1.2	50	0.4
TSP	1,160	0.4	1,330	1.2	660	2.0	640	1.8	730	2.8	790	3.3	720	3.1

1. Ton/peak-yr rounded to tens of tons
2. Relative increase over existing emissions in potential host counties
3. Rounded to one significant digit

Table 5.1.3-2

COMPARISON OF OPERATION EMISSIONS TO EXISTING CONDITIONS IN POTENTIAL HOST AREAS

Pollutant	AZ Emission Rate[1] ton/yr	AZ Relative Increase[2] %	CO Emission Rate ton/yr	CO Relative Increase %	IL Emission Rate ton/yr	IL Relative Increase %	MI Emission Rate ton/yr	MI Relative Increase %	NC Emission Rate ton/yr	NC Relative Increase %	TN Emission Rate ton/yr	TN Relative Increase %	TX Emission Rate ton/yr	TX Relative Increase %
CO	510	0.19	560	0.55	210	0.12	160	0.14	250	0.45	250	0.51	210	0.84
HC	40	0.04	50	0.17	20	0.03	10	0.04	20	0.10	20	0.08	20	0.23
NO_x	60	0.06	70	0.14	40	0.10	30	0.13	30	0.04	30	0.30	30	0.10
SO_2	<1	<0.01	<1	<0.01	<1	<0.02	<1	<0.01	<1	<0.01	<1	<0.03	<1	<0.01
TSP	350	0.12	370	0.33	140	0.41	110	0.30	170	0.65	70	0.29	140	0.61

1. Rounded to nearest ton
2. Rounded to two significant digits

C. Operations

During SSC operations, conventional air pollutant emissions would be relatively small (less than 20 ton/yr), comparable to typical small commercial or light industrial sources. For most operations, no conventional air pollutant emissions would result. One minor source would be the combustion of natural gas for heating purposes. Emissions from this operation are included in Table 5.1.3-2. These emissions would be spread out in at least 12 different buildings in the campus/injector area. Differences among states would result from climate. It is estimated that over 3,000 people would work at the SSC. The exhaust pipe emissions resulting from their commute traffic in the potential host counties are also included in Table 5.1.3-2.

The SSC conceptual design includes five emergency diesel-fired electric generators rated at 100 kW each and 22 generators rated at 50 kW each, resulting in a total project capacity of 1,600 kW. Nonemergency use of these generators is expected to consist of 1 hour of operation every 2 weeks to demonstrate readiness. Other sources of emissions at the site would include painting operations, the particulate matter associated with cooling tower drift loss, solvent evaporation from hand wipe operations in the vehicle maintenance and machine shops, laboratory fume hood vents, sawdust emissions from the carpentry shop, and fugitive hydrocarbon emissions from the cryogenics plants spaced approximately every 5 mi around the ring.

The emissions points would be provided with the required air pollution control equipment. Each of these sources would constitute a small increment compared to the construction emissions (and to the emissions already occurring in most of the seven sites). In aggregate, they would be below the levels requiring a PSD permit.

Also presented in Table 5.1.3-2 are comparisons of the emissions relative to the existing inventories in the host counties as estimated by the EPA.

5.1.3.2 Impact on Ambient Air Quality

Estimates of the downwind pollutant concentrations resulting from emissions inventories were made using atmospheric dispersion models such as those provided by the EPA in its Users Network for Applied Modeling of Air Pollution (UNAMAP) package. As suggested in EPA's Guidelines on Air Quality Models (revised) (EPA 450/2-78-27R, U.S. Department of Energy 1986) the UNAMAP's Industrial Source Complex (ISC) model and site-specific meteorological data (U.S. Department of Commerce 1988) were used in the analysis. In addition, the construction emissions inventories were used to estimate the worst reasonably foreseeable ground-level pollutant concentrations outside of the SSC property. These would be temporary and would cease when construction concluded.

There are no major sources of air pollution associated with preconstruction activities. Because the SSC does not have any large traditional sources that would generate air pollutant emissions, contributions of pollutants during operations would be negligible as shown in Table 5.1.3-2.

Dispersion of air pollutants is highly dependent on the distance between the source and the receptor. This is particularly true for near ground-level emissions associated with construction. An analysis of the emission inventory identified two areas where the potential impacts to the public were highest: the campus/injector area, primarily because of the large amount of construction activity; and the satellite E and F sites, because of the short distances between the source and the nearest possible member of the public. The highest off-site pollutant concentrations would occur during tunnel construction at the sites where there is no property buffer, i.e., the satellite E and F sites.

Table 5.1.3-3 summarizes the worst reasonably foreseeable or maximum off-site pollutant concentrations during the temporary construction period. They all occur near the property line, at satellite E and F sites, and decrease rapidly with distance downwind. Several states appear to exceed the 8-hour CO standard. This is because the background values were measured in large metropolitan centers and are not representative of the SSC site in each case. The values were used because they were the only data available. SSC-related emissions of CO are not expected to cause or to significantly worsen exceedances of CO standards.

One state, Arizona, appears to exceed the annual TSP standard. This is also because of high background data, in this case collected in 1978. Current monitoring data - not used in this EIS because 12 months worth are not yet available - indicate that the Arizona site will comply with this annual standard.

The value of 150 $\mu g/m^3$ 24-hour average for TSP is exceeded in North Carolina where it is a primary standard and in Colorado, Illinois, Michigan and Tennessee where it is a secondary standard. In Colorado and Illinois this is also the result of high background levels which quite possibly can be reevaluated with respect to the EPA fugitive dust policy in rural areas which allows the exclusion of infrequent high dust level days under the general philosophy that they were due to natural causes or were a unique occurrence such as a farmer plowing a field.

For the other three states, background data used were from metropolitan centers rather than from the rural sites. In addition to the possibility of developing better background values as discussed above, the analysis itself can be fine-tuned. The assumptions used to develop the emissions inventory and to run the model, coupled with the limited design and construction planning information available and the conservatively high fugitive dust emission factors used, ensure that this was an upper bound analysis. A more detailed, in-depth analysis, which can

Table 5.1.3-3

WORST REASONABLY FORESEEABLE AMBIENT AIR CONCENTRATIONS RESULTING FROM SSC CONSTRUCTION

Pollutant/Avg. Time	National or State AAQS[1]	AZ	CO	IL	MI	NC	TN	TX
		Background plus SSC impact[1] (Values for SSC contribution are in parentheses)[2]						
CO - 1 h	40,000	14,810 (1,058)	3,460 (1,168)	9,475 (1,175)	24,876[4] (1,176)	27,144[4] (1,144)	18,119[4] (1,119)	12,280 (1,170)
CO - 8 h	10,000	7,743 (867)	1,616 (470)	6,193 (793)	11,348[4] (948)	15,958[4] (958)	12,681[4] (681)	9,202 (842)
NO_x - Annual	100	91 (76)	37 (33)	47 (21)	76 (42)	71 (43)	80 (31)	60 (32)
SO_2 - 24 h	365	71 (38)	44 (23)	199 (31)	137 (38)	136 (46)	140 (29)	87 (37)
SO_2 - Annual	80	10 (8)	7 (4)	10 (2)	20 (5)	20 (5)	35 (3)	12 (4)
TSP - 24 h	260[5]	149 (58)	207[6] (47)	194[6] (64)	159[6] (52)	155[6] (74)	156[6] (66)	130 (75)
Annual	75[7]	83[6] (13)	64[6] (8)	51 (5)	51 (6)	55 (8)	52 (8)	39 (7)
PM_{10} - Annual	50	>9	>5	>3	>5	>5	>5	>4

1 All values are in micrograms/m^3
2 Receptor location 150 m downwind from E or F site.
3 Greater than (>) indicates that only the SSC impact is presented because background PM_{10} data is not available.
4 The Michigan, North Carolina, and Tennessee sites are administratively considered to be in attainment for CO. The background data used are from the Detroit, Durham, and Nashville metropolitan areas. In all likelihood, the SSC project is not expected to cause the carbon monoxide NAAQS to be exceeded at any site.
5 North Carolina observes 150 µg/m^3 for this standard. All others use this value as a secondary standard.
6 Exceedence is result of high background not characteristic of SSC site.
7 All states use 60 µg/m^3 as secondary standard.

only be performed once the site is selected and more design and construction planning information is available, will produce lower values that should show compliance.

An analysis of this type would be done after site selection in the Supplemental EIS or in preparation of the state construction permit application.

Traffic emissions were not explicitly modeled because their large spatial distribution would tend to disperse pollutants. Proposed SSC sites in Illinois, Michigan, and Tennessee are within regions that are designated as nonattainment for ozone. After site selection, the State agency responsible and/or the regional EPA office will be consulted to determine whether offsets are required for any nonattainment pollutants.

Standard industrial practice for the control of fugitive dust, such as watering and chemical soils stabilizers was assumed during the construction phase emissions inventory. For activities at any E and F areas having residences in very close proximity, identified possible mitigations include: wind screens, enclosures, construction scheduling, add-on dust removal equipment, etc. Possible mitigations for control of fugitive dust emissions from spoils disposal areas include the use of soil stabilizing agents in inactive areas and water sprays in active areas. These mitigations could be considered on a case-by-case basis during the detailed construction planning stage of the project if necessary. All or combinations of these mitigations would be considered during detailed design to further reduce the off-site ground-level concentrations.

5.1.4 Noise and Vibration

5.1.4.1 Noise Impacts

Noise, simply defined as unwanted sound, has the potential to produce significant adverse environmental impacts. Adverse impacts are realized through both high human annoyance and general noise environment degradation (increases in the ambient noise level). Section 5.1.4-1 discusses the projected noise environmental degradation and ambient sound level increases that would be perceived by people at the site alternatives. The assessments performed and the numerical results developed are described in greater detail in Appendix 9.

A. Definition of Impacts

Impacts due to increased noise levels require definition in terms of duration, intensity, and type of impact. Terms used in this analysis are operationally defined below. A comparison of noise levels from common sources is provided for general reference in Table 5.1.4-1.

Table 5.1.4-1

SOUND LEVELS OF SEVERAL MECHANICAL DEVICES

		dBA*	
LETHAL		-180-	
		-175-	
		-170-	
		-165-	
		-160-	
		-155-	
		-150-	
		-145-	
	Sonic Boom	-140-	
		-135-	
THRESHOLD OF PAIN			
		-130-	
	Jet Takeoff at 200 ft	-125-	
		-120-	
		-115-	Discotheque
PHYSICAL DISCOMFORT	Motorcycle at 20 ft	-110-	
	Dump Truck	-108-	Jackhammer (Peak)
		-105-	Power Mower
		-104-	Loader
		-100-	
	Freight Train at 50 ft	-95-	Newspaper Press
	Propeller Plane Fly-Over at 1,000 ft	-90-	Food Blender
		-85-	Electric Mixer
	Freeway Traffic at 50 ft	-80-	Washing Machine; Alarm Clock; Garbage Disposal; Electric Can Opener
		-75-	Office with Tabulating Machines
	Average Traffic at 100 ft	-70-	Vacuum Cleaner; Portable Fan
		-65-	Electric Typewriter at 10 ft
		-60-	Dishwasher Rinse at 10 ft; Air Conditioning Unit
		-55-	
		-50-	Normal Conversation at 12 ft
	Light Traffic at 100 ft	-45-	Refrigerator
		-40-	
		-35-	Library
		-30-	
		-25-	
		-20-	Motion Picture Studio
		-15-	
		-10-	Leaves Rustling
		-5-	
THRESHOLD OF HEARING			
		-0-	

*The unit of sound is the decibel (dB). The level of sound is typically measured using a sound meter, the A-scale, which corresponds closely to the way the human ear perceives sound. Therefore, the sound level for noise evaluations is frequently expressed in dBA.

1. Duration

Short-term impacts are projected temporary or transient effects of the proposed project caused by construction activities. Long-term impacts are projected effects of the proposed project which would occur during the operations phase.

2. Intensity and Type of Impact

Noise produced by project activities might produce two related impacts.

The first type of impact would be the response of people to increased noise levels and can be quantified as a percentage of those affected who would be highly annoyed by the increased noise level. This measure (percent of people highly annoyed) is a single indicator of the general adverse reaction of people to noise. High annoyance arises as a consequence of activity interference and interruption caused by noise; and as such, effectively summarizes noise impacts on humans. High annoyance has also been correlated by a large set of data which allows response, expressed as a percentage of population highly annoyed, to be characterized as a function of the day-night average sound level (L_{dn}), which is the dominant noise measure used in this assessment. Guidelines for Noise Impact Analysis (U.S. EPA 1982) recommends that the relationship shown in Table 5.1.4-2 be used for correlating the percentage of those highly annoyed with the resultant day-night average noise level.

High annoyance, as a function of day-night average sound level, was developed from surveys of community reaction to (primarily) aircraft noise, as well as some traffic and railroad noise in urban areas (US EPA, 1982). The degree of high annoyance produced by a given day-night average sound level in rural areas would be expected to be different from the high annoyance produced in urban areas. Therefore, although the percentage of humans highly annoyed by project noise is calculated as a function of distance, the population measure of the noise impact is expressed in terms of numbers of people exposed to a given day-night average sound level.

The second type of impact is general degradation of the noise environment which occurs both in the presence of and the absence of humans. Noise environmental degradation results from destruction of tranquility in wilderness areas to which urban dwellers go to escape city noise; or because the area is made unsuitable for future residential or other human development. In each of these cases, the quality of the environment is lowered (U.S. Environmental Protection Agency 1982).

Noise impacts are assessed in terms of quantification of the degree of noise level increase. In this assessment, general noise environment degradation is addressed in areas that experience an increase of 1) greater than 10 dBA, 2) between 3 and 10 dBA, and 3) less than 3 dBA.

Table 5.1.4-2

HIGH ANNOYANCE vs DAY-NIGHT AVERAGE SOUND LEVEL

Day-Night Average Sound Level (L_{dn})	Percentage of Those Highly Annoyed
40	0
45	0
50	2.3
55	4.6
60	8.7
65	15.2
70	24.5
75	36.9

Source: U.S. Environmental Protection Agency 1982.

Since sound levels add up logarithmically, adding a 40-dBA noise source to a 40-dBA background would result in a new noise level of 43 dBA, which represents a 3-dBA increase over the background level. However, adding a 40-dBA noise source to a 50-dBA background would not produce a noise level increase.

B. Noise Impact Assessments

Schools, residences, groups of residences, parks, camps, and wildlife refuges at each of the proposed sites are plotted on Figures 5.1.4-1 through 5.1.4-7. These figures were compiled from USGS quadrangles, aerial photographs, photos taken during site visits, and from information provided by site proposer groups. In general, this information yielded the number of houses located within certain levels of noise impact. The number of houses expected to be impacted by construction and operations at service and intermediate access areas is provided in Tables 5.1.4-3 through 5.1.4-9. The number of people in these households is estimated by using current census data of average occupancy per household (US Bureau of the Census 1988). Numbers of people expected to be impacted by construction and operations at service and intermediate access areas is provided in Table 5.1.4-10.

1. Construction

Noise would be generated by vehicle traffic, heavy-equipment operations, compressors, and road construction. The large spatial distribution of the noise sources would produce separate impacts from several sources, but no cumulative impacts from project activities as a whole.

A. Service/Intermediate Access Areas

During the construction phase, activities at service areas F and intermediate access areas E would have the greatest likelihood of causing noise impacts. Since these areas would be relatively small, they would have the greatest potential to be located close to residences and other sensitive locations. Furthermore, tunnel boring at each of these areas would be 24 h/d for 10 mo. The analysis presented in Appendix 9 indicates that noise levels at these sites would be expected to reach a day-night average sound level (L_{dn}) of 70 dBA at 630 ft from the center of a construction site and 60 dBA within 2,000 ft of the center of a construction site. Noise contours from the day and night construction scenarios are shown in Figures 5.1.4-8 and 5.1.4-9.

Impacts as a result of this noise would take two forms: high human annoyance and general degradation of the noise environment. Approximately 9 percent of those people living within 2,000 ft of the center of an E or F site, and 25 percent of those living within 630 ft of the center of an E or F site would be highly annoyed by the construction

Table 5.1.4-3

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
ARIZONA SSC SITE

Facility	Number of Houses Receiving: Greater than 70 dBA L_{dn}*	Number of Houses Receiving: Between 60 and 70 dBA L_{dn}**
E1	0	0
F1	0	0
E2	0	0
F2	0	0
E3	0	0
F3	0	0
E4	0	0
F4	0	0
E5	0	0
F5	0	0
E6	0	0
F6	0	0
E7	0	0
F7	0	0
E8	0	0
F8	0	0
E9	0	0
F9	0	0
E10	0	0
F10	0	0
Total	0	0

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-4

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
COLORADO SSC SITE

Facility	Number of Houses Receiving: Greater than 70 dBA L_{dn}*	Number of Houses Receiving: Between 60 and 70 dBA L_{dn}**
E1	0	0
F1	0	0
E2	0	0
F2	0	0
E3	1	0
F3	1	1
E4	0	0
F4	0	0
E5	0	0
F5	0	0
E6	0	0
F6	0	0
E7	0	0
F7	0	0
E8	0	0
F8	0	0
E9	0	0
F9	0	0
E10	0	0
F10	0	0
Total	2	1

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-5

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
ILLINOIS SSC SITE

Facility	Number of Houses Receiving: Greater than 70 dBA L_{dn}*	Number of Houses Receiving: Between 60 and 70 dBA L_{dn}**
E1	2	8
F1	1	12
E2	2	45
F2	0	191
E3	0	1
F3	1	2
E4	0	3
F4	0	8
E5	1	2
F5	0	27
E6	0	5
F6	2	9
E7	3	6
F7	12	38
E8	6	10
F8	1	18
E9	8	66
F9	0	1
E10	4	6
F10	0	0
Total	43	458

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-6

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
MICHIGAN SSC SITE

Facility	Number of Houses Receiving: Greater than 70 dBA L_{dn}*	Number of Houses Receiving: Between 60 and 70 dBA L_{dn}**
E1	0	0
F1	2	10
E2	0	4
F2	0	21
E3	1	9
F3	1	16
E4	0	12
F4	1	3
E5	0	6
F5	0	2
E6	0	12
F6	0	2
E7	0	5
F7	1	3
E8	4	14
F8	0	4
E9	4	8
F9	2	12
E10	5	7
F10	1	1
Total	22	151

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-7

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
NORTH CAROLINA SSC SITE

	Number of Houses Receiving	
Facility	Greater than 70 dBA L_{dn}*	Between 60 and 70 dBA L_{dn}**
E1	0	1
F1	1	18
E2	7	18
F2	2	13
E3	0	7
F3	3	27
E4	1	20
F4	10	38
E5	0	15
F5	1	4
E6	4	7
F6	0	7
E7	2	7
F7	4	18
E8	14	20
F8	1	12
E9	1	10
F9	1	8
E10	0	0
F10	0	0
Total	52	250

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-8

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
TENNESSEE SSC SITE

	Number of Houses Receiving	
Facility	Greater than 70 dBA L_{dn}*	Between 60 and 70 dBA L_{dn}**
E1	0	16
F1	0	3
E2	0	4
F2	3	6
E3	4	6
F3	2	6
E4	0	3
F4	1	3
E5	4	5
F5	0	3
E6	0	1
F6	0	1
E7	0	5
F7	0	0
E8	3	47
F8	0	8
E9	0	14
F9	1	8
E10	1	11
F10	2	6
Total	21	156

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

Table 5.1.4-9

ESTIMATED POPULATION DISTRIBUTION
CONSTRUCTION PHASE
E AND F AREAS
TEXAS SSC SITE

	Number of Houses Receiving	
Facility	Greater than 70 dBA L_{dn}*	Between 60 and 70 dBA L_{dn}**
E1	0	0
F1	0	8
E2	1	5
F2	1	4
E3	0	0
F3	3	4
E4	0	5
F4	0	3
E5	0	5
F5	0	0
E6	0	6
F6	0	3
E7	0	16
F7	0	8
E8	0	0
F8	0	3
E9	0	13
F9	0	3
E10	1	10
F10	3	7
Total	9	103

*Within 630 ft of the center of an E or F Area.
**Within 2,000 ft of the center of an E or F Area.

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Table 5.1.4-10

ESTIMATED POPULATION DISTRIBUTION AT E AND F AREAS

	Number of People[1] Receiving:		
	>70 dBA L_{dn} During Construction[2]	60-70 dBA L_{dn} During Construction[3]	55-60 dBA L_{dn} During Operations[4]
Arizona	0	0	0
Colorado	5	3	3
Illinois	454	1,246	45
Michigan	62	408	24
North Carolina	136	705	60
Tennessee	55	832	24
Texas	25	314	19

1. Number of people calculated by multiplying number of houses times the average occupancy value listed below (US Bureau of the Census 1988) and then adding people in schools, churches, etc.

State	People/Household
CO	2.57
IL	2.66
MI	2.70
NC	2.62
TN	2.63
TX	2.76

2. Within 630 ft of the center of an E or F area.
3. Within 2,000 ft of the center of an E or F area.
4. Within 700 ft of the center of an F area.

Figure 5.1.4-1

RESIDENCES AND SCHOOLS
ARIZONA SSC SITE

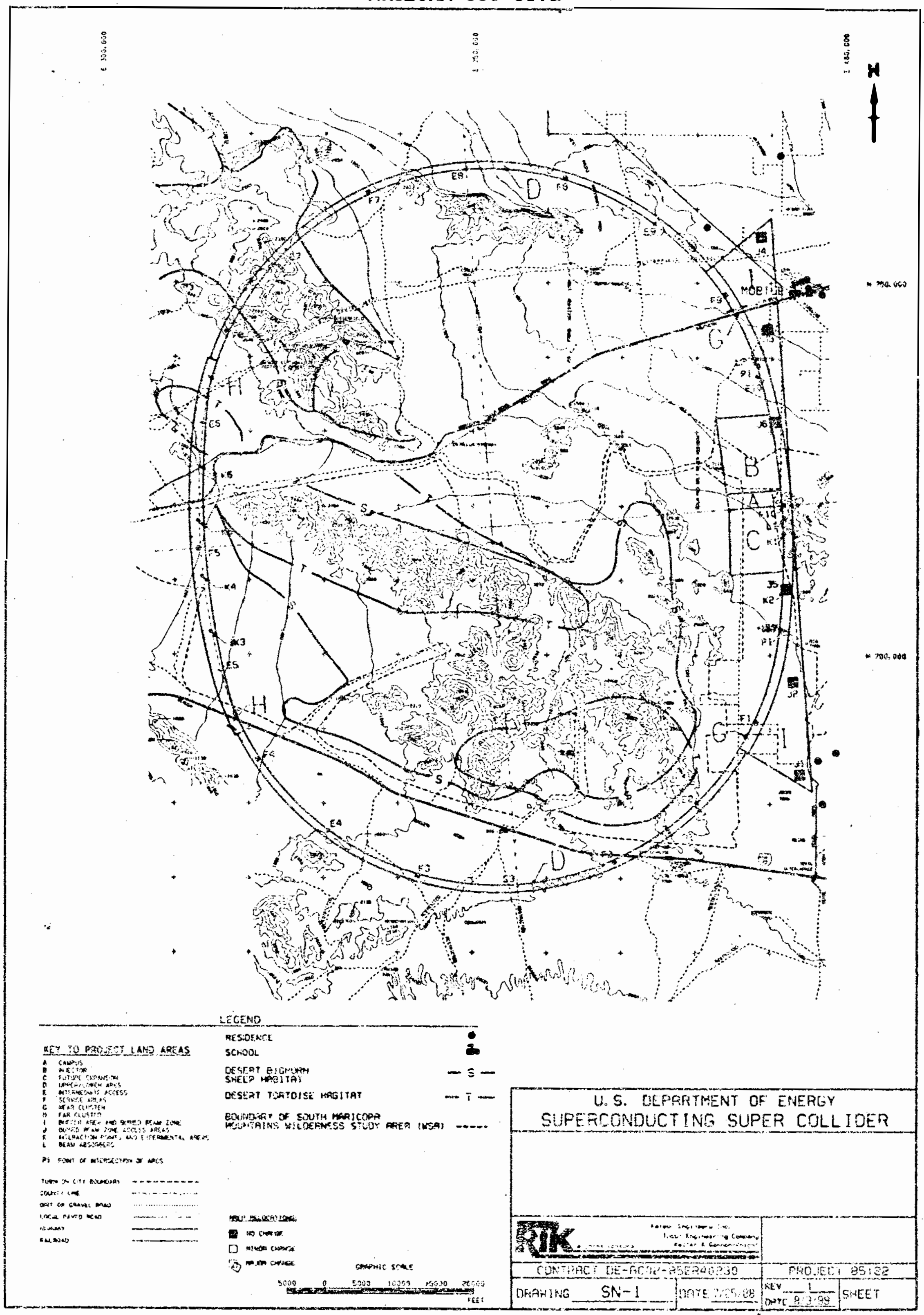


Figure 5.1.4-2

RESIDENCES
COLORADO SSC SITE

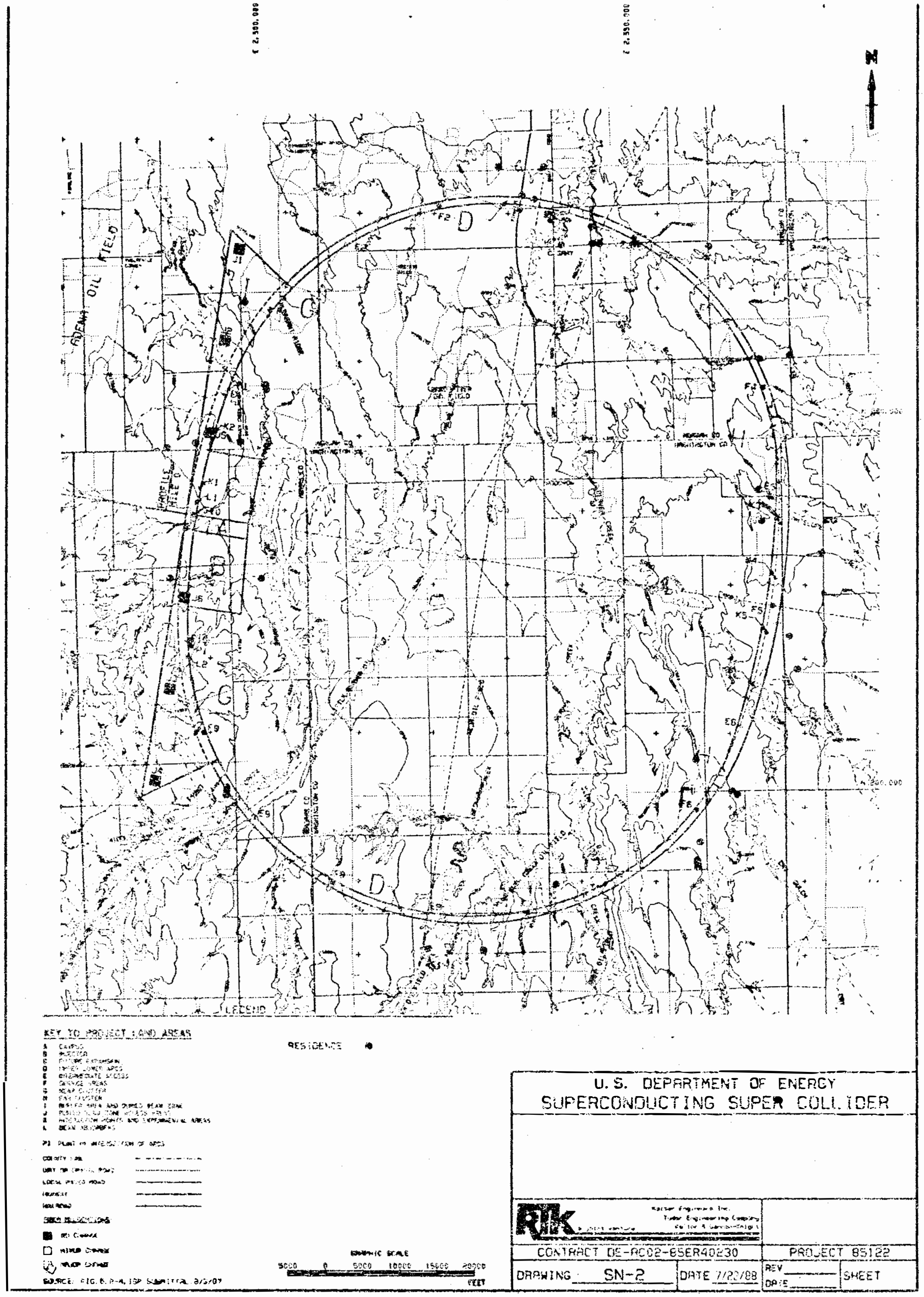


Figure 5.1.4-3

RESIDENCES AND SCHOOLS
ILLINOIS SSC SITE

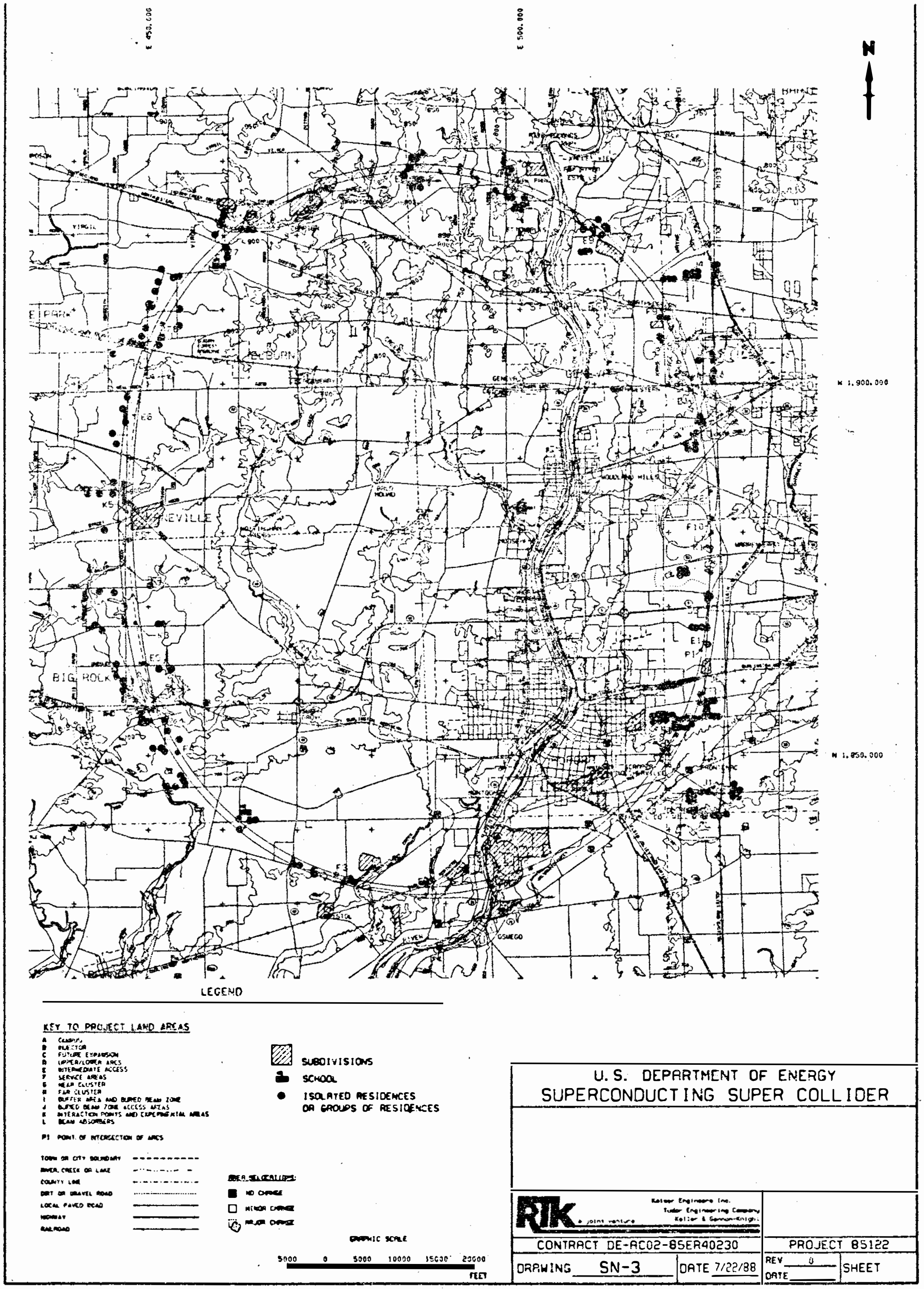


Figure 5.1.4-4

RESIDENCES
MICHIGAN SSC SITE

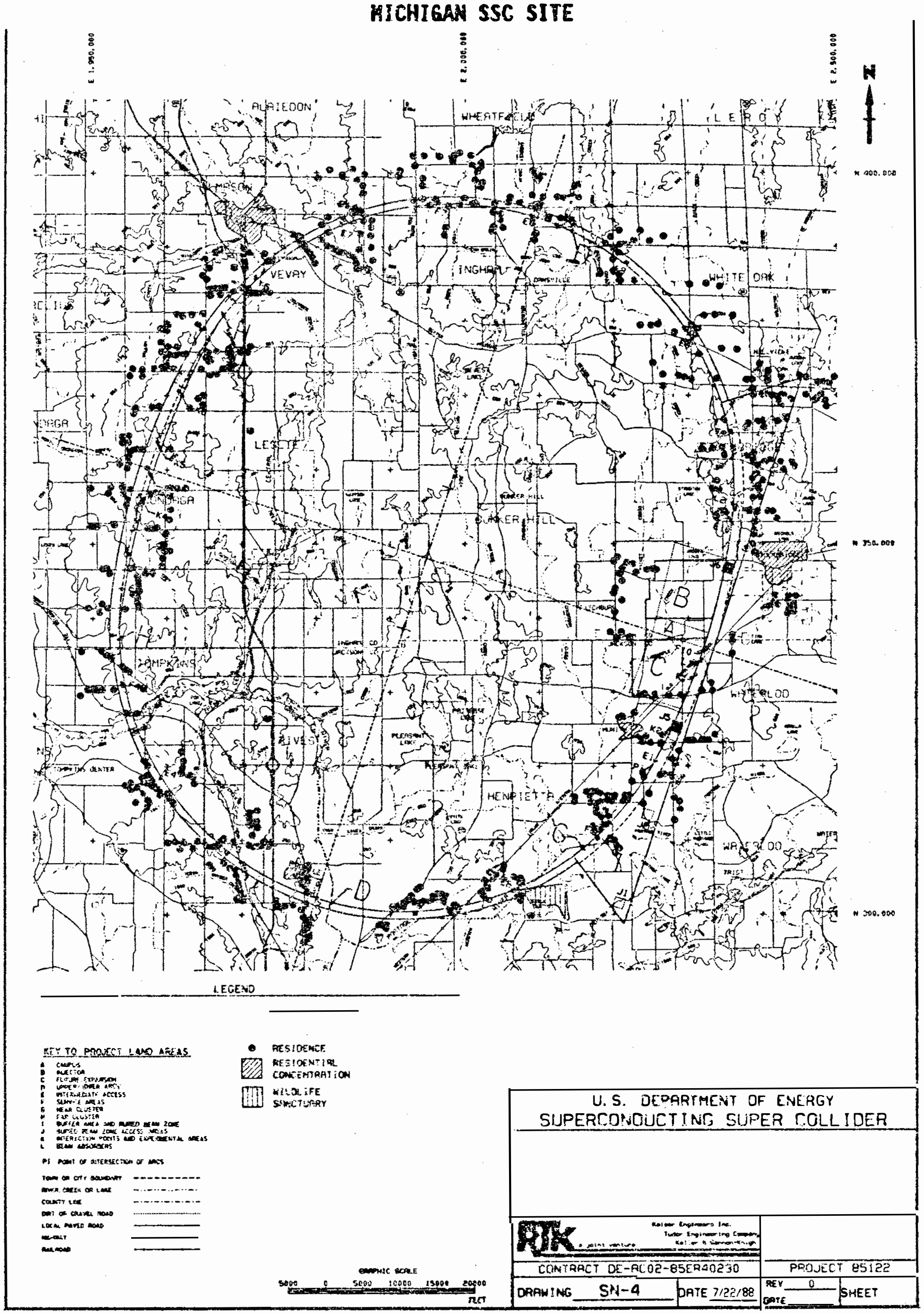


Figure 5.1.4-5

RESIDENCES
NORTH CAROLINA SSC SITE

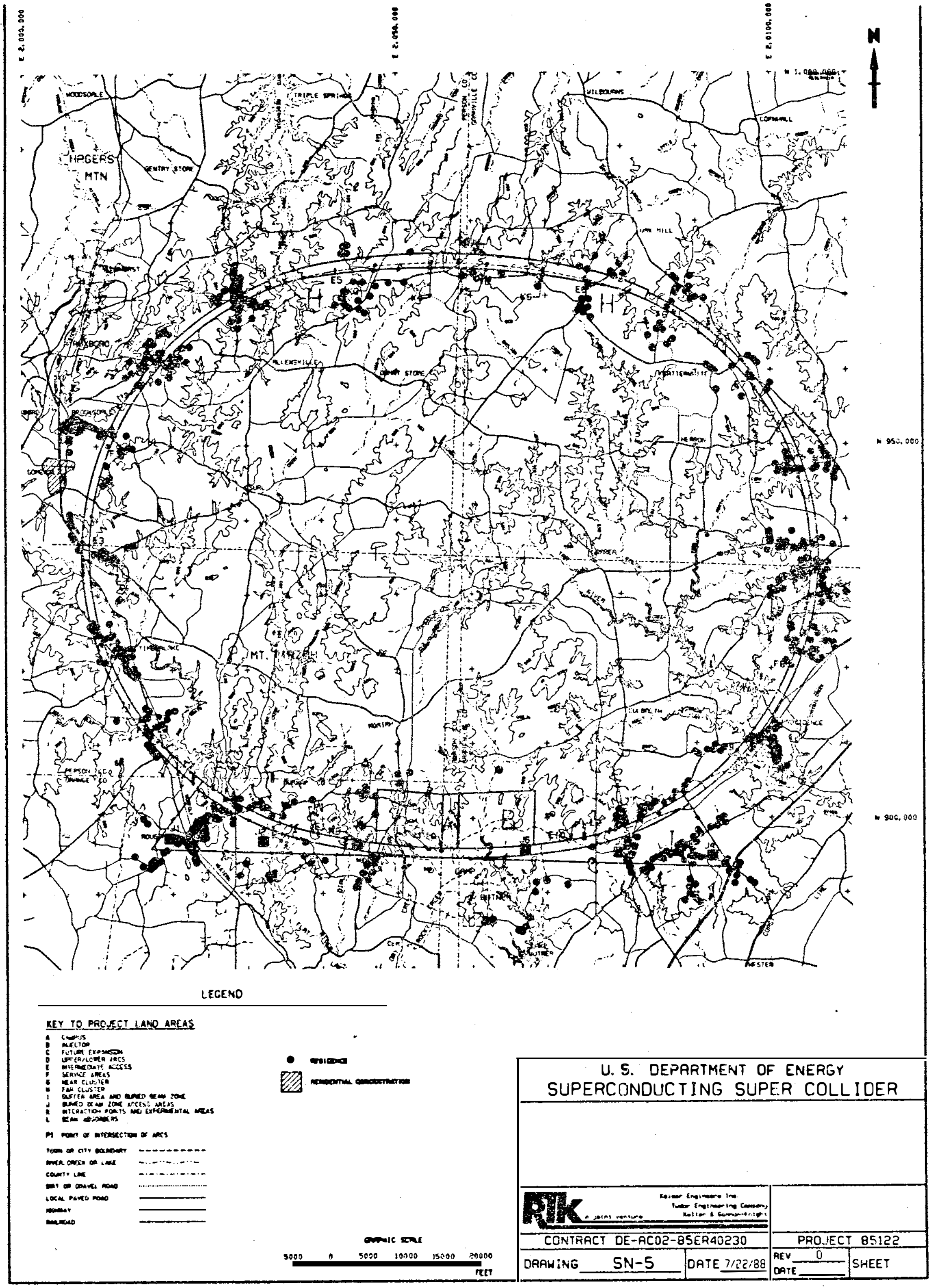


Figure 5.1.4-6

RESIDENCES
TENNESSEE SSC SITE

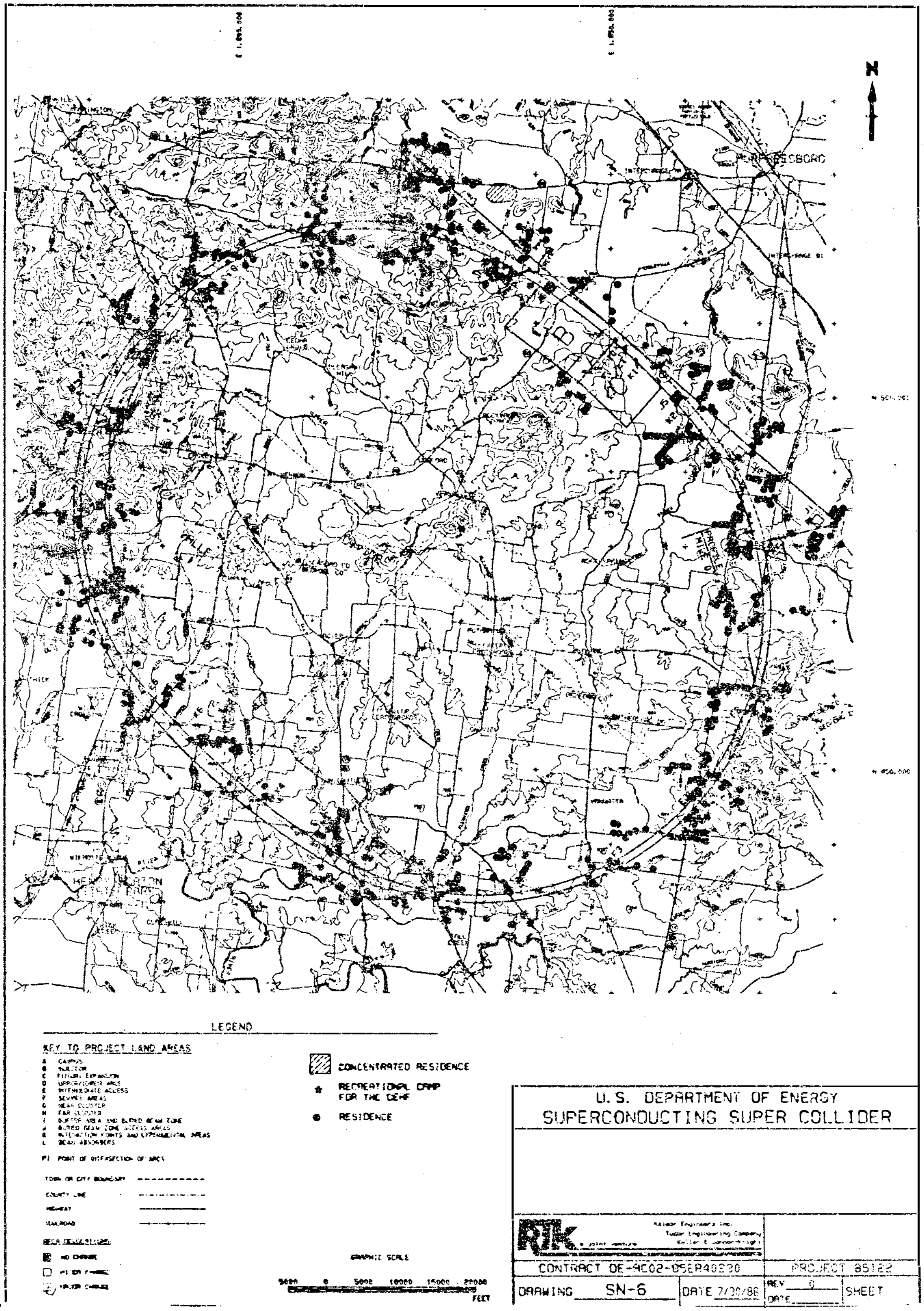


Figure 5.1.4-7

RESIDENCES AND SCHOOLS
TEXAS SSC SITE

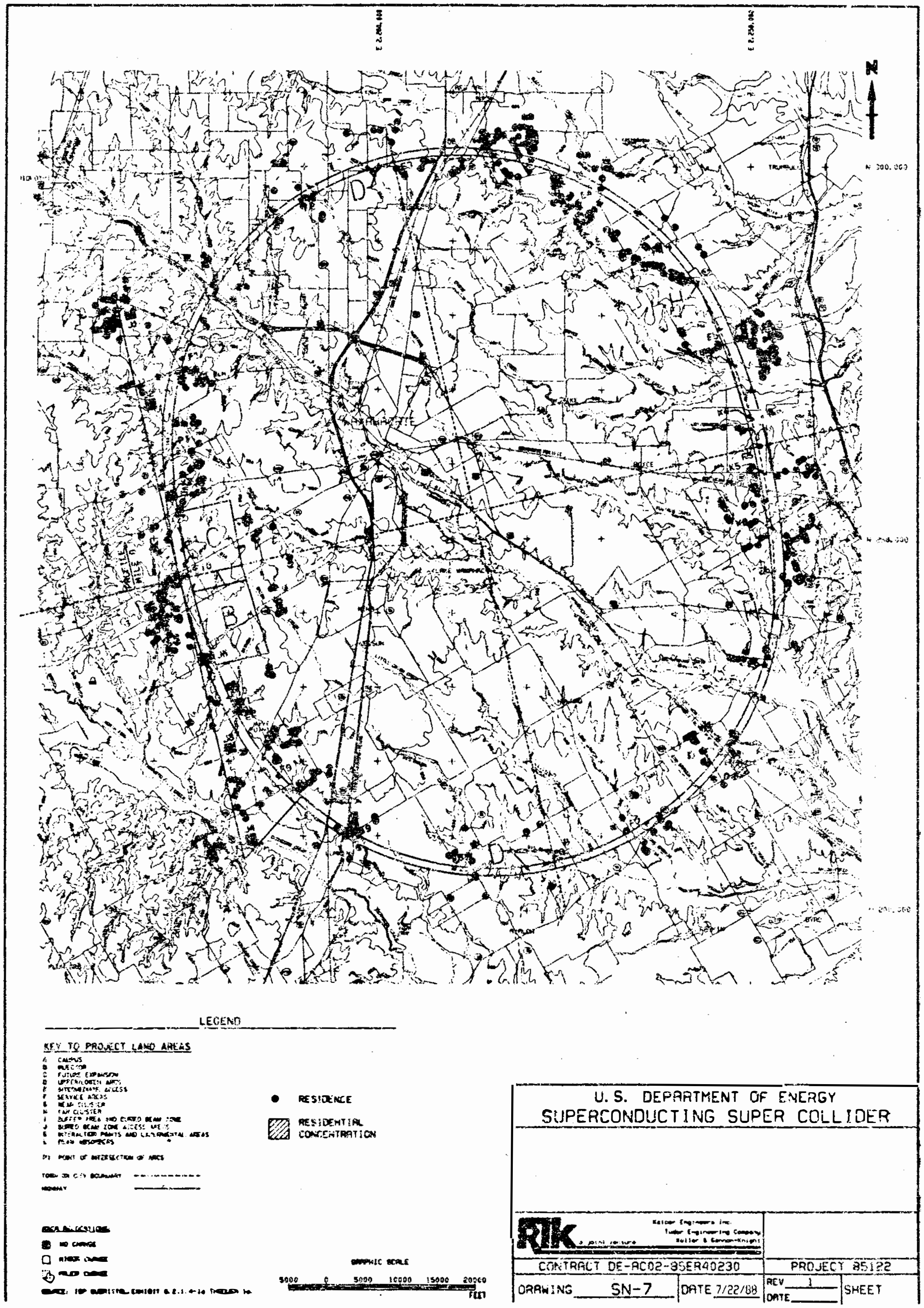
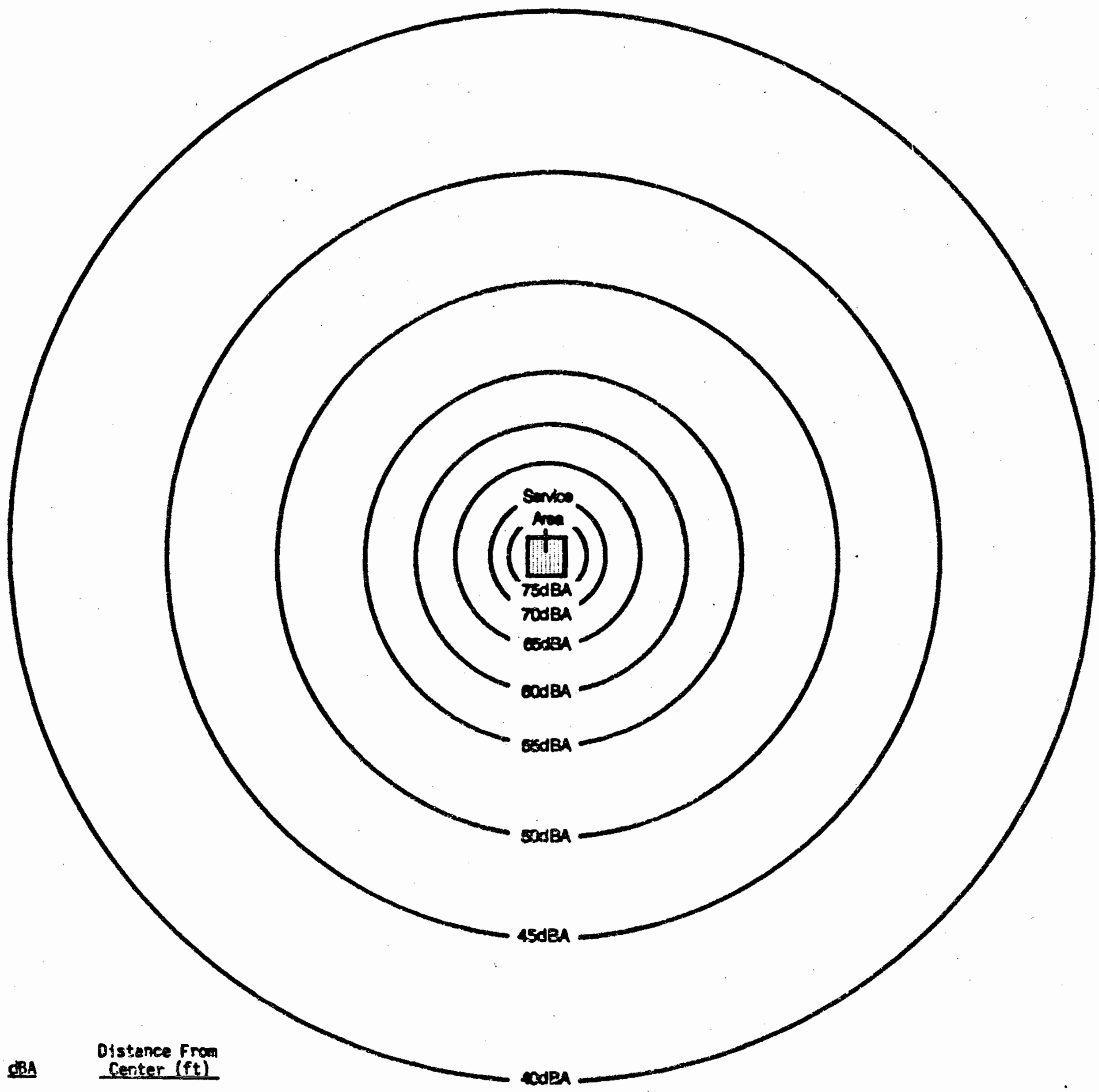


Figure 5.1.4-8

CONSTANT SOUND LEVEL CONTOURS
SERVICE/INTERMEDIATE ACCESS AREA
CONSTRUCTION PHASE - DAYTIME

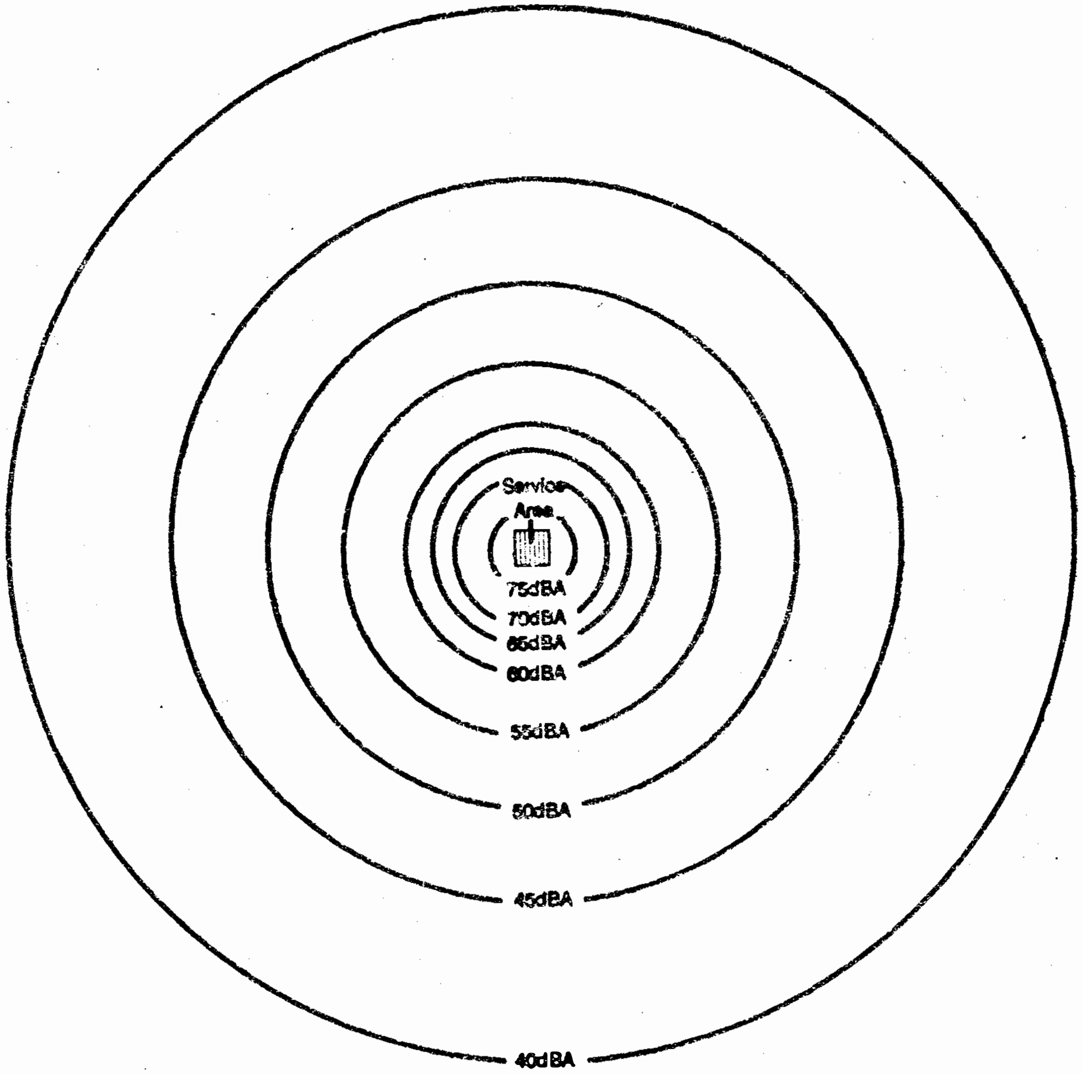


dBA	Distance From Center (ft)
75	250
70	750
65	1,100
60	1,750
55	2,400
50	3,600
45	4,900
40	6,600

1"=2000'

Figure 5.1.4-9

CONSTANT SOUND LEVEL CONTOURS SERVICE/INTERMEDIATE ACCESS AREA CONSTRUCTION PHASE - NIGHTTIME



dBA	Distance From Center (ft)
75	500
70	900
65	1,100
60	1,400
55	2,100
50	2,900
45	4,000
40	5,800

1" = 2000'

noise. Table 5.1.4-3 is a tabulation of the number of people living near E and F areas at each of the site alternatives who would experience sound levels in the stated ranges.

The background level in the vicinity or F area would also realize an increase during construction. This increase would depend on the preproject background level. The sites with the lower preproject background levels would realize increases for greater distances than the sites with the higher preproject background levels. Areas in Arizona, Colorado, North Carolina, Tennessee, and Texas fall into the first category; Illinois and Michigan, the second. For areas with a 40 dBA preproject background (Arizona, Colorado, North Carolina, Tennessee, and Texas), the increase in the background would be greater than 10 dBA for areas closer than 3,600 ft to the center of a service or intermediate access area, and between 3 and 10 dBA for areas between 6,600 ft and 3,600 ft of the center of a service or intermediate access area. For areas with a 50-dBA preproject background (Illinois and Michigan), the increase in the background would be greater than 10 dBA for areas closer than 1,750 ft to the center of a service or intermediate access area; and between 3 and 10 dBA for areas between 3,600 ft and 1,750 ft to the center of a service or intermediate access area.

To mitigate the impact of noise generated by construction activities at E and F areas, spoils loading activities would be restricted at the shaft area to 12 h/d (7 a.m. to 7 p.m.). Additional mitigations that would be considered at the time of detailed design to reduce annoyance to residents living near an E or F area would include berming or acoustically fencing the site perimeter, placing maintenance activities inside acoustically treated sheds, and relocating/reorienting the E and F areas and facilities. Additional mitigation techniques which would be considered during construction planning could include the following:

- The use of quieted construction equipment and use of atmospheric sounding techniques to avoid loud sounds, such as blasting, when conditions are conducive to atmospheric focussing of sound.

- Providing monetary grants to educational institutions for the purpose of noise control upgrading of existing classroom structures or structures proven to be in the planning stage at the time of the SSC request for proposal.

These mitigations could be utilized at selected locations at all sites.

B. Near Cluster/Far Cluster

Construction of facilities (other than E and F areas) at the near and far cluster would also cause noise impacts, but not to the same extent as at the E and F areas. Because of the larger project land areas at these locations, residents would be separated from project construction by greater distances, and few, if any, residents would likely be highly annoyed by construction at these locations. Construction of the campus, injector, and interaction halls was assumed to be on a 16-h/d basis, which would preclude impacts on residents close to these facilities at night.

C. Cut-and-Cover Tunnels

Noise produced by cut-and-cover construction of the collider ring, which is anticipated in Arizona only, would resemble that during new road construction. As discussed below, road construction would produce an estimated maximum hourly average sound level $L_{eq}(h)$ of 94 dBA at 50 ft. Activity for any specific section of the cut-and-cover construction would occur on a 16-h/d basis for 1.5 mo.

The noise due to cut-and-cover construction is calculated to be greater than 50 dBA for 1.5 mi away from a construction location. The number of humans highly annoyed would be low due to the extremely low population density.

D. Road Construction

New road construction and road upgrading, which would be required in varying amounts at all proposed sites, would produce an estimated worst-case, instantaneous sound level of 94 dBA at 50 ft. Road construction noise would be produced during normal daytime working hours only.

As was the case for cut-and-cover tunneling, the noise is calculated to be greater than 50 dBA for 1.5 mi away from a construction location. Humans located close to road construction sites would be highly annoyed by the activity but would not experience nighttime sleep disturbance.

E. Spoils Hauling

Noise produced by spoils hauling activities would reach an estimated instantaneous sound level of 88 dBA at 50 ft. In comparing spoils haul truck noise to passenger vehicle noise, a spoils haul truck produces noise which would measure approximately 82 dBA at 100 ft, which is approximately equal to freeway traffic noise at 50 ft. Spoils hauling activities are expected to take place during normal working hours (7 a.m. to 7 p.m.) only. Spoils hauling to support tunnel boring is expected to last approximately 5 months at each E or F site.

Impacts to the background sound level would be limited to the period spoils haul trucks use a specific road or route. Noise produced by a spoils haul truck is calculated to be greater than 50 dBA for 4,000 ft away from a haul route. Humans located close to haul routes would be annoyed by the activity, but would not experience nighttime sleep disturbance.

Mitigations that could reduce the degree of impact of spoils hauling include specifying routes that avoid residential concentration and enforced truck muffler maintenance.

2. <u>Operations</u>

A. <u>Service Areas/Intermediate Access Areas</u>

The service areas F would operate 24 h/d, 365 d/yr. The service areas that would liquify helium for cooling the superconducting magnets might be located close to locations where people live and work. Projected noise at a service area is estimated to reach an average day-night sound level (L_{dn}) of 59 dBA at the property line, and 55 dBA at 450 ft from the property line. The only routine noise source at intermediate access areas E would be a quiet tunnel ventilation fan. The fan would not be expected to be audible at points outside the intermediate access area.

Projected impacts to the background sound level during service area operations would be long-term. For areas with a 40 dBA preproject background, the increase is calculated to be greater than 10 dBA for areas located within 1,000 ft of a service area boundary, and between 3 and 10 dBA for areas located between 2,000 and 1,000 ft of a service area boundary. For areas with a 50-dBA preproject background, the increase is calculated to be greater than 10 dBA for areas within 150 ft of a service area property line, and between 3 and 10 dBA for areas located 1,000 ft and 150 ft of a service area boundary. Approximately 5 percent of the people living within 450 ft of a service area property line would be highly annoyed by the noise. These impacts are shown for the site alternatives in Table 5.1.4-3.

Analysis of the noise impacts was based on the assumption of certain standard industrial practices. The cooling tower was assumed to be of a quiet design. The emergency power generator was assumed to be enclosed in a shed. The cryogenic compressors were assumed to be individually enclosed. The pipeline that would connect the compressor building to the refrigeration building was assumed to be in a sound-attenuating trench. Nitrogen relief valves were assumed to be equipped with silencers.

Mitigative measures that would be considered to further reduce service area operations noise impacts include depressing the service area below grade, berming or acoustically fencing the service area perimeter, and rearranging the site so that the loudest noise sources would be centrally located. Additional mitigation techniques which would also be considered during detail design could include the following:

- o Inclusion of state-of-the-art noise control materials and techniques in the design of machinery buildings and equipment enclosures.

- o Require contractors responsible for design to use verified and validated sound-emission models to identify equipment that would represent a potential noise impact if not subjected to special quieting techniques.

- o Require designers and contractors to specify available quiet machinery and components in conjunction with the results of the modeling described above.

- o Enforce negative incentives for vendors of service area systems and components, with price penalties for vendors who fail to provide equipment which meets, and continues to meet, DOE system design requirements for sound emission limits.

Regulations or codes that would be applicable to operations phase noise emissions are discussed in Appendix 5. The service area noise emissions could be mitigated to comply with all regulations or codes discussed.

B. Near Cluster/Far Cluster

Major noise sources at the near and far clusters during operations would not include any single noise source louder than the service area. Air separation plants (one at each of the near and far clusters), shops, emergency power generator testing, and cooling towers would be the major noise sources. These sources were assumed to be treated with the same design or control measures as those described for the helium liquefaction facilities at the service areas. Impacts to the preproject background sound level past the property line are expected to be less than 3 dBA. Few, if any, humans would be highly annoyed by the noise produced by activities at the near and far clusters. The larger land areas would attenuate the noise levels at the boundaries to ambient or near-ambient pre-SSC levels. Mitigation measures that could be considered include berming or acoustically fencing the noise-producing activity or relocating or rearranging the noise-producing facility.

5.1.4.2 Vibration (Blasting) Impacts

Ground vibrations and airblast overpressures (noises) would result from explosives used to aid excavation of shafts, starter tunnels, injection enclosures, and interaction halls. In certain cases, explosives would also be used for construction of roads and utilities. The potential for environmental impacts from blasting is primarily limited to damage to structures. The blasting impacts assessment is described in greater detail in Appendix 9. Table 5.1.4-4 summarizes the impacts discussed below for the seven site alternatives.

A. Source Terms and Expected Impacts

1. Ground Vibrations

The best indicator of the intensity of ground vibrations is the peak particle velocity (PPV), which is a measure of how fast the ground moves. A PPV of 2 in/s has been found to be safe for poor plaster, which is the component in structures most sensitive to ground vibrations (Rose 1981). Several states and agencies have established regulations limiting PPVs to 2 in/s at public and private buildings. The measured PPV at a given location has been correlated with the pounds of explosives set off at any given time. For a 35-lb charge-weight-per-delay (the maximum value anticipated for SSC construction), the PPV will be less than 2 in/s for any structure located more than 360 ft away from the location of the explosion (E.I. duPont 1980). If any structures are located within the 360-ft sphere of influence, the charge-weight-per-delay will be reduced.

It has been observed that the average person can easily feel a motion that is on the order of 1/100 to 1/1000 of that needed to cause damage to his/her home, and would consider the motion "severe" at about 1/5 to 1/10 of that level. In actual practice, human response to ground vibration is increased when sound effects accompany the motion and the motion is of short duration. (Noise generated by airblast overpressures is addressed in the next subsection.) People located within a radius of 600 ft of a blast location would feel vibrations from a 35-lb charge-weight-per-delay explosion and would consider the vibration severe even though no structural damage would take place.

The duration of blasting activities at any location because of SSC construction is expected to range from 3 to 6 months, with one to three blasts per day.

As noted above, blasting would take place at the interaction points K, and at service F and intermediate access E areas for shaft excavation. At all K areas, the only structures within 600 ft of a blast location would be contractor offices, warehouses, shops, and contractor personnel. All proposed sites (except Arizona and Colorado), however, have numerous farms, homes, subdivisions, and industrial buildings located within the 600-ft sphere of influence near E and F areas, whose occupants would notice blasting and would consider it severe.

To mitigate structural damage from blasting, the PPV would be monitored during construction using seismographs, and blasting charge-weight-per-delay values would be adjusted to keep the PPV's below the levels that might cause damage.

Table 5.1.4-11

BLASTING IMPACTS

Specific Area of Impact	Phase	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Service/Intermed. Access Areas	Constr	No	No	Yes	Yes	Yes	Yes	Yes
Interaction Points/Injector	Constr	No	No	Yes	No	No	No	Yes
Roads	Constr	None	None	None	None	None	Yes	None

Yes - Structures within 600 ft of blasting locations
No - No known structures within 600 ft of blasting location
None - No blasting is expected during road construction at these sites

2. Airblast Overpressures

The airblast overpressure produced is a function of the quantity of explosives detonated and the depth to which the explosive is buried. Even a small quantity of explosive can generate a very high overpressure if the explosive is exposed at the ground surface. However, a very large quantity of explosives, if deeply buried, would generate small blast overpressures. Research indicates that overblast pressures on the order of 0.001 to 0.01 lb/in² (111 to 131 dBL) would not cause damage to structures (E.I. duPont 1980). The instantaneous sound level associated with a blast would be audible for long distances but would be of very short duration.

The principal mitigation of air blast overpressure impacts is the reduction of charge-weight-per-delay, especially when blasting is near the surface. Another mitigation that could minimize the impact from airblast overpressures is the practice of pouring coarse sand or fine gravel into a hole (stemming) after placement of an explosive charge.

The length of the column of stemming (depth of burial) is a critical factor in reducing the overpressure generated by a blast. It is anticipated that airblast overpressure would be monitored during construction and charge-weight-per-delay values adjusted to keep overpressures below the levels that cause damage to nearby structures.

3. Expected Impacts

Blasting impacts at the proposed sites are summarized in Table 5.1.4-4. The presence of structures is indicated; the number and type of structures at each proposed site within the 600-ft range has not been determined. All impacts would be short-term and mitigable.

5.1.5 Ecological Resources

The assessment of ecological impacts involves the identification of unavoidable changes in one or more of the following areas: 1) destruction or displacement of habitats or species; 2) changes in species diversity or composition; 3) revised or altered successional trends; 4) changes in occurrence of disease vectors and pest species; 5) increased rates of degradation of environmental quality; and 6) exposure of sensitive organisms or processes to environmental stresses of hazardous chemicals, radiation, noise, vibration, or dust.

The discussion of ecologically related impacts on each site alternative is presented in the following sections: sensitive communities and habitats; threatened and endangered species; wetland assessment; and commercially, recreationally, or culturally important species.

5.1.5.1 Sensitive Terrestrial/Aquatic Communities

A. Preconstruction

Impacts from preconstruction activities include site access for biotic surveys, where needed, and use of survey instruments and site confirmation activities, including test boreholes. The disturbance would be temporary and is considered negligible for all proposed sites. Special precautions would be required to minimize impacts of preconstruction exploration in sensitive areas such as wetlands, aquatic environments, and karst areas.

B. Construction

Most of the discussion below is related to the ground-disturbing activity from construction. However, after completion of ground-disturbing construction activity, ecological systems would recolonize and restabilize into a more managed natural system, and operations would not lead to additional impacts except for noise from the service areas. Operations noise will be referenced in the discussion below as it applies. (The impacts of continuing noise from service areas are discussed in Sections 5.1.5.2 and 5.1.5.4.)

1. Arizona

Construction of the SSC in Arizona would require the removal of a number of acres of Sonoran desert scrub communities of both the Arizona Upland and Lower Colorado types, as discussed below. All of these communities are widespread in southern Arizona. Impacts to wildlife in addition to habitat removal would be the increased presence of humans in previously remote wilderness study areas. No aquatic or wetland ecosystems are present within the vicinity of the proposed SSC site.

The area that would be disturbed by cut-and-cover or other construction activities is estimated at about 2,155 acres. This includes permanently and temporarily disturbed lands. If spoils disposal were to occur on site approximately 640 additional acres would be disturbed. Of those 2,155 acres, approximately 1,222 acres would require reclamation. Natural desertscaping and native plants would be used and where possible, recovered topsoil would be reapplied to the surface. Reclamation could be enhanced by use of fertilizers and spraying of blue-green algae that normally form crusts on desert soils. These algae would enhance nitrogen availability and allow more rapid development of desert shrub species.

The Sonoran desert plant communities are sensitive to the disturbance of the surface soil. Recolonization can take decades following disturbances from land clearing and offroad vehicle passage. Although these communities are abundant in southern Arizona, careful design and continuing surveillance can minimize the impact and accelerate the process of reclaiming the natural areas.

The State of Arizona Native Plant Law regulates the collection of many plant species in Arizona, including all cacti. Under the State law, major construction projects, such as the SSC, are allowed to remove included species, but require coordination with State officials. Mitigation of impacts to these species could include transplanting to areas not scheduled for site disturbance or to the campus area for landscaping purposes.

Several sensitive animal populations are found in the Arizona SSC site vicinity. These include Federal and state threatened and endangered or rare species discussed in Section 5.1.5.2 (desert tortoise, Gila monster, and desert bighorn sheep). This section also addresses sensitive native plants.

2. Colorado

The predominant vegetation type in the area of the proposed SSC site in Colorado is nonirrigated farmland, primarily, dryland wheat. The remainder is rangeland. Both the terrestrial and aquatic resources of this area of Colorado are under extensive management, and the impacts to native species/populations would result primarily from altered management strategies, land use patterns, and resource requirements. Riparian habitat conservation and/or restoration, both along the ring and in construction of the required access road, would be a key to minimization of impacts.

Approximately 3,395 acres would be disturbed (temporarily or permanently) for on-site construction. Of this disturbed land, 2,068 acres would be temporarily disturbed and would need to be reclaimed.

Because the predominant vegetation type in the area of the proposed Colorado site is farmland, natural plant communities are limited. The most sensitive habitat is the riparian woodland. However, riparian woodland does not occur within the immediate areas where surface facilities are proposed.

Wintering and migrating areas for the pronghorn antelope include the short grass prairie habitat on the proposed site adjacent to area C and also J5, K2, and E1. Some of this habitat would be lost if these surface facilities were built. The Colorado Division of Wildlife has identified wintering areas and migration corridors in the northwest quadrant of the ring.

The proposed project area lies within the Central Flyway, used in the spring and fall by a large number of sensitive migratory waterfowl. The major aquatic habitat supporting the Flyway in the vicinity is the South Platte river basin. Although some aquatic habitat may be on site it is limited in size and is not likely to support these species.

Barr Lake is west of the proposed site, but provides a habitat for a nesting pair of bald eagles that could be disturbed by the new access highway proposed by the State. The eagle population is under study by the U.S. Fish & Wildlife Service.

While no definitive surveys have been conducted, it appears that none of the three state-listed plant species known for that general habitat type are present in areas of the ring where surface disturbance would occur during construction. These species include the Colorado butterfly plant, which is also a Federal candidate species (C1), streaked ragweed, also a Federal C2 species, and showy prairie gentian. Additional discussions will be conducted with the State, and surveys will be conducted, as necessary, to assure mitigation in the final placement of facilities after the SSC site is selected.

3. Illinois

The Illinois site presents a mix of urban, suburban, high-quality farmlands, wetlands, other natural areas, and Federal research facilities. Little or no unmanaged land is present in the vicinity of the ring.

Approximately 494 acres would be disturbed during construction. Approximately 267 acres of this disturbance would be temporary and would be reclaimed. Native plants would be used, and some of these areas could potentially be used in the prairie restoration project.

The variety of natural areas are present in the vicinity of the proposed SSC site include wetlands, woodlands, prairies, savannas, bogs, fens, and other unusual or rare habitats. The State reports that most of these sites are along rivers, primarily the Fox River, or along railroads, in cemeteries, or on property owned and managed by educational institutions. Much of the forest land in northeastern Illinois lies along river margins or in forest preserves and other public lands. These areas are highly valued for recreation and provide important babitats for many species and are avoided by project placement. These areas are: 1) Spring Lake Nature Preserve in the vicinity of Fermilab, 2) West Chicago Prairie, 3) Elburn Forest Preserve, and 4) Ferson's Creek Sedge Meadow. The actual location and quality of these habitats have been avoided in the placement of the SSC. These areas, along with wetlands in the region, host more than 90 state-protected species. The presence of most of these species within the immediate ring area is unlikely, but some may be present and would be evaluated during preconstruction activities. Hardwood forested lands occur within the proposed fee simple boundaries. These forests are not expected to be impacted. However, they represent approximately 1 to 2 percent of the available forest in the region.

Approximately 7 prairie remnants are listed in the 16 township study areas reviewed by the State. Most of these areas are within nature preserves, and most are sufficiently far from anticipated construction sites along the ring to preclude direct impact. Several are, however, sufficiently close that attention must be taken to prevent or minimize unnecessary impacts. The largest designated "natural" area is the 675-acre prairie reconstruction project within the existing ring at Fermilab. The ongoing activities at recreating prairie and savanna habitats on previously heavily cultivated lands is beginning its second decade.

4. Michigan

The proposed SSC site in Michigan presents a collage of Grand River basin agricultural lands intermixed with small parcels of forest, wetlands, lakes, and streams. Construction of the SSC would displace some of these resources. Mitigation of wetland impacts during final design in consultation with the State of Michigan and other Federal agencies would be key to the final impacts of SSC construction in Michigan. Consideration is given below to the potential impacts of construction on the large number of nesting birds in the vicinity of the site. The discussion below is confined to impacts resulting from construction activities. Approximately 1,080 acres will be disturbed. The disturbance of about 678 of the acres would be temporary and those acres would be reclaimed. Native forbs and grasses would be used for reclamation except in areas where wetlands reclamation may be needed (see Section 4.7.6).

Several sensitive plant and animal communities are located near the fee simple area of the campus and near cluster. These communities are currently protected as part of the Waterloo Recreation Area and the Haehnle Wildlife Sanctuaries. Operations noise from the nearby E and F areas and adjacent J1 and J2 areas is not expected to impact the Waterloo Recreation Area or the Haehnle Sanctuary. While some noise increase could be detected, the levels would be near ambient (50 dBA). Noise at these levels would be expected to have no effect on the sandhill crane, which uses the Haehnle Sanctuary as a major migratory staging area. There are also several breeding pairs of sandhill cranes.

Sensitive communities that are present at the recreation area in the vicinity of the SSC include sphagnum bogs, a dry/mesic southern forest community north of Bartig Lake, and an unusual wetland bog. Construction of facilities in the fee simple area (J1) would produce the greatest risks to these communities. The magnitude and nature of negative impacts are based upon worst reasonably foreseeable analysis, because information about the nature and quality of these sensitive communities are not available, and details of plans for area J1 have not been finalized.

Most of the State-protected species are not presently found in the immediate site area and, therefore, are not expected to be impacted. These include the king rail, the least shrew, and kitten-tails (also a candidate for Federal listing). Two redhorse fish species and the spotted turtle are aquatic species listed by Michigan as rare, a category which requires monitoring but provides no special legal status. The two redhorse species are known to occur in the Grand River downstream of the two ring crossings. Because no construction is anticipated at surface level in these locations, no negative consequences should result. The spotted turtle, which is present in both the Waterloo Recreation Area and the Haehnle Wildlife Sanctuary, would not experience any direct impact since construction would not occur in these areas.

These areas support species of interest including the sandhill crane and great blue heron, since significant rookeries for both are present. Direct negative impacts to the species are not anticipated due to the distance to construction sites.

5. <u>North Carolina</u>

The site proposed for the SSC in North Carolina is biologically diverse and is occupied by natural and agricultural systems common to the Piedmont of North Carolina. Approximately 65 percent of the site is forested and the remainder is primarily in agricultural use. Several regionally unusual botanical resources and natural areas are present in the vicinity. Impacts discussed below are largely dependent upon final design considerations for specific facilities. Approximately 1,914 acres would be disturbed--807 of these acres would be disturbed temporarily and could be reclaimed. Native plants, such as black locust seedlings or lespedeza, could be used.

The following natural areas are discussed separately:

<u>Goshen Gabbro Forest.</u> The Goshen Gabbro Forest would not be directly impacted by construction or operations of the SSC. It is likely that some outlying populations or individuals of the unusual plant species associated with this assemblage could be lost to construction in area H or to secondary development in that vicinity. The species that appear to be at greatest risk are Indian physic, Lewis's heartleaf, and prairie dock. Each of these species is listed either as a Primary Proposed or Significantly Rare species by the North Carolina Plant Conservation and Natural Heritage Programs.

<u>Roanoke, Tar, and Neuse Rivers - Aquatic Habitat</u>. Aquatic ecosystems of the drainage basins within the site area have a potential for degradation due to ancillary facility development and runoff from SSC conditions. This area may be a significant refuge for rare and sensitive fresh water mussels, fish, and amphibians. Although the proposed SSC ring crosses under the Tar River northeast of E9, and no impacts are anticipated, downstream portions of the Tar and other rivers may be

affected by construction activities undertaken in adjacent wetlands and floodplains. Project activities would be planned to avoid sensitive aquatic habitats to the extent practicable, and the best available engineering control and mitigation measures would be implemented during construction.

Flat River Slopes Above Lake Michie. While some negative impacts of construction are inevitable on this biological community, the area is already bisected by several county roads. This habitat should be considered during preconstruction planning to minimize and/or mitigate negative impacts. With best available construction practice and proper mitigation during construction, including proper resource management plans for the fee simple area, these resources would be adequately protected.

6. Tennessee

The proposed SSC alignment in Tennessee is bisected by the divide between the Tennessee River and the Lower Cumberland River in an area of karst topography (potential for limestone sinkholes and caves). Unusual plant communities, particularly the cedar glades with their complement of endemic and remnant species, are present. As a result, a close interrelationship between surface waters, geologic features, and ecological resources exists. Exact siting of facilities would occur during final design and would determine the extent and significance of any ecological impacts. Approximately 1,489 acres would be disturbed. Of this amount, 672 acres would be temporarily disturbed and could be reclaimed. Native plants, especially black locust seedlings, could be used.

The cedar glades are a significant resource for a number of rare and threatened species. A detailed survey of their existence in areas of surface construction for the SSC would be evaluated during final design and mitigation of loss of the cedar glades considered, if needed.

The Snail Shell Cave system, with 12.7 mi of mapped passages, is the longest continuous cave in the Tennessee Central Basin. The system is a braided network of parallel streams with lateral passages with small wet-weather streams and residual pools and upper levels that act as water conduits only during flood stage (Barr, 1988).

The Snail Shell Cave system is physically isolated by shaly, noncavernous formations that preclude gene flow among many groups of obligate cave animals. The known fauna of the system include several endemics, as well as certain small, more widely distributed subterranean species. The troglobitic fauna (animals limited to caves and other subterranean microhabitats and unable to survive in surface environments) is a unique assemblage made up of endemics and more widely distributed species. The system contains three, possibly four, endemic troglobites: the blind cave salamander, the cave snail, the Trechine cave beetle, and possibly the cave millipede (Barr, 1988).

Should Tennessee be selected for the SSC, extensive surface and subsurface exploration would be done for the final siting of the SSC facilities. These geotechnical activities should identify both surface and subsurface karst features. Final placement of critical surface and subsurface facilities will take into consideration the potential for both construction and operational impacts to the cave system. As the collider ring will be placed well below the confining layer of the Snail Shell System (i.e., below the Pierce Confining Layer), no impacts are expected from tunneling. However, impacts to the cave system are possible from the construction of access shafts, borings, and surface facilities. Sensitive cave organisms may be adversely affected downstream by degradation of water quality.

Standard mitigation activities would be augmented by additional mitigation techniques specific to karst topography in order to reduce or eliminate the potential for subsurface contamination of cave systems by suspended particulates, sewage, petroleum products, trash, and additional volumes of water.

The Tennessee site proposal mentions Scales Mountain as an ecologically significant, large (more than 1,000 acres) forested area located in proximity to fee simple areas near the campus region G and I. Because complete information on natural habitats at this site is not available, worst-case analysis is assumed, and consultation with the State of Tennessee would continue.

The Duck River is a regionally important aquatic habitat and sport fishing resource. While not in the immediate area of construction, a number of its tributaries are crossed by the ring, including all far cluster construction, F4, E4, F3, and E3. The Hellbender and copper-cheek darter (status review species) and Birdwing pearly mussel and Cumberland monkeyface pearly mussel (listed species) are reported seen in the Duck River, several tributaries of which drain the far cluster and adjacent area (F4 and E4). Close control of surface runoff and sedimentation during construction should prevent significant impact to this resource. The Cumberland Plateau escarpment east of the proposed ring is a significant raptor migration corridor. The bald eagle and sandhill crane also use this route. The SSC construction and operation should not negatively impact the use of this route by these species. Two Tennessee-listed threatened species, Bewick's wren and the grasshopper sparrow, are rarely found in the project area although they are known to breed in the area.

7. Texas

The majority of the proposed SSC Texas site is occupied by grasslands and croplands. No remnants of the native Blackland prairie grasslands are known to occur in the immediate vicinity of the SSC. Many remaining native plants and most wildlife, as well as migratory species in the area, are dependent on riparian areas. Although many of these riparian areas are degraded by livestock use, their importance remains. Mitigation or avoidance of impacts to riparian communities during final design would be key to the significance of ecological impacts of construction of the SSC in Texas. Approximately 1,687 acres will be disturbed by construction. About 690 acres of this disturbance is temporary and would require reclamation. Native grasses and legumes would be used.

The USFWS identified two potentially important/sensitive habitats located at sites J4 and F6 of the proposed Texas site. Following a visit of site F6, the USFWS determined that surface disturbance would not likely cause significant terrestrial losses. Erosion control would be assured during construction so that water quality of Bardwell Reservoir would not be affected (see Appendix 11, Attachment A).

Detailed investigation of site J4 confirmed the quality of the habitat. Siting in this area would result in significant impacts to stream, riparian (wetland), and floodplain habitats. The USFWS noted that surface and subsurface facilities are proposed to straddle a stream and a diverse riparian corridor. The USFWS states that this area represents the highest quality habitat in the project area. The permanent stream, Chambers Creek, supports a diverse fishery, including largemouth bass, white bass, channel catfish, and numerous sunfish and minnows. Although flows become low during droughty periods, there are sufficient deep pools to provide quality habitat year round. Siting of the facility would disrupt the normal and required fish migration along Chambers Creek and thus reduce spawning. Siting of surface facilities in this area would require significant mitigation of fish and wildlife losses. Relocation of the J4 site out of the floodplain on either side of Chambers Creek would provide the required mitigation.

Native Blackland prairie grasslands are very rare due to decades of disturbance by man for agricultural purposes and urbanization. The specific project vicinity is characterized by elm-hackberry woods, cropland, and other native and introduced grasses. Agricultural cropland is the dominant vegetative cover. Because the site is located in the Blackland prairie vegetational area, a study was conducted by the Texas National Heritage Program on the site in two areas where there was a potential for Blackland prairie species. The vegetation found was indicative of the Blackland prairie sites, but no State endangered or threatened species or habitats were found on the project site. Therefore, it is not likely that Blackland prairie species would be affected.

5.1.5.2 Threatened, Endangered, and State-protected Species

Consultation with the U.S. Fish and Wildlife Service has been initiated in accordance with requirements of the Endangered Species Act of 1973. Documentation of the consultations for each State are presented in Volume IV, Appendix 11, Attachment A. The listed species are presented in Chapter 4, Table 4-17. This consultation will continue. State-listed species are presented in Chapter 4, Table 4-18.

Assessment of impacts from an ecological perspective to threatened and endangered species from SSC construction and operations includes: 1) Federal- and State-listed plant and animal species (including candidate or proposed species) within the SSC region of influence,

2) critical habitats for the species of concern, 3) recovery plans and other management plans for the species, and 4) previously known stresses that are affecting the species.

Preliminary consultations with the U.S. Fish and Wildlife Service, confirmation of information provided in the State's proposals, review of information provided by commenters on the Draft EIS, review of the literature, and limited habitat surveys have confirmed that there are no significant populations of threatened, endangered, candidate, or state-protected species present at any of the proposed SSC sites. A review of the designated critical habitats for endangered species (50 CFR 17) has confirmed that there are no designated critical habitats at any of the site alternatives. All sites, however, do contain habitat that is potentially attractive to listed and rare species. Individuals of these species may be present at any of the sites and could be adversely affected by SSC-related activities. Upon the selection of a site, additional detailed habitat surveys would be conducted to confirm the presence or absence of protected species and evaluate the magnitude of impact. The DOE would then begin consultation with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act, as well as consultation with the responsible State agencies to determine appropriate avoidance and mitigation. Results of the detailed surveys and the consultations would be discussed in a Supplemental EIS.

A. Arizona

Tumamoc globeberry (Federally-listed endangered) is found in habitats similar to those present at the proposed SSC site. Individuals of this species have been reported in Maricopa County south of Interstate 8 in the vicinity of the southern portions of the collider ring (Bisson 1988). This evidence somewhat increases the small potential for discovery of this species in other portions of the collider ring and associated facilities, particularly toward the southern end of the ring and the water well field. The water pipeline and service roads can be relocated to avoid any plants found within proposed rights-of-way. If Tumamoc were located on the collider right-of-way, it would be feasible to tunnel in that area without creating negative impacts to the plants. The probability of locating Tumamoc on the campus sites (which contains only marginally suitable habitat for Tumamoc), on one of the facility access points into the ring, or on some small features which cannot be relocated is extremely low. U.S. Fish and Wildlife Service consultation will continue in support of detailed site-specific surveys to confirm the presence or absence of this species, to determine specific habitat requirements, and to evaluate potential effects of project development. If the species is found, mitigation after consultation with the USFWS would be required.

The endangered bald eagle and peregrine falcon are wide-ranging species that may occur in the site vicinity at various times of the year but are not known to use the Maricopa Mountains for breeding. Because of their rarity in the region and the lack of preferred habitat, neither species would be adversely affected by the SSC project.

Several USFWS candidate plant species (which do not have specific Federal protection, but must be considered during project planning) are also regulated by the Arizona Native Plant Law. One species, the neolloydia, is a creosote-bursage scrub known to occur in Maricopa County on well-drained knolls and ridges. It has not been observed at the site. Other candidate species include the night-blooming cereus, Wiggin's cholla, and Thornber's fishhook cactus. The night-blooming cereus (C2) is more common than previously known. Its range extends across the entire southern half of Arizona. It has been observed in low densities at several locations along the eastern area of the ring. Since this area of the ring involves the most intensive site disturbance activity and the largest fee simple areas, negative impacts to this species and other cacti are probable. Site restoration would include revegetation with native species and replanting the cacti and other plants disturbed.

Candidate wildlife include desert tortoise, Gila monster, and Swainson's hawk. Both the desert tortoise and the Gila monster occur throughout the slopes and washes of the Maricopa Mountains and would be adversely affected by construction activities, noise, and human presence. Avoidance, relocation, and site restoration could mitigate such impacts. Swainson's hawk is a migrant associated with agricultural areas and is not expected to be adversely affected by the SSC project.

The most sensitive areas for populations of the desert tortoise typically occur in the mixed cacti/palo verde associations of incised washes and along rocky bajadas, mountain slopes and pediments. Tortoises and other reptiles may be stirred to activity during normally inactive periods by noise of construction and/or operation of the SSC. Such activity, if inappropriate to their physiological status at the time of disturbance, could be deadly due to desiccation, heat, and water stress.

Potential mitigation of impacts to the desert tortoise would include: (1) presence of an experienced tortoise biologist to monitor site disturbances in tortoise habitat and to monitor mitigative measures; (2) location, flagging, and avoidance of tortoise burrows: (3) proper handling and moving of tortoises encountered; (4) avoidance of site disturbance at critical times of the year (March-May, July-October); (5) construction of barriers to tortoise movement in dangerous areas and of safe corridors around such areas; (6) revegetate all disturbed sites with native Sonoran Desert plant species, particularly those of value to the desert tortoise; (7) briefings of project personnel about protection laws and mitigation measures; and (8) adequate habitat compensation. Since desert tortoises are likely to be found throughout the site, loss of tortoise habitat and potential loss of individuals could be expected without mitigation measures.

Very little is known of the status of the Gila monster in the site area. Measures taken to mitigate the desert tortoise impacts, other than physical removal and relocation to equally suitable habitat, would tend to mitigate Gila monster impacts because these two species occur in similar habitats.

One State-protected species, the desert bighorn sheep, could be adversely affected by construction noise, fencing, and the presence of humans. Depending upon the degree of acclimation to the disturbances, impacts to the sheep could range from no effect to total sheep avoidance of areas of disturbance.

Desert bighorn sheep are associated with the Arizona Upland desert scrub communities dominant in the Maricopa Mountains. The Maricopa Mountains presently support a small population of this species, and this area has been proposed as a location for future transplant programs. While desert bighorn sheep are not migratory in the classic sense, they do undergo significant seasonal movement and occupy a large range (estimates indicate many square miles for a mature ram). Principal activities associated with construction and operations of the SSC in Arizona that might impact the bighorn sheep are construction, road building, fencing, or other intensive human activities in the northern half of the far cluster, particularly K6, E6, F6, E7, and F7. Careful planning during design and attention to mitigation plans would be required to prevent negative consequences for this species. Alterations such as placement of water sources and fences can be effective in minimizing the magnitude of the impacts.

A literature review of the effects of noise from construction, blasting, vibration, and compressor operations on bighorn sheep indicates no long-term detrimental effects from noise levels similar to those expected from SSC construction and operations (see Appendices 9 and 11). While noise may temporarily displace bighorn sheep from areas adjacent to the noise source, it would not necessarily inhibit their return if they acclimate to the noise. Depending upon the degree of acclimation of individual sheep to the constant noise, effects could range from no effect to total sheep avoidance of areas adjacent to the noise source.

B. Colorado

Present projected water needs for the SSC should be met by obtaining water from Morgan County wells, augmented, if necessary, by previously allocated water from the Colorado Big Thompson system. The use of the Morgan County wells within the aquifer's tributary to South Platte River could result in slight water level fluctuations adjacent to the points of withdrawal. This would not affect downstream locations in Nebraska used by the endangered whooping crane, piping plover, and least tern because there would be no net changes in downstream flow. These slight fluctuations are not likely to affect the prey base of fish and waterfowl utilized by the winter concentrations of endangered bald eagles in the vicinity of Fort Morgan and Brush. Moreover, these water level fluctuations would not normally require flow augmentation from other water allocations; thus, the Colorado squawfish, humpback chub, and bonytail chub found in the Colorado River basin are not expected to be adversely affected.

The endangered bald eagle is known to nest in Barr Lake State Park near the origin of the State-proposed access highway. Although the nesting eagles are not expected to be disturbed by highway construction and use because the intersection is more than 2 mi from the nest site.

The endangered peregrine falcon is a wide-ranging migrant throughout Colorado. It is rarely observed, but may occasionally be present in the region. Because it typically occurs in the vicinity of larger bodies of water with high cliffs or other perches, it is not expected to be adversely affected by the project unless water depletions in the South Platte reduce their prey base of waterfowl and shorebirds.

Although prairie dog towns are present throughout the area of the collider ring and the State-proposed highway access, there is no evidence that the endangered black-footed ferret (exclusively co-located with this habitat) is present. Ferret populations are considered to be highly unlikely in the project area because the last probable sighting of the ferret in the area was more than 30 years ago. In addition, the increase in the dry land farming and grazing practices common to this area are historically linked with prairie dog eradication programs. However, small scattered prairie dog towns are present and would have to be surveyed to confirm the absence of the ferret.

Candidate species include ferruginous hawk and Swainson's hawk, which have been observed at the proposed SSC site. Other species that may be present in preferred habitat include swift fox, Preble's jumping mouse, long-billed curlew, western snowy plover, and mountain plover. These species are associated with undisturbed short grass prairie, and along with the candidate plants (Colorado butterfly plant, streaked ragweed, and showy prairie gentian), would not be expected in the vicinity of the site due to lack of habitat. State-protected species, such as the sandhill crane, plains sharp-tailed grouse, and greater prairie chicken would also not be affected due to lack of preferred habitat. However, detailed preconstruction surveys would be conducted to confirm their absence and evaluate the effects of project development.

C. Illinois

The Federally-listed endangered bald eagle and peregrine falcon are present in the region but are not expected to be adversely affected by the proposed project because of their large ranges and lack of breeding habitat in the proposed Illinois site area. The bald eagle and peregrine falcon are associated with aquatic habitats where large areas are available for foraging for preferred prey. Although the peregrine falcon is more cosmopolitan in its foraging habits, it normally breeds only in coastal areas and along river or mountain valleys where cliffs or other high perches are present. The bald eagle is particularly susceptible to human intrusion. As a result, nesting is not known or likely in the proposed site area.

The endangered Indiana bat is also a wide-ranging summer migrant to northern Illinois; caves suitable for winter hibernation occur in the southern part of the state. The Indiana bat forages for insects over riparian wetlands and depends on mature woodlands containing large trees with cavities or sloughing bark for roosting and nesting. Although the species is extremely rare and widely dispersed in the summer, recent habitat surveys indicate that there may be appropriate habitat in the vicinity of the proposed site. Potential foraging habitat may be present at J6, located near Kress Creek; nesting and roosting habitat may be available at areas B, J6, E8, and E9. Campus Area B may be the only area that cannot be avoided by relocating surface facilities, however, the amount of potential habitat removed represents only a small percentage of available habitat in northeastern Illinois.

To ensure that SSC construction avoids the specialized summer habitat for the Indiana bat, field reconnaissance will be made during the preconstruction phase to locate potentially affected riparian areas that have the particular characteristics that comprise optimal foraging and roosting habitat. If it appears that suitable habitat is present, construction plans could include the following measures to maintain habitat integrity:

- Prohibit removal of potential roosting trees within 100 ft of the foraging streams.
- Prohibit tree cutting or trimming in riparian woodlands during the maternity period of May through August.
- Minimize human intrusion and noise generation in riparian woodlands during the maternity period.

With these measures, construction and operations of the SSC should have minimal effect on the Indiana bat if Illinois is selected.

The threatened prairie bush clover and lakeside daisy are not likely to be present at the site in areas that would be disturbed. The preferred habitat of the prairie bush clover consists of dry-mesic or dry gravel prairie on steep slopes of bluffs and moraines. Field work conducted by the Illinois Natural History Survey (1988) located one prairie remnant on the proposed SSC site. This area occurs along a railroad right-of-way and is a wet-mesic prairie that does not contain suitable habitat for the species. Lakeside daisy is also associated with dry-mesic prairie. If suitable habitat is found in the site area or in areas proposed for ancillary facilities, these areas would be surveyed during preconstruction for the presence of these species. Expansion of the prairie restoration project on Fermilab grounds could provide mitigation if dry prairie conditions exist for these plants.

Seven candidate species for Federal listing and 92 State-protected species of plants and animals have biogeographical ranges that include the proposed site. The majority of these species are associated with undisturbed prairie and wetland or aquatic communities. Because of intensive agricultural development and rapid urbanization in the region, most of these species would be considered rare or absent unless they are already protected in parks or refuges. These areas will not be affected by SSC development. During preconstruction, all habitats at each of the proposed surface facilities would be surveyed to confirm the presence of rare, candidate, and State-protected species and to develop appropriate mitigation in the event any species found would be adversely affected.

D. Michigan

The summer range of the Federally endangered Indiana bat includes the proposed Michigan SSC site; however, no limestone caves or other suitable habitat for hibernation exists in the area. Although it is not known to have breeding sites in the region, a recent survey of the proposed surface facilities identified several of these sites that have potential foraging, roosting, and nesting habitat that could be attractive to summer populations of Indiana bats. Foraging, nesting, and roosting habitat may be present in campus areas A, B, and C along Thornapple Creek. This habitat would be lost because construction of surface facilities within these areas cannot be avoided by relocation of the facilities. Potential Indiana bat habitat in the areas of J2, J3, E1, F1, E2, and F2 can be relocated to a certain degree depending upon the proposed activity. Habitat in these areas would be avoided under the procedure described above for Illinois. Because the Indiana bat is known to range extensively throughout southern Michigan, the amount of potential summer habitat lost due to SSC development would represent an extremely small percentage of the overall habitat available for the species. Prior to site disturbance, all preferred habitats would be surveyed to determine the presence or absence of the species. If the species is found, the DOE would begin consultation with the U.S. Fish and Wildlife Service and Michigan Department of Natural Resources to determine appropriate measures to avoid or mitigate potentially adverse impacts.

Several Federally listed species of birds could pass through the area during migration, including bald eagle, peregrine falcon, Kirtland's warbler and piping plover. However, no impacts are expected.

The Michigan site has a great degree of habitat diversity and may contain populations of several candidate or State-protected species. Four candidate plant species for Federal listing, kittentails, bog bluegrass, log sedge, and prairie fringed orchid may be present in the site vicinity. The candidate species, loggerhead shrike has a breeding range that includes the site; however, the species' breeding range is contracting southward, and the actual presence or absence of breeding in the site region would have to be confirmed during preconstruction surveys. In addition, there are several State-protected species of wildlife (spotted turtle, king rail, least shrew, Mitchell's satyr), fish (black redhorse and greater redhorse), and plants (ginseng, golden-seal, edible valerian), that may be present at various locations on or near the site. The two species of fish are not expected to be adversely affected because the portions of the Grand River where they are known to be present would not be subject to surface disturbance.

Impacts to plants and wildlife from project development could include loss of habitat, direct mortality, and, in the case of wildlife, noise and human disturbance. The numerous wetlands and forested areas in the vicinity of the proposed surface facilities would be intensively surveyed to determine the presence or absence of the protected terrestrial plant and wildlife species and to develop appropriate mitigation measures.

E. North Carolina

Two Federally-listed species of birds are potentially present in the region containing the proposed North Carolina SSC site. The endangered bald eagle and peregrine falcon are occasionally found in the region as wide-ranging migrants, but neither is expected to breed locally. Because of habitat limitations, neither species would be present at the site, nor would they be affected by site development.

Harperella, a federally-listed endangered wetland plant, has been observed in North Carolina at only two locations. One of these is in Granville County along the Tar River approximately 2 mi downstream of the southeast portion of the ring. The plant is typically found along the margins of streams and pools, in rocky shoals or shallow gravel. Although no surveys for harperella have been conducted at the site, preferred habitats in areas likely to be disturbed by surface activities would be surveyed for the presence or absence of the plant. Any populations that are found would not be adversely affected because no construction is planned within riparian areas, and populations of harperella would be avoided during project development.

Candidate species that are proposed for Federal listing include the dwarf wedge mussel. Candidate species under review include a fish, Carolina madtom, and four plants, smooth coneflower, Barbara's buttons, nestronia, Lewis' heartleaf, and the migrant loggerhead shrike. With the exception of the dwarf wedge mussel, there are no available population data for these species in the vicinity of the site. The dwarf wedge mussel has been found in stretches of the Tar River that are not expected to be affected by SSC construction, but may also be present in other streams that would be crossed by access routes associated with the proposed surface facilities. Appropriate mitigative measures would include runoff control. The candidate species loggerhead shrike is known to breed in the site vicinity and could be adversely affected if its breeding habitat is disturbed by construction activities.

Local plant and animal species having special status in North Carolina include 11 plants (see Table 4-18), up to seven species of freshwater mussel (several are proposed for listing; Table 4-18 and Appendix 11), one fish (Roanoke bass), one amphibian (Neuse River waterdog), and one bird (loggerhead shrike). Surveys of the local drainage basins indicate that the Tar, South Flat, and Flat rivers and Mayo Creek contain important mussel populations that would require protection during surface

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disturbance. Field studies would be conducted to confirm any local populations of these mussels, as well as the other candidate or State-protected species, and to evaluate potential impacts. Mitigative measures would be planned and evaluated during the planning phase and incorporated in project design.

F. Tennessee

The cedar glades of Tennessee are sensitive habitats for several endangered, candidate, and State-protected species. The endangered Tennessee purple coneflower is found in cedar glades about 15 mi north of the proposed site. The nearest known population is just within the proposed collider ring on the eastern side of Cedar Grove Church. Cedar glades near the site would not be affected by the project location. However, other areas that may be affected by ancillary facilities have not been surveyed extensively for cedar glades, which could occur there. There are also 11 candidate plants (Table 4-17) and 12 State-protected plants (Table 4-18), many of which are associated with the cedar glade communities. Because of their sensitivity and economic importance to the region, cedar glades should be avoided in project development.

The endangered Indiana bat and gray bat are potentially present in the region. As discussed in the Illinois section above, the Indiana bat generally forages, roosts, and nests in forested riparian areas; recent site surveys have indicated that such habitat is present in the site vicinity. Although foraging habitat is not present on the site, potential nesting and roosting areas occur at several locations (areas B, J2, J5/K2, J6, E4, E5, E6, and E8). With the exception of Area B, habitat at each of the other sites can be avoided to a certain extent by relocation of the proposed surface facilities. At area B, habitat would be lost, but this habitat is only a small percentage of the total habitat available to the species within the region. Potential habitat for the Indiana bat would be surveyed prior to site disturbance, and the DOE would begin consultation with the U.S. Fish and Wildlife Service and State of Tennessee to determine appropriate avoidance or impact mitigation, which may include compensation for habitat lost.

The gray bat roosts in caves and forages over rivers and streams. No caves potentially housing the gray bat are located in or beneath SSC surface facility construction areas. Recent cave surveys have indicated that the Snail Shell Caves are periodically flooded, making them unattractive to the gray bat (see Appendix 11). Near the edge of the injector area are located a few small sinkholes that may connect to the far reaches of the Snail Shell Cave system. Injector construction is not expected to disturb the sinkholes. The tunnel depth is such that dissolution features are unlikely. Vertical shafts can be positioned to avoid features that connect directly to potential roosting areas should they be encountered. Hydraulic effects within fissures, which may interconnect and thus dewater the caves and disturb the ecology of roosting areas, could be avoided by sealing the tunnel (see Appendix 7) and by effective use of preconstruction site-configuration studies to avoid such areas.

The Snail Shell Cave system contains populations of the candidate Tennessee cave salamander, and recent surveys have revealed several species endemic to caves (Appendix 11). Additional fieldwork would be necessary to determine the population status and distribution of these species.

The endangered tan riffle shell mussel is probably only associated with larger tributaries and might be affected if erosion were significantly increased. Only two intermediate access points (E6 and E8), external beam access J4, and two interaction points (K5 and K6) come close to areas classified as wetlands. Likewise, the campus and injector areas have only minimal wetland habitat that could be affected. Other endangered species such as the birdwing pearly mussel and the Cumberland monkeyface pearly mussel, and the State-protected hellbender may also be present in the local river basins in areas that might be adversely affected by site disturbance.

G. Texas

Several Federally listed bird species may migrate through Ellis County. These include the whooping crane, bald eagle, Arctic peregrine falcon, interior least tern, and piping plover. None of these species has resident populations in the project area. They are not attracted to the habitats present in the vicinity of the proposed SSC site in Texas and would not be adversely affected by construction or operations.

The endangered black-capped vireo is known to nest in adjacent counties. Black-capped vireo habitat consists of a few small trees (typically oak or juniper) scattered among separated clumps of many bushes (usually oak or sumac). Bushes are in the open and their foliage reaches the ground. Nests are typically found near the ground in areas screened by foliage. The nearest known nesting habitat occurs along the White Rock Escarpment, approximately 2 to 3 mi west of a line parallel to the outer edge of the I region of the proposed site (Texas Parks and Wildlife Department 1988); the nearest known nest is in Dallas County, approximately 10-15 mi north of the site. Recent surveys conducted by Texas Parks and Wildlife Department (Wahl 1988) concluded that there was no adequate nesting habitat for the black-capped vireo on the proposed Texas site, because most of the area is recent or current cropland. Detailed habitat surveys during preconstruction could confirm this, and final placement of surface facilities could be altered to avoid any habitat that may be found. In addition, the service and access shaft areas would be placed in recently disturbed agricultural land. Therefore, it is unlikely that construction of the SSC would affect the black-capped vireo if the Texas site were selected.

The site area may contain preferred habitat for several candidate species, including the Swainson's hawk, western snowy plover, mountain plover, long-billed curlew, loggerhead shrike, and golden-cheeked warbler. Because of extensive agricultural development in the region, most of these species are unlikely to be present. None are known to breed in areas potentially affected by facility construction.

The State lists six protected species potentially present in the area. There are the wood stork (also Federally endangered but not considered present by the USFWS), white-faced ibis, American swallow-tailed kite, golden-cheeked warbler, timber rattlesnake, and Texas horned lizard. The first three species are associated with large expanses of wetlands that are not present at the SSC site. Surveys conducted by the Texas Parks and Wildlife Department indicate that there is no available nesting habitat for the golden-cheeked warbler. Only the timber rattlesnake and Texas horned lizard have confirmed populations in Ellis County, although population levels and distributions are unknown. Impacts would likely include loss of habitat, disturbance by noise and human presence, and direct mortality during construction or from collisions with vehicles. Preconstruction surveys of preferred habitats will determine population status and evaluate project effects on the species.

5.1.5.3 Wetlands Assessment

Executive Order 11990, Protection of Wetlands, requires the DOE to ensure consideration of wetlands protection in decision-making. The DOE regulations at 10 CFR 1022 establish procedures for DOE compliance. The DOE will take action to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the destruction of wetlands and the occupancy and modification of wetlands, and avoid direct and indirect support of wetlands development wherever there is a practicable alternative. All actions would also be in compliance with Section 404 of the Clean Water Act.

SSC facilities will be designed so as to avoid adverse effects and incompatible development in wetlands. Mitigative measures that will be considered include but are not limited to facility relocation, modification of actions, and no action. Measures that mitigate the adverse effects of the proposed SSC in a wetland may include minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas.

For each site, the wetlands impact assessment 1) identifies the location, extent, and quality of potentially affected wetlands (see Appendix 11); 2) describes the existing setting (see Volume IV, Appendix 5); 3) identifies the type and magnitude of expected impacts (see Volume IV, Appendix 11); 4) assesses the significance of such impacts (see Volume IV, Appendix 11); and 5) discusses appropriate mitigation measures that could be taken to reduce the magnitude of the anticipated adverse impacts associated with wetlands (see Volume IV, Appendix 11). Consultation with Federal and State agencies has been initiated. If necessary, relocation of facilities would be considered to avoid wetland encroachment following preparation of site-specific design drawings for the selected site.

A. Arizona

No wetlands have been identified in the project area. Xeroriparian habitat associated with larger ephemeral drainages and stock ponds are present in the project area but none are close enough to surface facilities to be impacted (see Volume IV, Appendix 5).

Construction Impacts

Due to the absence of wetlands within areas where surface facilities would be developed, no impacts to wetlands would occur.

Operations Impacts

A 135-acre evaporation pond (or a number of small ponds totalling 135 acres) would be created. This pond could provide a habitat for a number of plant and animal species.

B. Colorado

Surface facilities at the proposed SSC project site in Colorado could encroach upon approximately 4.7 acres of wetlands (see Volume IV, Appendix 11, Table 11.3.2.3-1 and Figure 11-1). All of the wetlands are moderately degraded from agricultural activities. However, these areas provide topographic relief and are among the only natural areas occurring within the study area.

Both the north/south access road and rail spur would cross palustrine emergent wetlands and flats associated with Badger Creek and its tributaries and a riverine wetland associated with Fort Morgan Canal. Each wetland that would be crossed is about 0.2 acres or less in size; these total approximately 1.6 acres for both the access road and rail spur. These wetlands are all moderately to severely degraded (see Volume IV, Appendix 11, Section 11.3.2.3).

The planned alignment of the east/west access road crosses over 40 wetlands totalling about 200 acres. Most of the wetlands are associated with small order, intermittent streams and are 0.5 acres or less in size. Most are moderately degraded from agricultural activities or severely degraded either from excavation and water level modification (e.g., canals along the western portion of the corridor) or from agricultural activities (e.g., farm ponds). However, a few wetlands exhibit slight to no degradation and are among the most extensive wetlands in size that would be encroached by collider and ancillary surface facilities (e.g., those associated with Beebe Seep, Neres Canal, and Bijou Creek).

Construction Impacts

Two of the surface facilities (area B and E1) to be initially developed at the proposed Colorado site could impact wetland habitats. Construction at these sites could result in the destruction or modification of about 3.7 acres of palustrine wetlands. However, this is a conservative estimate, and the amount of wetland habitats actually impacted would likely be lower (see Volume IV, Appendix 11, Section 11.2.2 and 11.3.2.3).

Facilities proposed for future expansion (area C and J6) could affect approximately 1 acre of wetlands habitats.

Spoils disposals, planned for upland sites away from wetlands, are not anticipated to impact wetlands.

Indirect construction impacts, such as siltation and erosion, could have a minor effect where wetlands habitat is situated in close proximity (within 250 ft of facility boundaries) to a construction site. There are wetlands adjacent to E4, F1, J2, and K6. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize impacts to the wetlands.

Wetlands impacts could also result from the construction of the various ancillary facilities (e.g., the railroad spur, east/west access road, upgrade of the north/south access road, and the installation of the gas and water pipelines). These facilities could disrupt an estimated 1,770 acres. The acreage of wetlands included in this total, particularly for the 541 acres related to pipeline construction, has not been determined as final routing alignments have not been established.

Operations Impacts

Operations of the SSC facility would not significantly impact existing wetlands. A 255-acre evaporation pond (or a number of smaller ponds totalling 255 acres) would be created. This pond could serve as habitat for a variety of plant and animal species.

Mitigation

Mitigation of wetlands impacts could be accomplished by relocation of surface facilities that are within or adjacent to wetlands. Facility E1 could be located up to 200 ft from its proposed location. This relocation could eliminate facility location within wetlands habitat. Also, J3 or J4 could be constructed instead of J6. Such an alternative facility choice would avoid wetlands impacts associated with development of the buried beam access zone areas. Location of ancillary facilities could also be adjusted during final design. Bridging wetlands may be possible under some circumstances. Best engineering practice for erosion control would be used to minimize surface runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate any wetlands loss where avoidance or other mitigation is not effective, replacement could be used as mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of applicable permits and regulations.

C. Illinois

Wetlands are abundant in the Illinois project area and comprise about 921 acres (115 wetlands) of the fee simple area where surface facilities would be located (see Volume IV, Appendix 11, Table 11.3.3.3-1 and Figures 11-2 through 11-8). Palustrine wetlands are the most common wetland type in the area but lacustrine and riverine wetlands are also found. A large amount of the wetland habitat (900 acres) lies within the Fermilab property (equivalent to areas A, B, and C of other alternative sites) (Volume IV, Appendix 11, Figure 11-2). Approximately 265 acres of these wetlands are part of the Fermilab Prairie Restoration Natural Area located in the middle of the existing accelerator ring where no construction is planned.

Most of the wetlands associated with surface facilities have been degraded to some extent. A total of 26 wetlands (about 142 acres) are severely degraded. Fifty-three wetlands (about 505 acres) are moderately degraded. Agriculture and/or residential and industrial development account for most of the degradation. The wetlands within the Fermilab Prairie Restoration Natural Area also show some degree of degradation due primarily to impounding, diking, and ongoing prairie restoration work. Twenty-five wetlands (about 227 acres) show little or no evidence of degradation. These wetlands are primarily confined to the Fermilab site. The only wetlands outside the Fermilab property that is considered to have little or no degradation is a riparian forested wetlands in the vicinity of F4 (Volume IV Appendix 11, Figure 11-3). The quality of wetlands (about 46 acres) shown on the USFWS wetland maps were not evaluated.

Construction Impacts

Six of the surface facilities to be initially developed at the proposed Illinois site could impact wetlands habitat (A, B, F4, F8, F9, and F10). Construction of these facilities could result in the destruction or modification of about 199 acres of wetlands. However, this is a conservative estimate, and the amount of wetlands impact would likely be lower (see Volume IV, Appendix 11, Section 11.2.2 and 11.3.3.3).

Facilities proposed for future expansion could impact an additional 290 acres of wetlands (in areas C, J5 and J6). Area C would be located in Fermilab and thus could impact any of the wetlands within this area depending on its location.

Spoils disposal is to occur within various quarry sites. Approximately 24 acres of wetlands occur in these quarries, and most are severely degraded. However, one 2.1-acre wetland in a quarry site has well-developed wetland vegetation that is only moderately degraded. Spoils disposal would eliminate all of these wetlands.

Indirect construction impacts, such as siltation and erosion, could affect wetlands adjacent (within 250 ft of facility boundaries) to proposed surface facilities. There are wetlands adjacent to sites J2 and J4. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize impacts to these wetlands.

Construction of ancillary facilities would disturb approximately 200 acres of land. The wetlands acreage included in this total has not been determined because the location of these facilities has not been finalized. One possible mitigative measure would be realignment of ancillary facilities, such as access roads and pipelines.

Operations Impacts

Operations of the SSC facility would not significantly impact existing wetlands.

Mitigation

Mitigation of wetlands impacts could be accomplished by relocation of surface facilities that are within or adjacent to wetlands. Facilities F4, F8, F9, and F10 could be located up to 200 ft from their proposed locations. These relocations would eliminate or minimize facility location impacts to wetland habitats. However, relocation of these facilities would not completely eliminate the potential for wetlands impacts. For F4, in particular, mitigative measures other than relocation may be required (see Volume IV, Appendix 11, Figure 11-3). Other mitigations could include the development of J1 or J2 rather than J5, and J3 or J4 rather than J6. These alternative facility choices would avoid wetlands impacts associated with development of the buried beam access zone areas. Locations for ancillary facilities could be adjusted during final design to minimize their impact on wetlands. Bridging wetlands may also be possible in some instances. Best engineering practice for erosion control would be used to minimize runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate potential wetlands loss where avoidance or other mitigation is not effective, replacement could be used as a mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of required permits and regulations.

D. Michigan

Wetlands are abundant in the proposed Michigan area and comprise approximately 567 acres (118 wetlands) of the fee simple areas where surface facilities would occur (Volume IV, Appendix 11, Table 11.3.4.3-1 and Figures 11-9 through 11-21). Most of these wetlands are classified as palustrine.

The wetlands acreage figures in the FEIS are based on a new survey which resulted in the development of more realistic (but still conservative) figures than were presented in the DEIS. The wetlands acreage figures for Michigan are significantly lower in the FEIS.

Many of the wetlands that could be affected have been degraded to some extent, largely due to agricultural practices. Some degradation has also been caused by residential and industrial development. About 215 acres of wetlands (31 wetlands) show moderate degradation and about 77 acres (17 wetlands) are severely degraded. However, 63 wetlands (268 acres) show little or no physical evidence of degradation. Seven wetlands totalling 7.3 acres shown on the USFWS wetland maps were not evaluated for quality.

Construction Impacts

Construction of nine of the surface facilities (areas A, B, E1, E4, E5, F1, F9, F10, and K2) to be initially developed at the proposed Michigan site could result in the destruction or modification of approximately 190 acres of wetlands habitats. However, this is a conservative estimate and the amount of wetlands impact that would occur is likely to be lower (see Volume IV, Appendix 11, Sections 11.2.2 and 11.3.4.3).

Facilities proposed for future expansion could impact an additional 319 acres of wetlands (areas C; J1 or J5; J3 or J6; and K4).

Spoils disposal is to occur within several abandoned quarry sites. Little wetland habitat exists in these quarries, and most are severely degraded.

Indirect construction impacts, such as siltation and erosion, could affect wetlands adjacent (within 250 ft of facility boundaries) to proposed surface facilities. Sites E2, E7, F2, F3, F5, F6, and K3 are adjacent to wetlands. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize impacts to these wetlands.

Construction of ancillary facilities could disturb about 252 acres of land. The wetlands acreage included in this total has not been determined because the locations of these facilities have not been finalized.

Operations Impacts

Operations of the SSC facility would not significantly impact existing wetlands.

Mitigation

Mitigation of wetlands impacts could be accomplished by relocation of surface facilities that are included within or are adjacent to wetlands.

Facilities E1, E4, E5, F1, F9, F10, and K2 could be located up to 200 ft from their proposed locations. These relocations would eliminate or minimize facility location impacts to wetland habitats. However, relocation of these facilities may not completely eliminate the potential for wetland impacts. F1 and F9, in particular, may require mitigative measures other than relocation (see Volume IV, Appendix 11, Figures 11-13 and 11-14). Other mitigations could include the development of J1 or J2 rather than J5, and development of J4 rather than J3 or J6. These alternative facility choices, combined with slight relocation of either J1 or J2, would avoid wetland impacts associated with development of the buried beam access zone areas. The locations of ancillary facilities could be adjusted during final design to minimize their impact on wetlands. Bridging wetlands may also be possible in some instances. Standard erosion control practices could be used to minimize surface runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate any wetlands loss where avoidance or other mitigation is not effective, replacement could be used as a mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of the required permits and regulations.

E. <u>North Carolina</u>

Wetland habitat is relatively common in the North Carolina proposed site area. Approximately 151 acres (53 wetlands) occur in fee simple areas associated with surface facilities at the proposed site in North Carolina (Volume IV, Appendix 11, Table 11.3.5.3-1 and Figures 11-22 through 11-30). Wetland types include palustrine wetlands (emergent and forested) associated with streams and farm ponds, riverine wetlands, and lacustrine wetlands (man-made reservoirs).

Nearly half of the wetlands (26 totalling approximately 71 acres) are moderately degraded and 8 wetlands (12.3 acres) are severely degraded. Degradation can be attributed to a variety of factors including agricultural practices and residential development. Wetlands totaling approximately 68 acres (19 wetlands) show little or no evidence of degradation.

<u>Construction Impacts</u>

Five of the surface facilities (Areas A and B and sites E2, E3, and F7) to be initially developed could impact wetland habitats. Construction of the proposed surface facilities at these sites could result in the destruction or modification of about 41 acres of wetlands. However, this is a conservative estimate, and the amount of wetlands impact is likely to be lower (see Volume IV, Appendix 11, Section 11.2.2 and 11.3.5.3).

Facilities proposed for future expansion (Area C; J1, or J2; and J3, J4, or J6) would impact a maximum of 98 acres of wetlands.

Spoils disposal areas would occupy an estimated 320 acres. All proposed disposal areas are at least 300 ft away from wetlands.

Indirect construction impacts, such as siltation and erosion, could affect wetlands adjacent (within 250 ft of facility boundaries) to proposed surface facilities. Sites E5, F9, and K6 are adjacent to several relatively small wetlands. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize indirect impacts to these wetlands.

Construction of ancillary facilities could disturb about 840 acres of land. The wetlands acreage included in this total has not been determined because the location of these facilities has not been finalized.

Operations Impacts

Operations of the SSC facility would not significantly impact existing wetlands.

Mitigation

Mitigation of wetland impacts could be accomplished by relocation of surface facilities (including aboveground structures within areas A and B) that are located within or are adjacent to wetlands. Facilities E2, E3, and F7 could be located up to 200 ft from their proposed locations. These relocations would eliminate or minimize facility locations within wetland habitats. However, relocation of these facilities may not completely eliminate the potential for wetland impacts. E3, in particular, may require mitigative measures other than relocation (see Volume IV, Appendix 11, Figure 11-24). Other mitigations could include the development of J5 rather than J1 or J2, and development of J3 rather than J4 or J6. These alternative facility choices would avoid wetland impacts associated with development of the buried beam access zone areas. Locations of ancillary facilities could be adjusted during final design to minimize their impacts on wetlands. Bridging wetlands may also be possible in some instances. Standard erosion control practices would be used to minimize surface runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate wetlands impacts where avoidance or other mitigation is not effective, replacement could be used as a form of mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of required permits and regulations.

F. Tennessee

Wetlands are relatively common in the Tennessee proposed site area. There are approximately 105 acres (113 wetlands) associated with planned surface facilities (Volume IV, Appendix 11, Table 11.3.6.3-1 and Figures 11-31 through 11-34). Most of these wetlands are farm ponds that are less than an acre in size. Palustrine emergent, palustrine forested, and riverine wetlands also occur within the proposed facility sites. Most of the wetlands are moderately degraded (71 wetlands, 61 acres) or severely degraded (27 wetlands, 23.3 acres) as a result of agricultural practices and livestock use. Few wetlands (4 wetlands, 15.7 acres) show little or no degradation; three of these are forested palustrine wetlands located in area C and one is a riverine wetland that passes through F1. Eleven of the wetlands (4.8 acres) located in areas B and C were not assessed.

Construction Impacts

Five of the surface facility sites to be initially developed at the proposed Tennessee site could impact wetland habitat (areas A, B, F1, K2, and K6) (Volume IV, Appendix 11, Table 11.3.6.3-1). Construction of the proposed surface facilities at these sites could result in the destruction or modification of 38 acres of wetlands. However, this is a conservative estimate and the amount of wetland impact that would occur is likely to be lower (see Volume IV, Appendix 11, Sections 11.2.2 and 11.3.6.3).

Facilities proposed for potential future development (Areas C; J1; J2; of J5; and J6) could impact a maximum of about 66 acres of wetlands.

Spoils disposal areas would be located in close proximity to each surface facility site. Approximately 3.1 acres of wetlands are associated with the 388 acres to be disturbed for spoils disposal sites. Those wetlands identified were moderately degraded and would be destroyed.

Indirect construction impacts, such as siltation and erosion, could affect wetlands adjacent (within 250 ft. of facility boundaries) to proposed surface facilities. Sites E5, E6, E10, F4, and K6 are adjacent to several small wetlands. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize indirect impacts to these wetlands.

Construction of ancillary facilities could disturb close to 340 acres of land. The wetland acreage included in this total has not been determined because the locations for these facilities have not been finalized.

Operations Impacts

Operations of the SSC facility should not significantly impact existing wetlands.

Mitigation

Mitigation of wetlands impacts could be accomplished by relocation of surface facilities that are within or adjacent to wetlands. Facilities F1, K2, and K6 could be located up to 200 ft from their proposed locations. These relocations could eliminate facility locations within wetlands habitats. Only two of the J areas are expected to be developed. Thus, other mitigations could include the development of J1 or J2 (coupled with slight relocation of either of these facilities) rather than J5, and the development of J3 or J4 rather than J6. These alternative facility choices would avoid wetlands impacts associated with development of the buried beam access zone areas. Location of ancillary facilities could be adjusted during final design to minimize their encroachment upon wetlands. Bridging wetlands may also be possible in some instances. Standard erosion control practices could be used to minimize surface runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate wetlands loss where avoidance or other mitigation is not effective, replacement could be used as a form of mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of required permits and regulations.

G. Texas

Wetlands are not common in the Texas project area. Approximately 41 acres of wetlands (14 wetlands) are associated with surface facilities (Volume IV, Appendix 11, Table 11.3.7.3-1 and Figures 11-35 through 11-39). Most of these wetlands are stock ponds that are each less than an acre in size, although a few palustrine forested wetlands also occur.

Wetlands in areas A, B, C, and K6 (6.6 acres, 8 wetlands) are moderately degraded from grazing and soil erosion. The palustrine forested wetlands (34.8 acres, 6 wetlands) that occur at sites J2, J3, J4, and J6, however, show little or no evidence of degradation.

Construction Impacts

Three of the surface facility sites to be initially developed at the proposed Texas site could impact wetland habitats (areas A, B, and K6). Construction of the proposed surface facilities at these sites could result in the modification or destruction of about 2.8 acres of wetlands. However, this is a conservative estimate and the amount of wetland impact that would occur is likely to be lower (see Volume IV, Appendix 11, Sections 11.2.2 and 11.3.7.3).

Facilities proposed for future expansion (areas C; J2 or J3; and J4 or J6) could impact a maximum of about 37 acres of wetlands.

Alternatives for spoils disposal include locations near areas of generation as well as the filling of old quarries. Spoils disposal would impact about 114 acres of land. Impacts to wetlands associated with spoils disposal cannot be assessed at this time because the locations of these areas have not been finalized.

Indirect construction impacts, such as siltation and erosion, could affect wetlands adjacent (within 250 ft of facility boundaries) to proposed surface facilities. Sites E1, E6, E9, and F6 are adjacent to several small wetlands. The erosion control measures planned for the construction of surface facilities (described in Volume IV, Appendix 7) should minimize indirect impacts to these wetlands.

Construction of ancillary facilities would disturb about 550 acres of land. The wetland acreage included in this total has not been determined.

Operations Impacts

Operations of the SSC facility should not significantly impact existing wetlands. A 396-acre evaporation pond (or a number of smaller ponds totalling 396 acres) would be created. The pond might provide habitat for a number of wetland plant and animal species.

Mitigation

Mitigation of wetland impacts could be accomplished by relocation of surface facilities that are located within or adjacent to wetlands. Facility K6 could be located up to 200 ft from its proposed locations. This relocation could eliminate facility location within wetland habitat. Only two of the J areas are expected to be constructed. Thus, other mitigations could include the development of J1 rather than J2 or J5, and the development of J6 (coupled with a slight relocation) rather than J3 or J4. These alternative facility choices would avoid wetland impacts associated with development of the buried beam access zone areas. The latter (development of J6) is of particular importance as it would avoid potential impacts with high quality wetlands associated with Chambers Creek. Locations of ancillary facilities could be adjusted during final design to minimize their encroachment upon wetlands. Bridging wetlands may also be possible in some instances. Best engineering practice for erosion control would be used to minimize surface runoff to adjacent wetlands. See Volume IV, Appendix 7 for a description of these erosion control practices.

To further mitigate wetland loss where avoidance or other mitigation is not effective, replacement could be used as a form of mitigation. Additional mitigation could be proposed as a result of consultation during final design with appropriate Federal and/or State agencies. All work within wetlands would be conducted in accordance with conditions of required permits and regulations.

5.1.5.4 Commercially, Recreationally or Culturally Important Species

Agricultural production, including livestock feeding, will not be measurably impacted by the proposed action at any site. Hunting, trapping, and fishing as recreational activities would be restricted at all seven site alternatives during construction and would continue to be tightly controlled within fenced fee simple areas for the operational life of the SSC. The exact locations of these areas will be determined later during final design of the project. Factors associated with SSC project siting and operations may additionally alter existing types and dispersal of current recreation patterns, and may change the number of visitors within an area; these effects would be analyzed in more detail upon selection of the SSC site.

A. Arizona

Although prohibited by State law, harvesting mesquite and collecting reptiles and cacti is likely to continue throughout this region because of increased access to the area provided by the project. It is difficult to predict exactly how poaching will be affected following SSC project activities in the area; while improved access, including off-road vehicle routes, may allow more poachers to enter the area, it may simultaneously inhibit them, due to greater habitation and population growth, in the area.

While access to the area would be increased by SSC facility construction, at the same time, greater institutional controls on access could be imposed as has been informally suggested by the BLM. One potential point of conflict could occur if extensive fencing is used for control of public access. In some areas, this would be in direct conflict with the recommended desert bighorn sheep and desert tortoise mitigation efforts, which require prohibition of fencing in key migratory range habitats. The impact of fencing on desert tortoise, however, depends on the type of fence used. Four- to five-strand barbed wire would have virtually no impact on the species; a chain-link fence to the ground, on the other hand, would severely curtail tortoise movements. Fencing and other controls could be instituted in consultation with BLM and Arizona Game and Fish Department.

No information is available on hunting frequency or success in the area; however, Arizona Game and Fish Department management should not change substantially as a result of SSC presence beyond the construction period. There are no fish, and therefore, no fishing at or near the Arizona SSC site. Feral burros are unlikely to be adversely affected.

Effects of noise, blasting, and compressor operation on the physiology and behavior of bighorn sheep are relatively well studied because of previous large-scale projects in other sheep ranges, such as Lake Powell and the Alaskan pipelines. The results of these studies suggest that the previous experience of the bighorns with noise of similar magnitude and intensity determine their individual reactions to new noise sources. Typically, animals respond less to noise alone than to noise accompanied by visible action, such as helicopters or human intruders. Depending upon the degree of acclimation of individual sheep to the constant noise, effects of SSC construction and operations could range from no effect to total sheep avoidance of areas adjacent to the noise source.

B. Colorado

There are no commercially or culturally important species along the SSC ring in Colorado; however, many species of recreational potential are present. Recreational hunting does occur in the area. Colorado Small Game Management Unit 36, which includes the project area and the surrounding South Platte River bottomlands, ranks first in the State for mourning dove harvest (Colorado Division of Wildlife 1987). Both pronghorn antelope and mule deer are hunted in the area, and badger, beaver, coyote, and red fox are trapped. Beyond possible localized restrictions and increased hunting from in-migrants during the construction period, the SSC should not alter these activities. Sport fishing in the reservoirs northwest of the site would be unaffected by the SSC project.

C. Illinois

Hunting, fishing, environmental education, and bird watching are the primary recreational uses of the area of the Illinois site. The Fox River supports a major and diverse recreational fishery, which is not expected to be negatively impacted by construction of the SSC.

Within the area, most hunting occurs on private land and along the Fox River. Hunting leases on agricultural land are also common, the lease rate being variable depending on the number and types of species present. In general, most leases are for ring-necked pheasant, waterfowl, and white-tailed deer hunting. Cottontail rabbit is also a frequently sought species. The populations of game species in the area have been declining over recent years due to continually increasing pressures of urbanization. Access to this resource, while somewhat limited during construction, should return during operations. No measurable impact to small mammal or game bird abundance is anticipated due to the SSC.

D. Michigan

Numerous recreationally important species, particularly sport fish, are found within the proposed SSC ring alignment in Michigan. The Grand River is the major site of recreational use of this resource. Fishing is also done in Sycamore Creek. Michigan regulations requiring remediation of wetland habitats, coupled with regulations protecting and enhancing opportunities for anadromous fish populations, should serve to minimize any significant negative impacts to the fisheries along the SSC alignment.

Game mammals hunted throughout the area include cottontails, white-tailed deer, and fox squirrels; waterfowl hunting is also common. Furbearing mammals trapped and hunted include muskrat, mink and raccoon. Limitations and restrictions on recreational activities could reduce the amount of hunting, fishing, and commercial trapping in some areas, particularly those immediately adjacent to facility concentrations.

Passive recreational activities, such as bird watching and nature photography, are inevitably a part of the Haehnle Wildlife Sanctuary and Waterloo State Game Area usage and are not expected to be impacted by SSC construction or operations, except for increased usage.

E. North Carolina

Numerous species of recreational significance occur in the predominantly rural and natural areas of the proposed SSC site in North Carolina. Hunting, fishing, birding, and hiking are all pursued in the area. Fishing is not expected to be adversely impacted.

Current estimates indicate that approximately 10 percent of the public hunting area of the State-owned Butner Game Lands would be within fee simple areas. Limitations on hunting within SSC areas would have a small effect on hunting activities, because extensive game lands occur in many other parts of the region, including areas surrounding Mayo Reservoir and Mayo Creek.

Active recreational uses such as boating, water sports, camping, and bird watching at the Corps of Engineers lake in the area, Falls of Neuse Lake, and Lake Michie would remain unaffected by the SSC except for increased usage.

F. Tennessee

In Tennessee, no public hunting areas or State Wildlife Management Areas are located within the project area. The closest is about 15 mi north of the proposed ring alignment. Hunting and fishing occurs on private property and along rivers and streams throughout the area. Several streams in the area support sport fisheries, such as the smallmouth bass in Stones River, among many others. These sport fisheries would remain unaffected by the SSC project.

The four-county area, which is host to this ring alignment, is part of the Middle Tennessee Wildlife Management Region, which has the highest percentage of deer harvest for the State. Comparatively little habitat would be eliminated by construction of the SSC. The wildlife populations are expected to suffer no measurable impact other than localized displacement. Wild turkeys, which have been reestablished within recent years in this portion of Tennessee, are currently increasing in numbers. Local flocks might experience loss of range during construction of individual dispersed SSC facilities. However, displacement and loss of habitat and range for these species would be temporary.

Several ranches that raise and train Tennessee walking horses are present in the immediate area of anticipated SSC construction, e.g., E4. The potential for impact from noise and vibration from construction and operation of compressor units has been considered in a special review by Bowles, Awbrey and Jehl (1988), and is summarized in Section 11.3.6.4, Appendix 11, Volume IV. In general, noise would be expected to cause minor immediate behavior changes in the horses, but would have no long-term adverse effects.

G. Texas

In Texas, hunting, trapping, and fishing are popular in this largely rural/suburban area. Hunting and fishing would not be affected significantly by the SSC except for increased usage. As recreational activities, they would continue to be under pressure due to urbanization/suburbanization in the region. Localized restrictions on such activities within fee simple areas would serve to balance possible increase in the rates of sport fishing and game hunting from increased population growth in the immediate SSC area.

5.1.6 Health Hazards (Radiological and Hazardous Materials Impacts)

The proposed SSC project, from preconstruction through decommissioning, would have some potential impacts on human health. These impacts are addressed in terms of both worker health and safety and public health and safety during "normal" conditions (the public is defined as people working or residing in SSC-adjacent areas affected by the project). In addition, serious accident scenarios (i.e., "abnormal" conditions) were examined for their potential impacts on both worker and public health and safety. The potential impacts were categorized as radiological, hazardous/toxic, or safety. For additional detailed discussions of health and safety concerns associated with the SSC project, see Appendix 12.

5.1.6.1 Routine Occupational Impacts

Occupational health hazards could arise during preconstruction, construction/installation, operations, and decommissioning of the proposed SSC project. The most significant hazards, focusing on the major impacts and mitigative measures, are addressed. Additional safety reviews and hazards analyses of the proposed SSC project will be carried out through the process of formal Safety Analysis Reviews (SAR) as design and operational details become established.

A. Radiological

No man-made sources of radiation other than those associated with a construction project of this magnitude, e.g., industrial radiography sources, moisture density gauges used in roofing and highway construction, etc. would be present at the SSC during construction. It is assumed that some radon will infiltrate the tunnel excavation from the surrounding material during construction, particularly in Arizona and Colorado. With a continuous tunnel ventilation rate equivalent to 0.46 air exchanges per hour, the radon concentration is estimated to be about 14 to 16 pCi/l at these sites. Other sites are estimated to have levels from about 3 to 6 pCi/l (see Appendix 12). Tunnel construction contractors would be required to monitor for radon and to provide continuous ventilation during excavation when workers are present.

The SSC would be designed and operated such that radiological doses to workers would be minimized to as low as reasonably achievable throughout the SSC's operating life. Operating safety procedures similar to those in practice at Fermilab and SLAC would be established and workers would be trained in these procedures before operations begin. No exposure to radiation by workers at Fermilab and SLAC has ever been above the DOE limit of 5 rem/yr, except for a single incidence at Fermilab where a worker received 5.01 rem in a single year. The goal normally achieved at Fermilab and SLAC is less than 1 rem/yr individual occupational exposures. The SSC would administrate similar goals. The primary risk of exposure to workers would occur as a result of maintenance activities in certain areas of the collider where small amounts of residual radiation would be present (typically at a level of some tens of mrem/h at a distance of 1 ft from the emitter).

The occupational radiation exposure records at Fermilab show that for the first two years of operations, total exposure to workers reached a peak of nearly 500 person-rem/yr for the third year of operations (when considerable difficulty with magnets was experienced) with a gradual falling-off to a level of 30 to 50 person-rem/yr over the past four years (after the superconducting magnets came into operation). Fifty percent or more of this is directly due to the fixed-target program. On the basis of Fermilab operating experience, due to and the fact that the SSC would accelerate a much smaller number of protons per year than Fermilab, and because the SSC would not have an equivalent fixed-target program, the CDG estimates that for the first few years of operations, average worker exposure would be 40 person-rem/yr, falling to an average of 20 person-rem/yr after that time. (If Illinois were the selected site for the SSC, the Fermilab machine would be used as the injector for the SSC. The fixed-target program would be reduced, and the number of particles accelerated per year would be reduced to SSC specifications.) The SSC would be designed and operated with the goal that all exposures would be as-low-as-reasonably-achievable (ALARA), applying DOE Order 5480.1B, Environmental Protection, Safety, and Health Protection Program for DOE Operations.

B. Hazardous/Toxic Materials

Exposure to hazardous/toxic materials (HTM's) is possible during construction and operations of the SSC, and to a lesser extent during decommissioning. The impacts on the health of the workers involved in these tasks are projected to be very similar to those at Fermilab. Safety and handling programs similar to those at Fermilab would be established. As discussed in Appendix 12, essentially all of the anticipated occupational health hazards are site-independent and can be attributed to the SSC facility and its operations. Only two site-dependent hazards, the possibility of contracting Valley Fever at the Arizona site and the threat of fire ant stings at the Texas site, were identified.

During SSC construction, workers are expected to encounter a variety of health hazards that would be common to any construction project, such as welding fumes, solvent vapors, noise, and dust. Hazard severity would be a product of the concentration of the hazardous/toxic material (or intensity in the case of noise) in the work area and the duration of work in those conditions. Construction activities involving HTM's are likely to have a low impact on worker health for two reasons: 1) the breathing zone concentrations of the airborne hazards are expected to be low unless the work is being performed in a confined space, in which case, protective or supplied breathing apparatus would be required; 2) since the hazards that might arise during construction are normal for the construction industry, they can be anticipated and would be addressed in the construction contractor's health and safety program.

Mitigative measures would include work procedures to reduce the amount of hazardous emissions generated, safety procedures to promote safe handling of HTM's, and the use of personnel protective equipment. Access control measures during tunneling operations would also be used.

The potential for contracting Valley Fever at the Arizona site is a special case requiring special control measures. The hazard is expected to exist when sections of undisturbed soil containing the pathogenic fungal spores would be disturbed during construction activities and the spores would become airborne. Soil samples would need to be taken in areas of major soil-disturbing activity to determine locations of especially high spore density and the actual potential for release of the spores. The impact on workers in these areas would depend on individual susceptibility (as well as possible immunity gained from previous infection), the concentration of airborne spores, and the duration of exposure. In addition, workers outside (downwind) the immediate area of concern could be affected as well since the spores are readily transported by wind. It is difficult, therefore, to estimate the degree of impact on SSC workers.

Mitigative measures to minimize the impact of Valley Fever spores that would be considered and evaluated if the Arizona site were selected include:

- Minimizing the scope of soil disruption during facility and road construction.
- Confining soil-disturbing activities to periods of low wind velocity.
- Using dust suppressants to reduce dust.
- Requiring the contractor to implement work methods that minimize the generation of dust.
- Using respirators to protect workers against inhalation of the spores (work procedures would balance protection from spore inhalation with potential risk of heat stress).

The presence of imported fire ants at the Texas site is a potential hazard to construction workers, as well as SSC operating personnel during the life of the facility. The severity of the hazard will depend on the density of the fire ant population in those areas of the proposed SSC footprint that will be disturbed by construction and operation activities, and on the effectiveness of any control measures used to combat the fire ant problem. If the SSC is sited in Texas, a survey would be conducted prior to the start of construction to determine the location and extent of fire ant infestation. Potential control methods could then be evaluated. The impact on workers would depend on the effectiveness of control measures, the implementation of work procedures to avoid contact with the fire ants and the individual worker sensitivity to the fire ant venom.

Potential mitigative measures to minimize the impact of fire ants could include:

- o Worker training to recognize and avoid fire ant habitats
- o Insecticides and fumigants
- o Broadcast treatments (baits with toxicants)

It is recognized that eradication of fire ants is not feasible with presently available techniques. At best, their impact can only be reduced to a manageable level. Any use of insecticides or fumigants would be in accordance with Federal and State regulations for their application and would designed to minimize impacts on the local environment.

C. Safety

As with the hazards from HTM's discussed above, personnel involved in construction of the proposed SSC would be likely to face a variety of safety hazards. The safety hazards encountered would resemble those found on most tunneling and construction projects. These hazards include injury from machine tools, electric shock, fire, and tripping/falling. SLAC has had two tunneling and construction projects in the past 10 years and, although the scale was much smaller (4 mi of tunnel rather than 53 mi), there were no major injuries or fatalities during construction. Management and safety requirements for contractors similar to those used successfully by SLAC would be used for the SSC.

Mitigative measures for safety hazards would focus on training and standard construction safety practices.

5.1.6.2 Public Health Impacts

A. Radiological

Radiological impacts associated with the SSC have been analyzed extensively in Appendices 10 and 12 and can be predicted with reasonable confidence. The overall radiation exposure to residents in the area of the SSC is expected to be very low. The dose equivalent (a measure used for radiation protection) to the maximally exposed individual from SSC operations varies from 0.002 to 0.013 mrem at the proposed sites. This is less than 1/1000th of the dose equivalent from natural background radiation to which all individuals are subject. Therefore, there is no reason to believe that persons residing in the area of the SSC will take on any risk associated with radiation that is measurably different than that experienced by other persons in the proposed state.

1. Direct Radiation

In one sense, the proposed SSC would be similar to a television set which, when turned on, generates a beam of particles; when the television set is turned off, the beam stops. In a television set, the beam consists of electrons from a heated electrode; in the SSC, the beam consists of protons from hydrogen gas. Direct radiation would occur when the SSC is turned on and the proton beams collide with matter. When the SSC is turned off, the proton beams and the accompanying direct radiation would cease. A remaining source of radiation would be material within the machine that has been made radioactive by being struck by the beam itself or by the secondary particles produced in collisions. The majority of this small amount of radioactive material would be contained in the heavily shielded beam absorbers. The only secondary particles not absorbed by the beam absorbers and earth shielding are muons. These are weakly interacting particles which, at very high energies, can travel several miles, even through dense material (see Appendix 10). This fact has been taken into account in the design of the SSC. However, there are certain very limited underground areas which may require some restrictions outside of the 1,000-ft controlled area as discussed in the following paragraphs.

Table 5.1.6-1 shows the calculated maximum annual radiation exposure to an individual under the worst conceivable conditions under normal operations. The numbers that stand out in Table 5.1.6-1 are those for "Muons at depth of beam plane," particularly those for the interaction regions (IR's) and beam absorbers. The differences at the various sites are the result of the differences in soil density at tunnel depth at those sites. The cited annual exposure rates would be those received by an individual who remained fulltime during every operating minute of the SSC for a full year at a fixed position. The fixed position would be just outside the controlled area aligned within a few feet both horizontally and vertically from where the muon beam emerged and at the depth of the tunnel. The depth of tunnel below the surface at the surface facilities, exit shafts, and IRs for site alternatives is:

Arizona	45-800 ft
Colorado	75-205 ft
Illinois	335-610 ft
Michigan	85-220 ft
North Carolina	95-270 ft
Tennessee	285-670 ft
Texas	85-245 ft

This means that to receive the calculated dose, the individual would have to be underground at that depth. A check has been made of the general topography in the areas where IR's and beam absorbers would be at the proposed sites to see if there might be topographical depressions that would bring the surface below tunnel depth. This could not be a quantitative check, since detailed design of the proposed SSC does not yet exist. In general, there appears to be no area at any of the proposed sites where it would be possible to reach tunnel depth without digging or excavating to that depth. When the specific site is chosen and when detailed design has been completed, the DOE and/or the State could make arrangements with local property owners to restrict deep excavations in the narrow regions where muons might penetrate.

Table 5.1.6-2 presents the results of similar calculations for the public as a whole. The calculations are based on the total population in the area.

2. Air Pathway

a. Air Activation Products

During operations, secondary particles produced by proton interactions would activate some air molecules, i.e., make them radioactive. The majority of the air activation products have very short half-lives (see Appendix 10). The projected dose equivalent to the general public from venting the tunnel at the ten service facilities and the four interaction regions is presented in Table 5.6.1-2. Engineering controls such as filters were not considered in the dose equivalent calculations. The dose equivalent to the total public from air activation products at the highest dose site (Illinois) is 0.11 person-rem/yr. This number is the product of the average individual dose times the number of people in the area, and should be compared to the total public annual radiation dose to that same population from background radiation of 360,000 person-rem/yr. In terms of maximum individual dose rate (see Appendix 12, Table 12.3.1-2), this is about 0.016 percent of the 40 CFR Part 61 Subpart H limit for whole body dose (25 mrem/yr).

b. Radon and Its Progeny

Radon (Rn-222) is a relatively short-lived (3.8 days half-life) noble gas decay product of radium (Ra-226). The noble gas properties of radon provide it with transport capabilities which allow it to move into structures, such as the tunnel and interaction halls. The concentration emanating into the structures is dependent upon the Ra-226 concentration and the transport characteristics of the rock. The buildup of Rn-222 and its progeny in the structures depends on the ventilation rate.

The tunnel is unoccupied during beam operation and not under continuous ventilation; thus, radon would build up in the tunnel and would need to be vented prior to entry of personnel. The expected dose to individuals and the dose equivalents to the general public for radon and radon progeny from the SSC tunnel ventilation are presented in Tables 5.1.6-1 and 5.1.6-2.

It should be emphasized that radon would not be produced by beam operations, but is a natural product for which the underground structures serve as a collector and source. This is true for all underground structures in the area of the proposed sites and is not unique to the SSC. There is some inherent mitigation to radon infiltration provided

Table 5.1.6-1

ESTIMATED DOSE (EQUIVALENT RATE) TO THE MAXIMALLY EXPOSED INDIVIDUAL DURING CONSTRUCTION AND OPERATIONS OF THE SSC AT SITE ALTERNATIVES*

Specific Impact	Phase	AZ	CO	IL	MI (mrem/yr)	NC	TN	TX
External Radiation								
Limit 100 mrem/yr	Construction	0	0	0	0	0	0	0
DOE Order 5480.1B[2]	Percent of Limit	0	0	0	0	0	0	0
	Operations[1]							
	Skyshine	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Hadron Beam Absorber	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Muons at depth of beam plane							
	IR	7	2	0.2	0.2	0.008	0.02	0.4
	Beam Cleanup	0.2	0.03	0.006	0.006	<0.001	<0.001	0.02
	Beam Absorber	20	5	0.9	0.9	0.04	0.05	2
	Muons at surface	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Percentage of limit at surface	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Air Pathway	Construction[3]							
Limit 25 mrem/yr	Air Activation							
(40 CFR 61)	Products	0	0	0	0	0	0	0
	Percent of Limit	0	0	0	0	0	0	0
	Radon + Progeny	0.004	0.007	0.002	0.002	<0.001	<0.001	0.001
	Percent of Limit	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Operations							
	Air Activation							
	Products (IR)	0.002	0.003	0.004	0.003	0.001	0.002	0.002
	Percent of Limit	0.008	0.012	0.016	0.012	0.004	0.008	0.008
	Radon + Progeny (Service Facility)	0.007	0.013	0.003	0.004	0.001	0.002	0.002

Table 5.1.6-1 (Cont)

ESTIMATED DOSE (EQUIVALENT RATE) TO THE MAXIMALLY EXPOSED INDIVIDUAL DURING CONSTRUCTION AND OPERATIONS OF THE SSC AT SITE ALTERNATIVES*

Specific Impact	Phase	AZ	CO	IL	MI (mrem/yr)	NC	TN	TX
	Total of Air Activation5 Products plus Radon (IR or Service Facility)	0.007	0.013	0.004	0.004	0.002	0.002	0.002
Aquatic Pathway	Construction	0	0	0	0	0	0	0
	Operations	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dose Eq Rate[4] From Background Radiation (mrem/yr)		311	451	401	359	373	428	364
Comparison of Dose Eq. Rate from SSC to Background (BKG)	Construction							
	SSC	0.004	0.007	0.002	0.002	<0.001	<0.001	0.001
	Percent of BKG	0.0012	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001
	Operations							
	SSC	0.007	0.0013	0.004	0.004	0.002	0.002	0.002
	Percent of BKG	0.0002	0.0003	<0.001	0.001	<0.001	<0.001	<0.001

BKG = Background

1. Dose equivalent rate from protons, neutrons, and muons are for continuous exposure in a small area. This area would be different for different particles, so these dose equivalents are not additive for a single individual.
2. EIS Volume I, Chapter 6, Section 6.3.2.
3. Assumes that on average during the construction phase 50% of the tunnel face will be exposed and radon will infiltrate there.
4. Dose includes 200 mrem/yr from radon at all sites.
5. As the maximally exposed individual could not be at the Service Facility and the IR hall at the same time, the maximum dose equivalent at either the Service Facility or the IR from EIS Volume IV, Appendix 12, Tables 12.3.1-4 to 12.3.1-17 is reported.

*Calculations based on SSC beam intensity 3 times higher than design specification. There is no radiation produced in preconstruction activity.

Table 5.1.6-2

ESTIMATED POPULATION DOSE (EQUIVALENT RATE)
DURING CONSTRUCTION AND OPERATIONS OF THE SSC AT SITE ALTERNATIVES*

Specific Impact	Phase	AZ	CO	IL	MI	NC	TN	TX
					(person-rem/yr)			
External Radiation	Construction	0	0	0	0	0	0	0
	Operations[1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Air Pathway[3]	Construction[2]							
	Air Activation Products	0	0	0	0	0	0	0
	Radon + Progeny	0.013	0.014	0.20	0.003	0.002	0.002	0.003
	Operations							
	Air Activation Products	0.001	0.001	0.11	0.001	<0.001	<0.001	<0.001
	Radon + Progeny	0.026	0.028	0.39	0.006	0.004	0.004	0.006
	Total	0.027	0.029	0.50	0.007	0.005	0.004	0.007
Aquatic Pathway	Construction	0	0	0	0	0	0	0
	Operations	0	0	0	0	0	0	0
Total Population Dose Eq Rate From Background Radiation		9,400	14,000	360,000	11,000	11,000	13,000	11,000

Table 5.1.6-2 (Cont)

ESTIMATED POPULATION DOSE (EQUIVALENT RATE) DURING CONSTRUCTION AND OPERATIONS OF THE SSC AT SITE ALTERNATIVES*

Specific Impact	Phase	AZ	CO	IL	MI (person-rem/yr)	NC	TN	TX
Comparison of Population Eq. Rate from SSC to Population Dose Eq. from Background (BKG)	Construction							
	SSC	0.001	0.001	0.20	0.003	0.002	0.002	0.003
	Percent of BKG	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Operations							
	SSC	0.027	0.029	0.50	0.007	0.005	0.004	0.007
	Percent of BKG	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

1. Skyshine.
2. Assumes that on average during the construction phase, 50% of the tunnel face will be exposed and radon will infiltrate there.
3. Total of 14 source points (10 service facilities plus 4 IRs). Individual values from EIS Volume IV, Appendix 12, Tables 12.3.1-4 to 12.3.1-17.

*Calculations based on SSC beam intensity 3 times higher than design specification. There is no radiation produced in preconstruction activity.

by tunnel engineering requirements. In areas where the tunnel is in solid, nonporous rock, infiltration of radon gas would be reduced. In areas where the tunnel would be in porous or amorphous material, where radon infiltration could be a problem, the tunnel may be lined with concrete for structural support. For this assessment, to maximize calculated potential impacts, the tunnel was assumed to be unlined and in amorphous material in all cases. This comment is only applicable to the operations phase when the tunnel is complete. Projected radon doses to the public during construction are also shown in Table 5.1.6-2.

c. Neutron Skyshine

Neutron skyshine is the rescattering of neutrons by air nuclei above a source back down to the surface of the earth. Since neutrons would be produced copiously in SSC interaction halls, calculations were carried out to determine the significance of the effect. Because the interaction areas would be either deeply underground or well-shielded overhead by both massive detectors and concrete shielding, the contribution of neutron skyshine to the environment at every site would be less than 0.001 mrem/yr (see Appendix 10 and Appendix 12).

3. Aquatic Pathways

When the SSC beam strikes any material and when the beams collide with each other, many secondary particles are produced that are energetic enough to produce additional particles; when these additional particles strike matter, they produce a new generation of particles and continue to reproduce until the total energy is dissipated. In the case of hadrons at SSC energies, this cascade of particles would take place in a relatively small region of space and would be completely dissipated within about 35 ft of material (soil) from the source. However, the interaction of the cascade with soil would cause activation of constituents in the soil. This has been studied extensively by Borak (1972) and others. There are two leachable isotopes that are formed in sufficient quantities whose longer half-lives allow significant migration: tritium (H-3) and sodium (Na-22) (see Appendix 10).

The EPA standard for public drinking water is based on an annual dose equivalent of no more than 4 mrem from man-made radionuclides in public drinking water.

The current EPA standard for tritium in public drinking water is 20 pCi/ml based on a yearly dose equivalent of 4 mrem. (EPA has proposed to raise this to 90 pCi/ml based on currently accepted methods of calculating dose, but comparisons to EPA standards in this document are made using the 20 pCi/ml limit.) The standard for Na-22 is 0.5 pCi/ml. If two or more radionuclides are present, the sum of their annual dose equivalents should not exceed 4 mrem. During normal operations, the largest possible source of cascade interaction with the soil would be in the two primary beam absorbers. The function of the beam absorbers is to accept and absorb the spent beams at the end of each accelerator cycle (about once per day) and to accept and absorb the full beam in the case of beam aborts. As designed, the beam absorbers would be extremely efficient in this function. It has been calculated that over the lifetime of the proposed SSC, the total H-3 and Na-22 buildup in the soil downstream of the beam absorbers would be approximately 0.24 pCi and 0.182 pCi, respectively (Toohig 1988).

4. Transportation

In operations and maintenance of the SSC, low-level radioactive waste (LLRW) would be produced. The LLRW annual output is estimated to be 8,000 ft^3 (220 m^3) containing 10 Ci. For purposes of this assessment, it is assumed that the LLRW would be transported to the DOE facility at Richland, Washington, with an average of ten drum shipments and two shipments of low specific activity (LSA) boxes per year (see Appendix 10). The primary radionuclides are Mn-54 and Na-22. For impact assessment, the entire waste is considered to be Na-22 since it poses a higher human hazard potential.

The projected annual dose equivalent to the drivers and total annual collective population dose equivalent are presented in Table 5.1.6-3.

Table 5.1.6-3

ANNUAL DOSE EQUIVALENT FOR THE SSC TRANSPORTATION OF LLRW

	AZ	CO	IL	MI	NC	TN	TX
Total anual dose to collective population along route (person-rem/yr)	0.18	0.13	0.21	0.24	0.31	0.25	0.22
Total annual dose for each driver* (mrem/yr)	499	338	560	640	835	665	575

*Assumes two drivers, the same two drivers would make 12 trips/yr

B. Hazardous/Toxic Materials

There are no anticipated public health impacts from the HTM's that are expected to be used in the construction and operation of the proposed SSC.

At the Arizona site, however, a potential hazard to the public would exist from the Valley Fever spores discussed above as an occupational concern. If the spores were dispersed as a result of SSC construction activities, they could be carried by winds to the adjacent community and could pose a threat of disease to susceptible residents and passersby. The impact is difficult to assess for the reasons previously presented, but it includes a small risk of serious illness.

Mitigative measures would be the same whether the risk is to workers or the public and would serve both groups.

5.1.6.3 Accident Impacts and Risks

A. Radiological

Radiological impacts from the worst-case accident (loss of beam) have been evaluated. Even at three times the design intensity, the dose equivalent to the maximally exposed individual is below the annual exposure from natural background radiation.

1. Loss of Full Beam

The accidental loss of the full beam at the SSC would cause major damage to the machine and a considerable disruption to the experimental program, as well as create undesirable radiation. For these reasons, the SSC would be designed with sufficient redundancy to protect against accidental beam loss under every conceivable scenario of multiple and simultaneous equipment failure. The superconducting magnet accelerator at Fermilab has similar redundancy and has not experienced an accidental beam loss in its operating history. Even though such an event is viewed as extremely unlikely, the impacts of a full beam loss have been assessed and the results discussed below.

a. External Radiation

The general public would be protected from external radiation associated with a full beam loss by the shielding provided by the earth cover. External radiation exposure could occur in two areas, directly above and adjacent to the loss point and on an axis tangent to the beam loss point.

The dose equivalent contribution from hadrons directly above the loss point would be highly dependent upon the intervening shielding depth. The dose decreases by approximately a factor of 10 for every yard of soil/rock. At the average tunnel depth at all of the sites, a loss of beam would produce no measurable dose from hadrons at the surface. An assessment was made (see Appendix 10, Table 10.1.3-4) to determine the maximum hadron dose which would occur at the shallowest depth for the proposed tunnel. Because the hadrons are absorbed in a short distance, the area of potential exposure is less than 30 ft in diameter. The probability that a beam loss would occur in a specific spot (the shallowest point) of the SSC ring is less than 1 in 100,000. The probability that an individual would be at that spot at that instant (lasting at most, one beam revolution time, or 1/3500th of a second) is vanishingly small. At the seven proposed sites, the combination of minimum depth and lowest soil density would occur at one point on the proposed Texas site. If a full beam loss were to occur at this particular point on the proposed Texas site, and an individual were at that point at that instant, that individual would receive a dose of 2 mrem.

The muon "beam" which would result from a beam loss would travel at a tangent to the ring from the point of loss and would not have an effect above the tunnel as was the case with hadrons. This muon beam is highly directed (an approximate vertical spread of 1 ft in 10,000 ft). In order to receive a dose from this beam, an individual would have to be positioned in the plane of the beam which is at the depth of the ring at the loss point. Even then, the total, one-time dose from muons would be less than the annual dose equivalent from background radiation (see Appendix 10, Table 10.1.3-8) and would fall by a factor of about 2 every 500 ft along the tangent line.

On the tangent line closest to the loss point, it is not likely that an individual would be at that precise location (within a few feet in the horizontal direction and below ground at tunnel depth) at the precise instant the beam would accidentally be lost.

b. Air Pathway

The only air available for the beam to activate in an accidental beam loss would be the air in the tunnel. The path length in air within the tunnel would not be extensive; any air activation products formed would be of short half-life, and retention in the unvented tunnel for some 30 minutes would reduce their radioactivity to releasable levels. Not until the radioactivity in the air reached a safe level for public release, would the vent fans be started.

c. Groundwater Pathway and Soil Activation

The loss of the full beam would result in the production of some radioactivity in the soil immediately adjacent to the loss point by neutrons produced from the cascade of particles formed when the protons interact with matter.

Studies have been carried out at Fermilab on the activation of soil and the subsequent leaching of radionuclides from that soil. For this assessment, it was assumed that the two radionuclides of interest, H-3 and Na-22 (other radionuclides formed have very short half-lives or do not leach appreciably from the soil), were produced in beam loss and migrate without diffusion directly to a water well positioned at 50 m from the tunnel (SSC-SR-1026 1987). Such a well would be within the controlled zone for the SSC from which wells are excluded by design. Nevertheless, even if all of the H-3 and Na-22 produced in the soil by a full beam-loss accident reached one particular well 50 m from the tunnel, the concentration of radioactivity in that well for each of the site alternatives would be (from Appendix 12):

- For Na-22, in pCi/ml (EPA standard is 0.5 pCi/ml)

- Colorado	0.042
- Illinois	0.0051
- Michigan	0.0013
- North Carolina	0.060
- Tennessee	0.0012

- For H-3, in pCi/ml (EPA standard is 20 pCi/ml)

- Colorado	0.24
- Illinois	0.076
- Michigan	0.027
- North Carolina	0.35
- Tennessee	0.043

It should be noted that, although the accidental beam loss is assumed to occur only once, the above calculation takes into account the fact that the Na-22 and H-3 would be leached out of the soil over a period of many years. The numbers appearing above are the maxima (see Appendix 12). These maxima would appear in Colorado and North Carolina approximately 2 years after the accident; in Illinois, 5 to 8 years; in Michigan, 6 to 12 years; and in Tennessee, 8 to 18 years.

Arizona and Texas are not included in the calculations because there is essentially no groundwater flow at tunnel level at those sites. However, in these two cases, and in the cases where hydrogeologic conditions at various points around the tunnel at the other possible sites are such that there is no groundwater flow, it is possible to calculate the level of radioactivity in the soil as a result of a full beam loss. The total amount of radioactivity produced in the soil near the tunnel by an accidental beam loss would be (from Appendix 11):

H-3	9.1×10^9 pCi
Na-22	2.4×10^9 pCi
TOTAL	1.15×10^{10} pCi

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In Appendix 10, radioactivity is assumed to be in a block of soil of dimensions 4m x 3m x 20m.

If it is further assumed that the radioactivity does not move at all, that it is uniformly distributed throughout the soil block, and that the soil density is 2.24 g/cm^3, this amount of radioactivity would contaminate such an (underground) block of soil to an average level of 21 pCi/g. This is to be compared with the naturally occurring radioactivity in rocks which ranges from approximately 30 to 40 pCi/g (NCRP 45). Most of the radioactivity induced from the beam loss (80 percent, or about 17 pCi/g) is due to tritium which has a half-life of 12.3 yr. (The half-life of Na-22 is 2.6 yr.) In 12.3 years the amount of radioactivity from tritium would be 8.5 pCi/g; the amount from Na-22 would already be insignificant. In 25 years, the amount of radioactivity from tritium would be 4.25 pCi/g. The radioactivity would be concentrated closer to the tunnel and would diminish by about a factor of 10 for each meter past the tunnel wall. The differences between the soil calculation and the groundwater to a well calculation are: in the soil case, the radioactivity is assumed to stay in the same place; and in the well case, the radioactivity moves to the well over a period of time; in the well case the radioactivity is diluted by the water in the aquifer (see Appendix 12).

2. <u>Loss of Coolant in a Beam Absorber</u>

Over the majority of the accelerator complex, cooling water will be circulated well away from areas where beams would normally interact. The only notable exception will be the beam absorbers. The beam absorbers would have a graphite core surrounded by aluminum. The aluminum would be surrounded by steel and the steel by concrete (see Appendix 10). The aluminum cylinder would be cooled by a closed loop water system containing 1,600 liters of water. This water would become slightly radioactive because of the interactions of the cascade with the water in the coils. The only long-lived radionuclide produced is tritium. The activity of accumulated tritium over the assumed SSC operating lifetime of 25 years, assuming 2×10^{17} protons per year, is 0.14 Ci.

The tritium inventory in the coolant could be reduced or maintained at some administrative limit by periodically draining the system as is the practice at Fermilab.

The beam absorber would contain a liner system that would be monitored for any leaks that might develop. The liner system would contain a sump and secondary drainage system to collect and retrieve any water from leaks. In the unlikely event that a leak should develop in the system, it could be drained. If all systems failed, the amount of water that could escape the system would be dependent upon the gradient established by the position of the leak and the pressure within the system. In this case, the maximum loss of water is estimated to be 2 percent. The consequences of a loss of 2 percent would be similar to the release of tritium into the soil from a full beam loss.

The beam absorber is being designed so that loss of coolant would not impair its integrity, i.e., the graphite itself would not be directly cooled. Thus, the heat generated by a single beam dump into the absorber with no coolant would not damage the beam absorber.

3. Transportation of Low Level Radioactive Waste (LLRW)

Based on Fermilab experience, it is estimated that the SSC would generate 12 shipments per year of LLRW, and that these would be transported by truck from the SSC site to DOE's LLRW disposal site at Richland, Washington. Each shipment would be 600 to 1,000 ft^3 (total of 8,000 ft^3/yr) of solid material in containers, and would contain 0.75 to 1.26 Ci (total of 10 Ci/yr) of radioactive material. These assumptions were used as input to the computer code RADTRAN III.

The analysis resulted in the following (see Appendices 10 and 12 for detailed analysis):

- Total expected values of exposure dose to the population as a whole in an accident analysis would be less than one thousandth of a person-rem per year.
- Total latent cancer fatalities would be 1 in 100 million.
- Total genetic effect would be 1 in 10 million.

Transportation hazards of SSC LLRW could be easily mitigated by:

- Minimization of distance traveled.
- Minimization of generated wastes.
- Solidification of waste.

B. Hazardous/Toxic Materials

An accident with considerable potential for worker injury would be a major loss of cryogens in the tunnel. The liquid helium within the superconducting magnets is at a temperature near 4K (near absolute zero), and any exposure of any part of the body to such a temperature would cause severe tissue damage. On the basis of preliminary design and experience at Fermilab and other facilities using large amounts of cryogens (e.g., NASA), the DOE consideres the impacts of a large-scale cryogen loss on human health and safety would be small because workers encountering such a release would be able to evade the "plume" of escaping material rather easily by either walking or riding the transporter ahead of it. In addition, studies have shown that the cryogenic vapors would tend to stratify near the ceiling (helium) or the floor (nitrogen) in the tunnel environment, thus allowing for the remaining air space to provide sufficient oxygen for workers to breathe as they escape the area. Personnel would not normally be in the tunnel when cryogens are present (SSC Central Design Group 1988).

Mitigative measures to prevent or minimize the release of cryogens include elements of the SSC design such as pressure sensors; pressure relief valves and vent systems; strategically located shutoff valves; and warning sensors for oxygen, helium, and nitrogen strategically positioned throughout the tunnel.

Release of cryogens at the service areas presents no problem to the public. The cryogens (helium and nitrogen) are nontoxic and would readily dissipate into the atmosphere.

C. Safety

The most serious accident that could occur in the category of safety hazards is a fire in the tunnel. The SSC technical components that would be in the tunnel are designed to be non-flammable or fire-resistant. Very little in the way of combustible materials would be present in the tunnel during normal operations, thus effectively eliminating the risk of fire in the tunnel during operations. If somehow a fire did develop, even a rapidly-spreading fire, the beam could be extracted (in 1/3000th of a second) and radiological effects of the beam would not contribute to the problem. The residual radioactivity in the tunnel would be essentially all in metallic, nonflammable material.

However, there is a risk that a fire could occur during the construction and installation of the project. The impacts of a tunnel fire could be most serious in the time period before the full installation of the ventilation system and the warning sensors/alarm system. Additional materials would be in the tunnel at that time and a number of tasks would be taking place (such as welding) that could increase the possibility of a fire. (There would be no cryogens in the tunnel at this time.) Personnel training and implementation of fire protection procedures would be the primary means of fire prevention and control, with special emphasis on these during construction and installation.

The most common safety hazards associated with any large construction project are traffic accidents. Truck traffic expected for delivery of construction materials and hauling spoils to disposal sites has been estimated for all sites (see Table 5.1.6-4). The fewest truck mi/yr were about 2 million for the Tennessee site. The greatest, 19.5 million, was estimated for the Arizona site.

Using state accident rates (average for all types of vehicles), the increases in injury accidents/injuries and fatal accidents/fatalities due to truck traffic were estimated. The estimated number of injury accidents/injuries per year ranges from 2 to 40; the number of fatal accidents/fatalities is estimated to be much less than one per year.

Table 5.1.6-4

METHODOLOGY USED TO CALCULATE ESTIMATED INJURIES AND DEATHS DUE TO TRUCK TRAFFIC FROM SSC CONSTRUCTION AND SPOILS DISPOSAL

Calculation Parameters	AZ	CO	IL	MI	NC	TN	TX
No. of truck trips/day[1]							
Construction materials	93	86	64	95	103	81	74
Spoils disposal	480	480	480	480	480	480	480
Truck trip distance[2]							
Construction materials	40	75	40	70	25	40	45
Spoils disposal	70	25	10	15	5	1	25
Total truck mi/d[3]							
Construction materials	7,440	12,900	5,120	13,300	5,150	6,480	6,660
Spoils disposal	67,200	24,000	9,600	14,400	4,800	960	24,000
Combined total	74,640	36,900	14,720	27,700	9,950	7,440	30,660
Total truck mi/yr[4] (millions)	19.406	9.594	3.827	7.202	2.587	1.934	7.972
Statewide accident rate[5] (per 100 million mi)							
Injuries	205	-	248	229	214	-	-
Injury accidents[6]	-	107	-	-	-	118	103
Fatalities	3.2	-	2.2	2.4	3.1	3.0	2.4
Fatal accidents[7]	-	2.2	-	-	-	2.8	2.1
Projected max. annual rates due to SSC truck traffic							
Injuries/yr	40	-	9.5	16	5.5	-	-
Injury accidents/yr	-	10	-	-	-	2.3	8.2
Fatalities/yr	0.62	-	0.08	0.17	0.08	-	-
Fatal accidents/yr	-	0.21	-	-	-	0.05	0.17

1. Trips for construction materials are based on maximum estimate. Trips for spoils disposal are based on worst case of 10 tunnel boring machines running simultaneously.
2. Assumed construction materials would come from closest large metropolitan area. Spoils disposal distance was based on most likely (worst case) choice of the options presented by each state. The actual distances traveled may be lower.
3. Based on roundtrip mileage.
4. Based on maximum number of trucks for 260 days.
5. Includes all types of vehicles and is a statewide average value. Commercial vehicle rate would be lower and rates for the specific SSC area would be different from the state average. These data are not readily available. Also, some statistics are given as injuries per 100 million VMT and others as injury accidents per 100 million VMT. No consistent data from state to state.
6. Multiple injuries may result from an injury accident.
7. Multiple fatalities may result from a fatal accident.

5.1.7 Land Resources

Section 5.1.7.1 is a site-specific land use impact assessment conducted at both the regional and facility level. Impacts in the latter case are addressed first, followed by evaluations of the implications at the regional level. The focus of the assessment is to determine how SSC project development would alter land uses in the affected areas. In order to do this, the affected environment is described first, followed by a a definition of SSC project facilities by characteristic land use/zoning designations (see Chapter 4). Comparisons are made between existing and proposed land use followed by the assessments themselves. For this assessment, "facility" means the land required by the DOE plus a 1,000-ft band on either side of the site boundaries. "Regional" means the counties where the property is located.

Land use changes caused by SSC project development, including the relocation of affected property owners, would create a number of indirect or secondary impacts such as increased demand on housing supplies; tax base changes; changes in transportation, traffic, and circulation; changes in background noise levels; changes in scenic/visual character; and increased development pressure. Each of these concerns are addressed in the following other resource-specific sections of this chapter: Noise (Section 5.1.4), Socioeconomics and Infrastructure (Section 5.1.8), and Scenic and Visual Resources (Section 5.1.10).

Section 5.1.7.2 addresses impacts resulting from the total and permanent removal of prime, unique, and important farmlands due to construction of SSC units, i.e., lands that are physically covered by buildings, roads, and spoils sites.

5.1.7.1 Land Use

A. Comparisons Between Existing and Proposed Land Use Changes

Standardized land use/zoning designations are used for determining the land use changes associated with project development and the degree of difference expected. The results are presented in Table 5.1.7-1. A "major" degree of difference is ascribed to those cases where there is likely to be a wholesale change in land use/zoning character, such as a change from "rural" or "agricultural" to a "medium industrial" use. A "minor" degree of difference is ascribed to those cases where there is likely to be a perceptible shift in land use/zoning character, but less so than with the other case.

Upon review of the data presented in the table, it appears that despite obvious variations in regional settings, there is a high degree of congruence among the seven sites in terms of types of land use changes anticipated by SSC project development. As a result, the following generalizations can be made:

Table 5.1.7-1

DIFFERENCES EXHIBITED BETWEEN EXISTING AND PROPOSED LAND USE/ZONING DESIGNATIONS FOR SITE-SPECIFIC PROJECT FACILITIES REQUIRING BUILDING CONSTRUCTION

	Associated	CURRENT USE/ZONING						
SSC Project Facility	Zoning Designation	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Campus Area A	Medium Industrial	Rural	Agric	Instit/Resrch	Agric	Rural	Rural/Resid	Agric/Rural
Injector Area B Major	Medium Industrial	Rural	Agric	Instit/Resrch	Agric	Rural/Mil	Rural/Resid	Agric/Resid
Intermediate Access Areas E								
E1	Light Industrial	Rural	Agric	Mixed	Agric	Rural	Rural/Resid	Wooded
E2	Light Industrial	Rural	Agric	Farm	Mob. Home Dist.	Agric	Rural/Resid	Pasture
E3	Light Industrial	Rural	Agric	Mixed	Agric	For	Agric	Agric
E4	Light Industrial	Rural	Agric	Mixed	Agric	Resid	For	Agric
E5	Light Industrial	Rural	Agric	Farm	Agric	For	For	Range
E6	Light Industrial	Rural	Agric	Farm/Mixed	Agric	For	Agric	Past/Wetl
E7	Light Industrial	Rural	Agric	Farm/Mixed	Agric	Rural/For	Rural	Agric
E8	Light Industrial	Rural	Agric	Mixed	Agric	Rural/For	Rural	Range/Wetl/Agr
E9	Light Industrial	Rural	Agric	Resid	Agric	Agric/For	Rural/Resid	Wetland
E10	Light Industrial	Rural	Agric	Mixed	Agric	Agric	Rural/Resid	Pasture
Service Areas F								
F1	Medium Industrial	Rural	Agric	Mixed	Agric	Rural	Rural/Resid	Pasture
F2	Medium Industrial	Rural	Agric	Resid	Agric	Agric	Rural/Resid	Past/Range
F3	Medium Industrial	Rural	Agric	Agric/Mixed	Agric	Resid	Agric	Agric Distr
F4	Medium Industrial	Rural	Agric	Farm/Mixed	Agric	Agric	Agric	Agric
F5	Medium Industrial	Rural	Agric	Farm/Mixed	Agric	For	Agric	Range
F6	Medium Industrial	Rural	Agric	Farm/Mixed	Agric	For	For	Range/Wetl
F7	Medium Industrial	Rural	Agric	Farm/Mixed	Agric	Agric/For	Rural	Agric
F8	Medium Industrial	Rural	Agric	Estate/Mixed	Agric	For/Agric	Rural	Agric
F9	Medium Industrial	Rural	Agric	Manu/Mixed	Agric	For/Agric	Rural/Resid	Agric
F10	Medium Industrial	Rural	Agric	Resrch/Mixed	Agric	Rural	Rural/Resid	Agric
Interaction Points and Experimental Areas K								
K1	Light Industrial	Rural	Agric	Inst/Agric	Agric	Rural	Rural	Agric
K2	Light Industrial	Rural	Agric	Inst/Agric	Agric	Rural	Rural	Past/Range
K3	Light Industrial	Rural	Agric	Farm	Agric	For	For/Agric	Range
K4	Light Industrial	Rural	Agric	Farm	Agric	Agric	Agric	Range
K5	Light Industrial	Rural	Agric	Farm	Agric	Agric/For	Rural/for	Pasture
K6	Light Industrial	Rural	Agric	Farm	Agric	Agric/For	Agric	Pasture

- Three types of SSC project facilities are expected to exhibit major degrees of difference in land use: campus area A. injector area B, and service areas F.

- Two types of SSC project facilities are expected to exhibit minor degrees of difference in land use: intermediate access areas E and interaction points and experimental areas K.

The only exceptions to these generalizations are the Illinois and Michigan sites, which have portions of the SSC project sited in compatibly zoned areas. In addition, the Michigan intermediate access area E-2 site is located in an area that is currently zoned as a mobile-home district. As such, the site is classified as having a "major" degree of difference. The proposer has indicated that it would relocate the existing mobile-home park, thereby causing the adjacent land use to revert to a more characteristic agricultural setting, and therefore be classified as a "minor" degree of difference.

B. Assessment of Land Use Changes - Local Impact

The land use/zoning designation changes identified are used to measure impact. For this assessment, all land use changes for primary project facilities are considered to be long-term, though not irreversible, since SSC project facilities can conceivably be removed with current land uses reinstated. The only discriminator then is magnitude or size of the impacts. The following generalizations can be made about the sites. Those facilities that produce large, measurable impacts are campus area A, where construction would involve approximately 200 acres out of the 350-acre total surface area required; injector area B, where construction would involve approximately 280 acres out of the 1,700-acre total surface area required; and service areas F, where construction would involve approximately 2.5 acres at each of the ten sites, for a 25-acre total surface area required. Experimental hall construction (K areas) would disturb 5-23 acres per hall. Those facilities producing small measurable impacts are intermediate access areas E, where construction would involve approximately 1 acre at each of the ten sites, for a 10-acre total surface area required. As stated before, the only exceptions are Illinois and Michigan, where present land uses in some areas are compatible with proposed SSC land use.

C. Evaluation of Development Implications - Regional Impact

Site-specific evaluations of regional impacts compare hypothetical land use development with the SSC with probable development without the SSC. Near cluster quadrant development would likely spawn the greatest amount of associated land use changes due to the types of activities and employment associated with campus area A, injector area B, two interaction points and experimental areas K, four service areas F (including the one located in the injector area), and two intermediate access areas E. As a result, a host of needs would emerge, some of which would be supplied by firms located in new development areas outside the entrance area and along the major access road leading to campus area A. The range of new development would likely include a mix of retail businesses, such as automobile service stations, restaurants, and personal services establishments; hotels/motels; technical support services, such as computer and other equipment servicing centers; and project-related research and technology (R&D) support and/or spin-off firms.

Far cluster quadrant development would likely promote the second greatest amount of associated land use changes due to the types of activities and employment associated with four interaction points and experimental areas K; three service areas F; and two intermediate access areas E. As a result, daily needs of workers would emerge, some of which would be supplied by retail businesses located in either nearby communities or in newly developed areas located along the periphery of the far cluster area. The range of new retail businesses would likely include automobile service stations, fast-food eateries, and restaurants.

Upper and lower arc quadrant development would likely promote low levels of associated land use changes due to the periodic spacing of three intermediate access areas E and three service areas F, per quadrant. As a result, little in the way of retail business development would emerge.

The development scenario with the SSC appears to be an appropriate model for likely development in Michigan, North Carolina, Tennessee, and Texas. The development scenario does not seem to fit as well for Arizona, Colorado, and Illinois. The Arizona and Colorado sites are similar to each other in that both sites are located in rural areas where there is a lack of either current transportation access and/or a network of settlements to serve as nodes for commercial growth. The Illinois site differs from the development scenario because of its generally rural/suburban location where there is a sufficient business and commercial base from which to support the needs of SSC workers.

SSC project development in Arizona would, undoubtedly, create more demand for and pressure on existing BLM-managed recreation and wilderness resources in the project area. SSC project development would cause a shift in classification of the area by BLM from a "semi-primitive, motorized" area to a "roaded, natural" area. This represents a one-step change toward "modern urban" forms of recreation opportunities in BLM's lexicon. All three BLM Wilderness Study Areas (WSA), i.e., north Maricopa Mountains (AZ-020-157), south Maricopa Mountains (AZ-020-163), and Butterfield Stage Memorial (AZ-020-164), would experience a long-term loss of wilderness character as a result of SSC project development. This would occur both in the directly impacted areas and in the larger viewshed areas of each respective WSA, as visitors' perceptions of naturalness would be adversely affected. SSC project and associated development would cause a loss of naturalness and would likely lower or even eliminate solitude and sensitive recreation opportunities.

SSC project development in Arizona will result in inconvenience to livestock grazing operations permitted by the BLM. Increased accessibility may result in vandalism to livestock management improvements, such as fencing and stock ponds. Grazing management units may need to be segregated as new roads are installed and facilities are fenced. As a result, grazing allotment permittees may need to increase the supervision of their operations.

Projected land uses near the proposed SSC sites would be significantly different than if the SSC were not constructed at that site. The only exception appears to be Illinois. The greatest changes are expected close to the near and far cluster with minor or no changes in the vicinity of the upper and lower arcs.

5.1.7.2 Impacts of SSC on Farmlands at the Proposed Sites

Table 5.1.7-2 shows considerable differences between the total of farmland acreages (as defined in the Farmland Protection Policy Act) impacted by the types of proposed actions. The Arizona site has no impacted acreage. The North Carolina and Tennessee sites have the highest estimate of impacted farmlands. These are determined by the construction of 25.3 mi of a four-lane highway in North Carolina and by the construction of spoils disposal sites in Tennessee amounting to approximately 360 acres. Half of the impacted prime farmlands in Colorado are due to the 58 mi two-lane highway connecting the site to Denver, and one-third of the impacted farmlands in Texas are due to 22 mi of two-lane paved roads anticipated to be constructed all around the site.

Among all categories the construction of new roads represents the highest impact when all sites are considered together: an average of 38.5 percent of impacted farmlands are due to road construction. Although the proportion of farmlands covered by spoil disposal sites is less than one-fifth of the impacted farmland acreage, this category differentiates sites considerably because of its large range; the Illinois site has no acreages of farmlands used for spoils disposal sites, while the Tennessee site covers more than 100 acres of farmland for spoils.

The estimated total permanently removed prime and important farmland:

Arizona	0 acres
Colorado	819 acres
Illinois	197 acres
Michigan	341 acres
North Carolina	955 acres
Tennessee	606 acres
Texas	588 acres

None of these acreages is as much as one percent of the total prime farmlands inventory of the seven regions.

Table 5.1.7-2

SUMMARY OF PERMANENTLY CONVERTED AND TEMPORARILY DISTURBED FARMLANDS IN THE SSC REGION

	Permanently Converted		Temporarily Disturbed	
	Prime	Important	Prime	Important
AZ	0	0	0	0
CO	0	819	0	1,129
IL	185	12	217	14
MI	205	136	346	230
NC	630	325	459	237
TN	415	191	341	157
TX	430	158	297	109

5.1.8 Socioeconomics and Infrastructure

5.1.8.1 Economic Activity, Labor Force, and Income

The location of the proposed SSC sites and their associated Regions of Influence (ROI) for the socioeconomic analyses are shown in Figure 5.1.8-1 through 5.1.8-7. The ROI includes all the counties shown for each site in these figures. Two levels of impact are evaluated for each state: regional for the areas shown in the figures and local for the counties in which the SSC would actually be sited.

It is not possible to predict with certainty the detailed regional labor market characteristics more than a decade into the future or the extent of local hiring and worker in-migration. A reference case was constructed for each region to provide an indication of the likely conditions, including the likely extent of worker in-migration due to the SSC. Depending on the worker category treated, this reference case considered the size of each region's labor force, recent unemployment rates, and adult education levels. The approach taken in each category is as follows:

- Construction craft labor is assumed to in-migrate inversely to each region's unemployment rate, as shown by results of a 1979 work force survey covering 51 large construction projects (U.S. Army Corps of Engineers 1981).

- Direct clerical workers and all secondary workers are assumed to in-migrate as a function of the ratio of the region's unemployment rate to the rate for the nation.

- Direct technical workers are assumed to in-migrate as an inverse function of the size of the region's unemployed labor force, and inversely with the ratio defined by the percent of the region's adult population with 16 or more years of education compared to that percentage for the nation.

- SSC managers, physicists, and other professionals (except for visiting scientists, all of whom would be in-migrants) are assumed to in-migrate as an inverse function of the adult education ratio used for technical workers, and also inversely with the region's labor force size.

Direct relocations of residences and businesses because of land acquisition are an impact of the project (see Table 5.1.8-1). Relocations are subject to Federal relocation benefits described in the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) and the DOE relocation rules "Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs" (10 CFR 1039, 51 FR 7000).

Figure 5.1.8-1

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED ARIZONA SITE

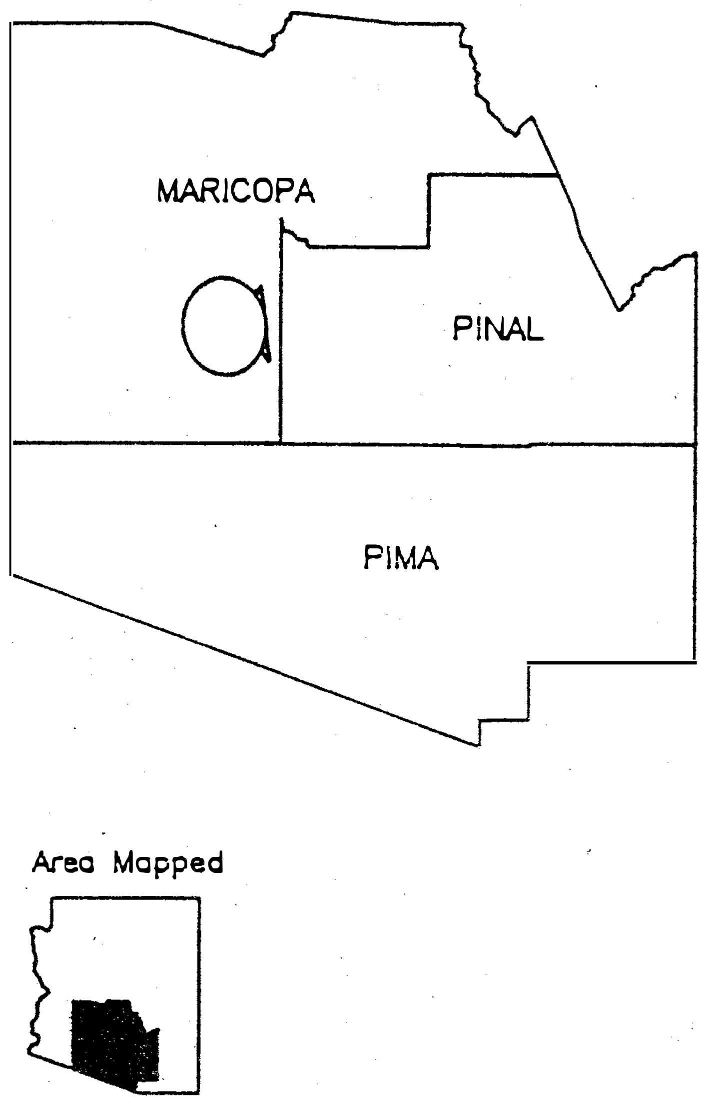
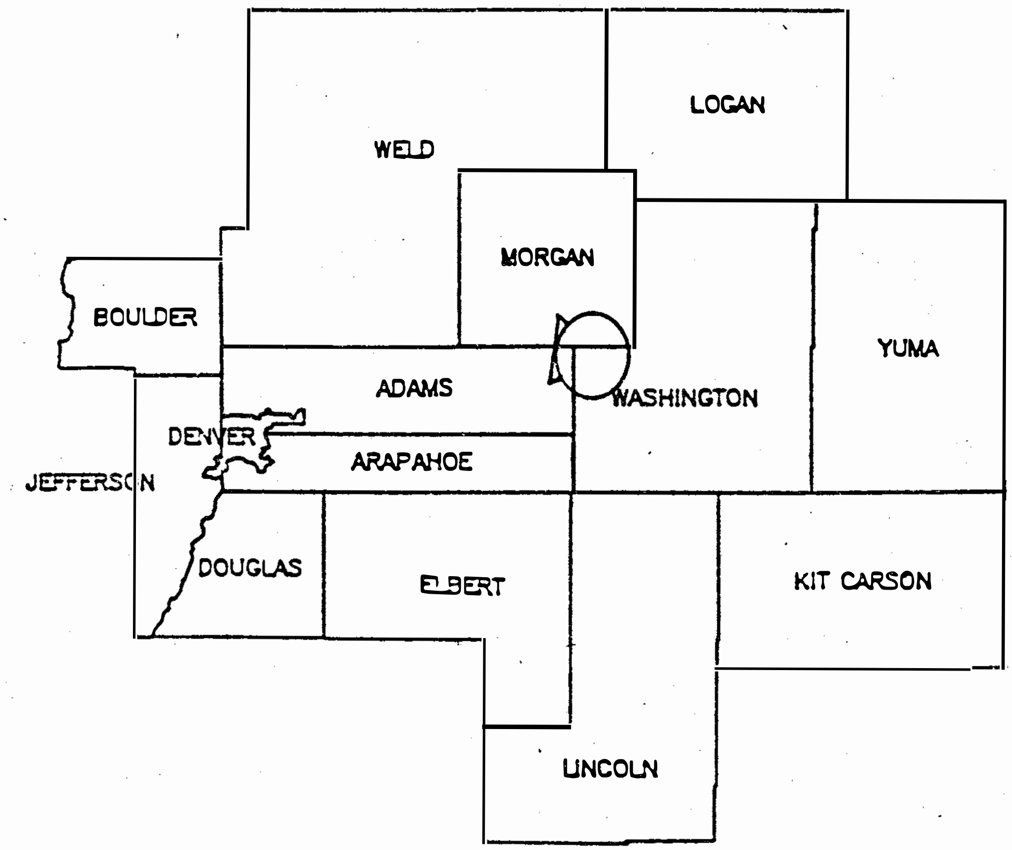


Figure 5.1.8-2

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED COLORADO SITE



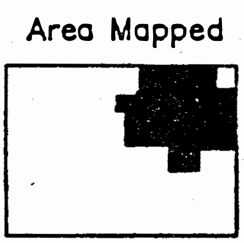


Figure 5.1.8-3

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED ILLINOIS SITE

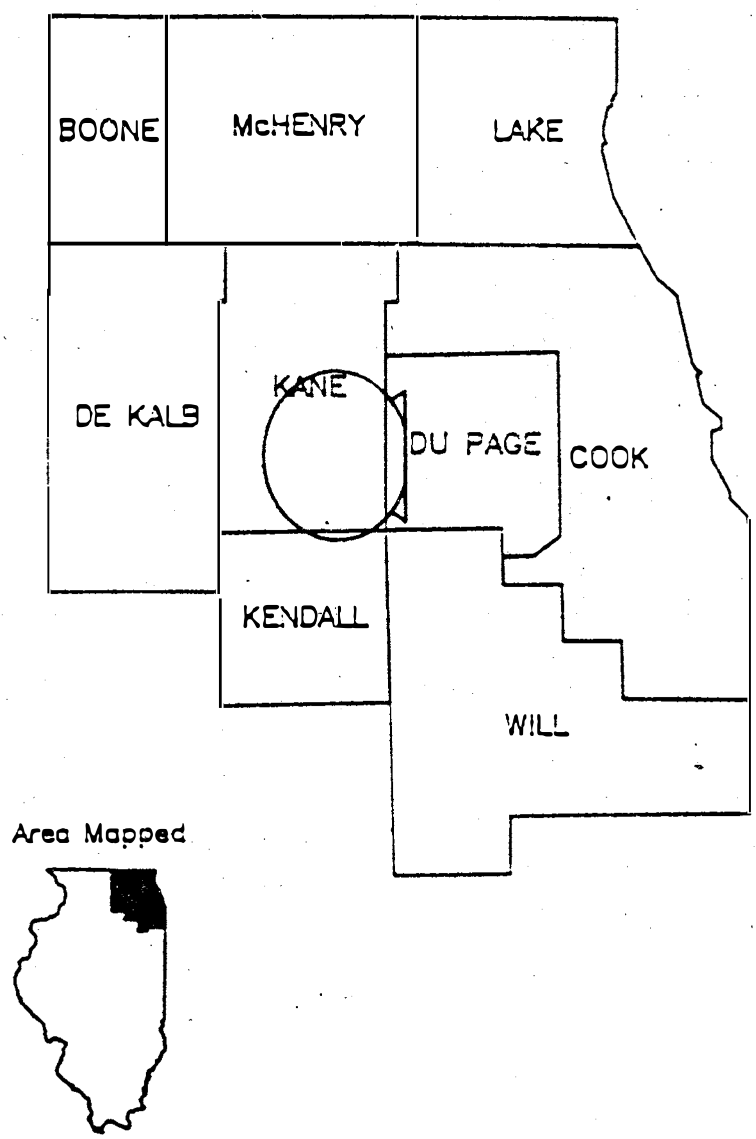
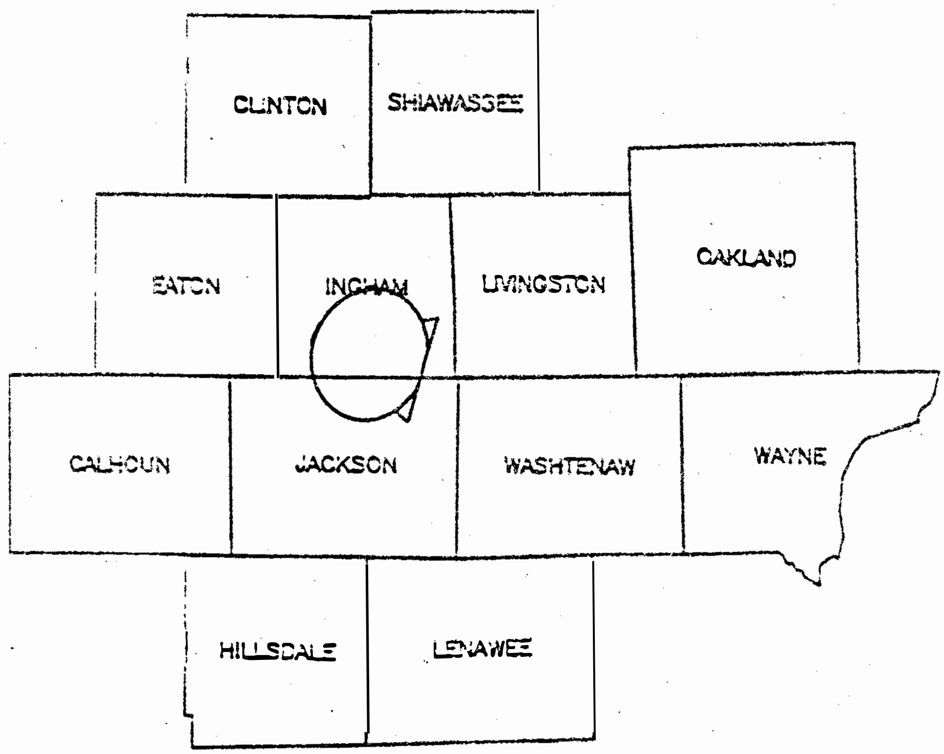


Figure 5.1.8-4

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED MICHIGAN SITE



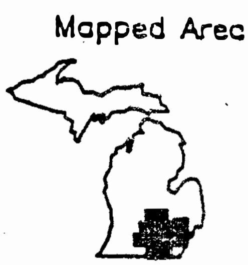
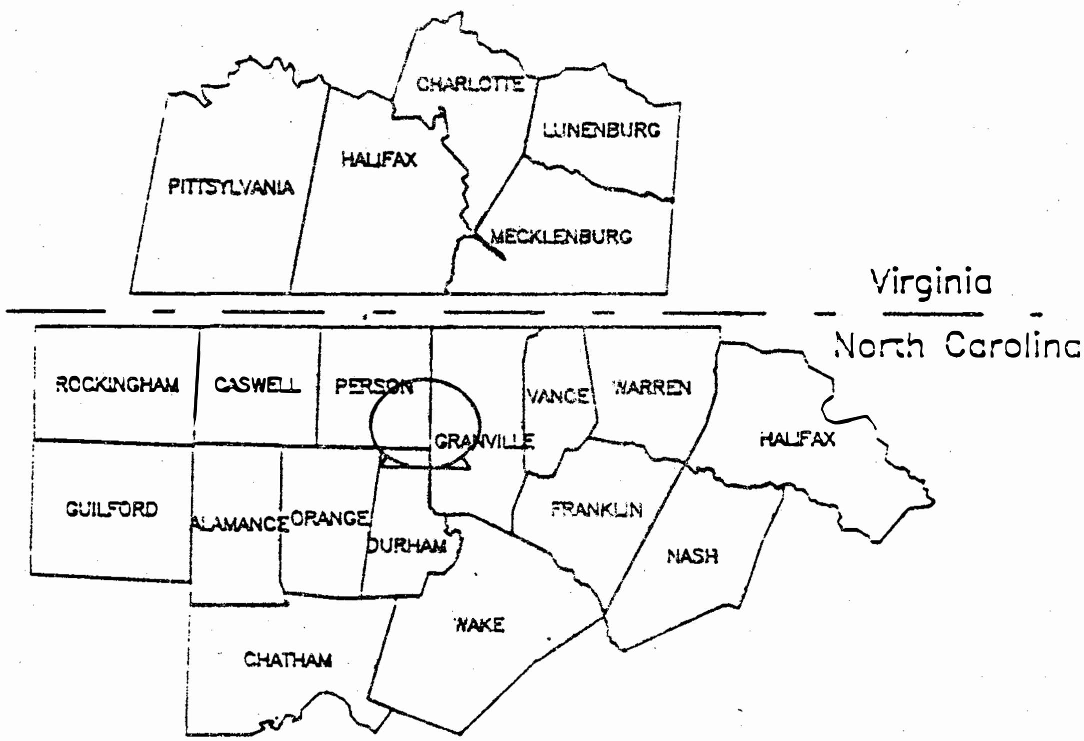


Figure 5.1.8-5

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED NORTH CAROLINA SITE



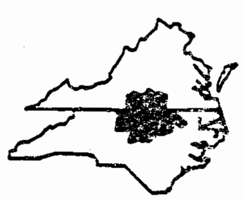
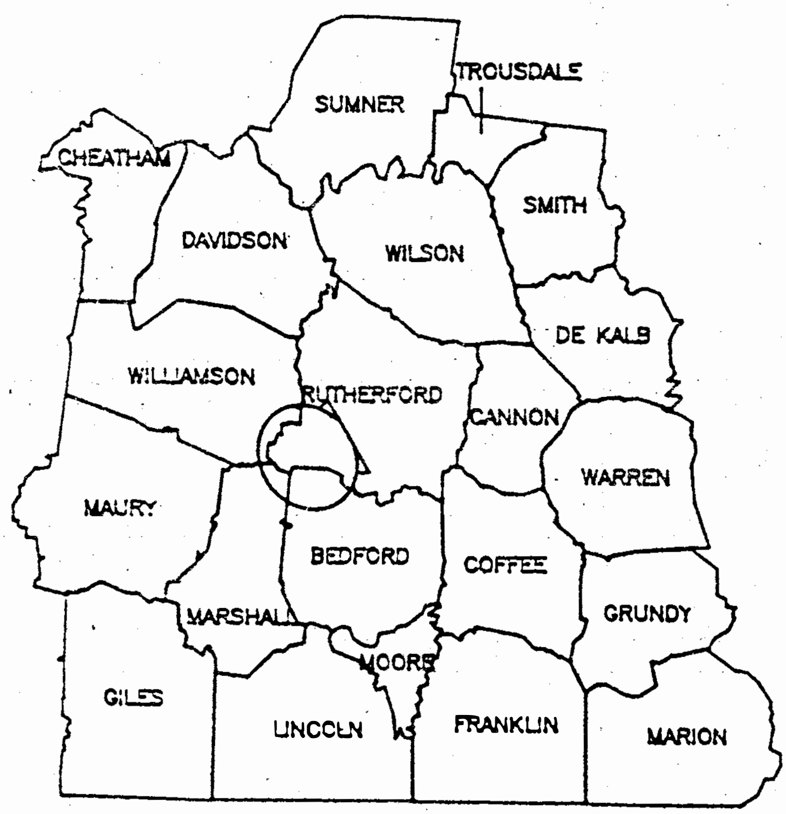


Figure 5.1.8-6

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED TENNESSEE SITE



Area Mapped

Figure 5.1.8-7

SOCIOECONOMIC REGION OF INFLUENCE FOR PROPOSED
TEXAS SITE

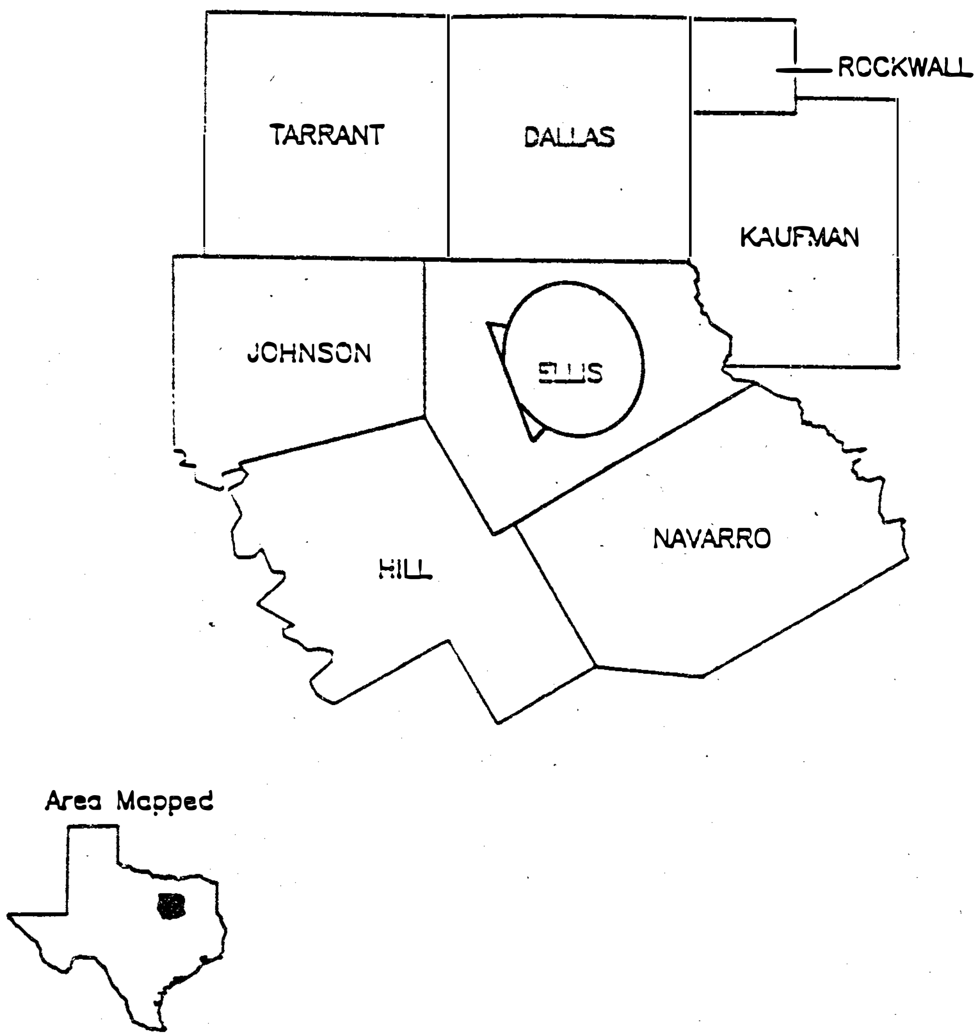


Table 5.1.8-1

SUMMARY OF SITE-SPECIFIC LAND ACQUISITION PLANS - PARCELS

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
PROPOSED PARCEL ACQUISITION							
Total Number of Parcels Affected	224	157	3,305	801	826	898	614
Fee Simple	224	157	437	333	*	434	318
Strat. Fee	0	0	2,868	468	*	464	296
Affected Parcels, by Ownership			*	*	*	*	*
Federal	82	0					
State	5	4					
Local	0	0					
Private	137	153					
Total Number of Ownerships	139	67	2,750	687	780	807	420
Fee Simple	139	67	*	286	*	*	240
Strat. Fee	0	0	*	401	*	*	180
Total Number of Relocations	6	23	219	221	180	128	175

* Not furnished by the State proposal

1CHP5Y336889

These laws cover the payment of fair market value for acquired property and specific relocation benefits such as payment towards moving and new residence purchase.

The total number of affected landowners and tenants would create an incremental demand for housing and business property in the ROI's. The change in the quality of life is discussed in Section 5.1.8.5.

Five types of impacts are presented below. These are: 1) economic activity, labor force, and income; 2) demographics and housing; 3) public services; 4) public finance; and 5) quality of life/social well-being. The discussion presented below is quantitative where possible, allowing comparison of impacts against baseline trends in the regions as well as comparison of impacts among sites.

Two years are used for comparison and for illustrative purposes in this chapter, the peak year of construction, 1992; and the first year of full operations, 2000. The peak year of construction represents the maximum number of persons involved in construction for most trades. It therefore represents the peak effect in terms of impact on communities. The first year of full operations represents the approximate level of employment through the rest of the life of the SSC.

Direct economic impacts from SSC construction and operations would not vary substantially among the seven regions. Indirect and induced impacts would exhibit a greater range, however, because of differing economic conditions in the various regions. There would be marked differences between regions in terms of total SSC-related impacts relative to baseline conditions.

Total SSC-related employment impacts, including both direct and indirect, at the peak of construction activities range from about 9,400 jobs in the Tennessee region to about 10,500 jobs in the Illinois region (see Table 5.1.8-2). Most of this variation is caused by differences in secondary (indirect and induced) economic activity. Peak direct employment impacts (in 1992) would be about 3,500 jobs in the Illinois region; about 3,800 to 3,900 jobs in Michigan, North Carolina, Tennessee, and Texas; and almost 4,000 jobs in Arizona and Colorado.

Peak secondary employment ranges from 5,000 to 6,000 jobs. Illinois would have a higher secondary employment impact than other sites because of higher numbers of transactions among industries and other higher indirect effects which are regional characteristics.

When fully operational, the SSC would directly employ about 3,250 persons, regardless of the region (see Table 5.1.8-2). Varying indirect effects, coupled with differing rates of output being produced on the average by workers in the various regions, result in total employment impacts during operations ranging from about 6,200 jobs in Arizona to more than 7,000 jobs in Illinois.

The SSC job impacts range from 0.2 to 1.5 percent of total current jobs in the ROI (see Table 5.1.8-2). The highest job gains relative to regional baseline employment would occur if the SSC is located in Tennessee where SSC-related jobs during peak construction would be about 1.3 percent of baseline jobs. The corresponding figure for the North Carolina region is about 0.9 percent, with the relative increase less for all other regions. During full operations, SSC-related jobs would exceed baseline employment by less than 1 percent in all of the regions, ranging from a low of less than 0.2 percent in Illinois to over 0.8 percent in Tennessee.

Total SSC-related annual earnings (including direct, indirect, and induced earnings) range from about $260 million in the Tennessee region to about $335 million in Illinois (see Table 5.1.8-3). All monetary values cited in this section are in terms of 1988 dollars unless otherwise indicated. This wide range can be explained in part by differences in total employment, and in part by differing earnings per worker levels. Varying makeup of the indirect and induced employment gains, whether in manufacturing or in services or in other economic sectors, also contribute to this variation. Total annual earnings during full operations vary from about $160 million in the North Carolina region to almost $210 million in Illinois.

Indirect and induced economic effects are triggered by direct SSC-related regional spending, including the goods and services procured in the region for construction and operations of the SSC and consumer spending in the region by workers directly employed by the SSC. These direct SSC sales demands range from about $216 million in Tennessee to $265 million in Colorado during the peak year of construction, and annually from about $144 million in North Carolina and Texas to nearly $160 million in Arizona during full operations.

Low rates of transactions among businesses and indirect effects in the Arizona region lead to the lowest levels of total SSC-related sales there, about $370 million during the peak year of SSC construction and about $235 million annually during full operations. The greatest annual impact to total sales (more than $495 million) would occur in Illinois during the year of peak construction. During full operations, total sales impacts would be greatest in Illinois (more than $300 million a year).

By considering regional unemployment rates, labor force sizes, and relative levels of education among the adult populations of each region, in-migrant workforce estimates were prepared. Recent high unemployment in the Colorado and Michigan regions contributes to relatively low in-migrant workforce estimates; resident labor forces there would be more likely to seek SSC-related employment than in the other regions.

Table 5.1.8-2

SSC-RELATED REGIONAL EMPLOYMENT IMPACTS

	Peak Year of Construction 1992	First Year of Full Operations 2000
	(Number of jobs)	
Arizona ROI		
Direct SSC jobs [1]	3,976	3,248
Total SSC-related jobs [2]	9,477[4]	6,160
Percent of baseline jobs [3]	0.[illegible][4]	0.35
Colorado ROI		
Direct SSC jobs [1]	3,982	3,248
Total SSC-related jobs [2]	10,361[4]	6,381
Percent of baseline jobs [3]	0.72[4]	0.37
Illinois ROI		
Direct SSC jobs [1]	3,452	3,234
Total SSC-related jobs [2]	10,495	7,030
Percent of baseline jobs [3]	0.26	0.17
Michigan ROI		
Direct SSC jobs [1]	3,627	3,248
Total SSC-related jobs [2]	9,621	6,322
Percent of baseline jobs [3]	0.42	0.27
North Carolina ROI		
Direct SSC jobs [1]	3,858	3,248
Total SSC-related jobs [2]	9,615[4]	6,399
Percent of baseline jobs [3]	0.93[4]	0.55
Tennessee ROI		
Direct SSC jobs [1]	3,775	3,248
Total SSC-related jobs [2]	9,417	6,856
Percent of baseline jobs [3]	1.31	0.85
Texas ROI		
Direct SSC jobs [1]	3,819	3,248
Total SSC-related jobs [2]	9,651	6,513
Percent of baseline jobs [3]	0.44	0.26

1. Onsite employment; 1992 impacts include some preoperations
2. Direct, indirect, and induced employment in the region because of SSC
3. Total SSC-related employment as a percent of projected future employment in the ROI without the SSC
4. 1991 is peak year for secondary and total SSC-related jobs

Table 5.1.8-3

SSC-RELATED REGIONAL EARNINGS AND SALES IMPACTS[1] DURING PEAK YEAR OF CONSTRUCTION AND FIRST YEAR OF OPERATIONS

	Peak Year of Construction 1992	First Year of Full Operations 2000
	($ million, rounded to nearest $100,000)	
Arizona ROI		
Total SSC-related earnings[2]	$312.0[5]	$180.3
Direct SSC sales demand[3]	250.4[5]	159.1
Total SSC-related sales[4]	370.5[5]	235.8
Colorado ROI		
Total SSC-related earnings[2]	327.3[5]	181.7
Direct SSC sales demand[3]	265.6[5]	150.4
Total SSC-related sales[4]	479.8[5]	268.1
Illinois ROI		
Total SSC-related earnings[2]	336.0	207.7
Direct SSC sales demand[3]	231.4	146.8
Total SSC-related sales[4]	496.5	301.7
Michigan ROI		
Total SSC-related earnings[2]	318.2	185.8
Direct SSC sales demand[3]	240.8	157.4
Total SSC-related sales[4]	465.0[5]	282.1
North Carolina ROI		
Total SSC-related earnings[2]	266.4[5]	162.5
Direct SSC sales demand[3]	238.2[5]	143.5
Total SSC-related sales[4]	415.2[5]	247.8
Tennessee ROI		
Total SSC-related earnings[2]	259.9[5]	174.9
Direct SSC sales demand[3]	216.2[5]	152.2
Total SSC-related sales[4]	404.2[5]	281.2
Texas ROI		
Total SSC-related earnings[2]	304.6[5]	186.4
Direct SSC sales demand[3]	230.4[5]	144.5
Total SSC-related sales[4]	446.7[5]	267.9

Notes: 1. All figures are in millions of 1988 dollars
2. Includes direct, indirect, and induced earnings in the region
3. Includes SSC purchases of goods and services, and consumer spending by direct SSC workers
4. Includes direct, indirect, and induced sales in the region
5. 1991 peak year

As shown in Table 5.1.8-4, Michigan would have the lowest in-migrant work force and would have about 2,230 in-migrant workers during peak construction and about 1,530 in-migrant workers during full operations. Colorado is next with peak construction year numbers of in-migrants at 2,790 and 1,850 during full operations. Although unemployment rates are relatively lower in the Illinois region, the regional labor force is large enough to reduce in-migration there in response to SSC-related jobs. Estimates for Illinois lie near the mid-range--about 3,300 in-migrant workers during peak construction and about 2,400 such workers during full operations. Labor force impacts in Texas would also be at about the mid-range. Conversely, low unemployment rates in Arizona and relatively small labor forces in North Carolina and Tennessee result in estimates near the high end of the range for these three regions. The estimates during peak construction are highest in North Carolina at about 5,000 in-migrant workers. During full operations, estimates of in-migration are highest for Tennessee at about 3,620 workers.

5.1.8.2 Demographics and Housing

Regionally, total population increases related to the SSC during the peak of SSC construction would range from about 6,700 persons in Michigan to about 15,100 persons in North Carolina (see Table 5.1.8-5). Relative to baseline population, the population impact of more than 14,600 in the Tennessee region would be highest during the construction phase at about 1.1 percent. The peak impact in North Carolina would be just under 0.83 percent of baseline population. The peak population impacts might never exceed one-half of 1 percent of baseline population for any of the other regions; impacts in both the Illinois and Michigan regions would be the lowest, each under 0.15 percent.

Regionally, during full operations, reference case population impacts would range from a low of about 5,300 persons in Michigan to almost 13,000 in North Carolina and Tennessee. That impact in the Tennessee region represents about 0.9 percent of projected baseline regional population in the year 2000. North Carolina population estimates for the year 2000 are over 0.6 percent of baseline population. All other regions would experience population impacts of 0.3 percent or less of baseline population.

Housing demand is estimated based on in-migrant workers. Approximately two-thirds of the in-migrants typically have families. It is assumed that each family would demand housing. Singles are assumed to demand housing at a rate of 2.24 individuals per unit demanded.

Estimates of peak housing demands during construction range from about 1,800 in the Michigan region to nearly 4,100 in North Carolina. During full operations, the lowest housing unit demand would be about 1,250 in Michigan, and the highest would be almost 3,000 in Tennessee.

Local impact could result from the implementation of the project. However, local area housing markets mostly would not experience sizeable impacts caused by the SSC, compared to projected housing stocks (see

Table 5.1.8-4

SSC-RELATED REGIONAL LABOR FORCE IMPACTS: IN-MIGRANT WORK FORCE*

State	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
					(rounded to tens of individuals)							
Arizona	720	2,470	4,400	4,410	3,650	3,790	3,050	2,440	2,290	2,690	2,920	3,000
Colorado	430	1,560	2,750	2,790	2,330	2,470	2,020	1,620	1,460	1,680	1,810	1,850
Illinois	510	1,680	3,130	3,290	2,850	2,940	2,390	2,010	1,840	2,150	2,320	2,380
Michigan	300	1,170	2,100	2,230	1,970	2,120	1,760	1,400	1,220	1,400	1,500	1,530
North Carolina	850	2,810	5,000	4,970	4,090	4,270	3,490	2,810	2,660	3,140	3,410	3,490
Tennessee	830	2,650	4,810	4,860	4,110	4,340	3,610	2,910	2,750	3,250	3,530	3,620
Texas	490	1,740	3,180	3,290	2,860	3,010	2,460	1,950	1,780	2,070	2,240	2,290

*Number of individuals who would in-migrate to the ROI to fill a direct or indirect job created as a result of the SSC being located in that state.

Table 5.1.8-5

SSC-RELATED REGIONAL POPULATION AND HOUSING IMPACTS

	Peak Year of Construction 1992	First Year of Full Operations 2000
Arizona ROI		
Population impact [1]	13,240	10,490
Percent over baseline [2]	0.43	0.29
Housing unit demand [3]	3,610	2,460
Colorado ROI		
Population impact [1]	8,350	6,300
Percent over baseline [2]	0.38	0.26
Housing unit demand [3]	2,290	1,520
Illinois ROI		
Population impact [1]	9,890	8,250
Percent over baseline [2]	0.13	0.11
Housing unit demand [3]	2,700	1,950
Michigan ROI		
Population impact [1]	6,680	5,290
Percent over baseline [2]	0.14	0.11
Housing unit demand [3]	1,830	1,260
North Carolina ROI		
Population impact [1]	15,060	12,960
Percent over baseline [2]	0.83	0.65
Housing unit demand [3]	4,070	2,870
Tennessee ROI		
Population impact [1]	14,640	12,690
Percent over baseline [2]	1.12	0.93
Housing demand unit [3]	3,990	2,970
Texas ROI		
Population impact [1]	9,880	7,960
Percent over baseline [2]	0.28	0.20
Housing unit demand [3]	2,700	1,880

Notes:
1. Based on work force in-migration; includes in-migrant workers, their families at time of arrival to the region, and natural increases in population following their arrival (rounded to tens)
2. Population impact as a percent of projected future baseline population in the ROI (rounded to significant digits)
3. Demand for housing units in the ROI associated with in-migration; includes demands of families as well as that by individual workers who may share dwellings (rounded to tens of units)

Tables 5.1.8-5 and 4-26). Noteworthy exceptions would be housing markets of Fort Morgan and Brush in Morgan County, Colorado, where the SSC-related housing demand would be large compared to baseline housing requirements. The other important exception might be in the village of Stockbridge in Ingham County, Michigan, where the housing demand could double as a result of the SSC.

5.1.8.3 Public Services

Regionally, demands for public services would not increase substantially overall because of SSC-related population impacts for any of the seven regions. Only in Arizona, North Carolina, and Tennessee during peak construction, would total government employment require an increase of more than 400 jobs (see Table 5.1.8-6). As few as 210 would be needed in Michigan at the peak of SSC construction. Public employment impacts during operations would range from less than 170 in Michigan to 426 in North Carolina.

Localized SSC-related public service impacts would show greater variances. Entirely new service systems would be needed near Arizona's proposed site since the area currently is not developed. Rural eastern Adams County in Colorado would require a major expansion of its services, and services in Morgan County would also require expansion. Public services in the village of Stockbridge, Michigan, would similarly need to be built up in anticipation of a potential doubling of population as a result of the SSC. Local services in Illinois, North Carolina, Tennessee, and Texas could probably absorb SSC-related demands with less disruption.

On-site services would be provided by the DOE's Management and Operating (M&O) contractor. Typically, on-site emergency services, security, and other operational support such as gasoline stations are provided. DOE M&O contractors would also work with local public service agencies to coordinate other services and provide emergency planning for the facilities and the host community.

5.1.8.4 Public Finance

Net public finance effects are the differences between the state, regional, and local government revenues with the project-implemented and the no-action alternatives for any site.

Regionally, net public finance effects to state governments from SSC construction and operation would vary widely among the seven sites, mainly because of differing tax rates. For purposes of this analysis, credit has not been taken for the positive changes in land values and tax revenues on lands surrounding the SSC. These benefits are expected to be substantial but cannot be accurately predicted, especially during the construction period. There are also major differences in the projected effects to local government jurisdictions which result, in part, from differing tax rates but also because of the differing levels of SSC-related population effects in each local area and because private land would be transferred to Federal ownership.

Table 5.1.8-6

SSC-RELATED EDUCATION AND PUBLIC EMPLOYMENT IMPACTS

	Peak Year of Construction 1992	First Year of Operations 2000
Arizona ROI		
School enrollments[1]	2,759	2,510
Teachers required[2]	143	130
Total government employment[3]	477	377
Colorado ROI		
School enrollments[1]	1,700	1,463
Teachers required[2]	90	78
Total government employment[3]	296	223
Illinois ROI		
School enrollments[1]	2,029	2,004
Teachers required[2]	99	98
Total government employment[3]	329	275
Michigan ROI		
School enrollments[1]	1,374	1,262
Teachers required[2]	63	58
Total government employment[3]	210	167
North Carolina ROI		
School enrollments[1]	2,972	2,813
Teachers required[2]	170	161
Total government employment[3]	495	426
Tennessee ROI		
School enrollments[1]	2,968	3,058
Teachers required[2]	147	151
Total government employment[3]	456	396
Texas ROI		
School enrollments[1]	2,031	1,900
Teachers required[2]	113	106
Total government employment[3]	368	297

1. Eligible public school enrollment, the portion aged 5 through 17 of total regional population impacts iated with reference case in-migration
2. Public school (full time equivalent) teachers required to maintain current student-teacher ratios in the region, given reference case enrollment impacts
3 Total (full time equivalent) government employees required to maintain current levels of service in the region, given reference case in-migration

Also regionally, net revenue effects for each state government peak in 1992 at between $5.8 million in Texas and $15.2 million in North Carolina. The other five state governments are anticipated to experience peak net revenue effects of between $10.9 million and $12.4 million. During full operations beginning in the year 2000, annual net revenue effects are expected to range between $3.2 million in Texas and $8.4 million in North Carolina (see Table 5.1.8-7). The application of four different types of taxes contribute to revenue: sales and use, motor fuels, vehicle registration, and public utilities taxes. The state governments would also receive net revenue effects from taxes and fees paid by SSC professional staff since these workers might have relatively higher earnings than the average wage earner in each state.

At the local level (see Table 5.1.8-8), government jurisdictions in Maricopa County, Arizona, would experience both the largest positive annual fiscal impact during operations and the largest negative annual fiscal impact during the early years of construction. These relatively large impacts would be due to the large number of SSC-related workers expected to live in that county. Most of the counties studied would experience negative fiscal impacts during early construction years due largely to expenses for needed infrastructure improvements to accommodate SSC-related growth.

After these capital improvement costs are incurred, most counties would experience positive financial effects from the SSC. In some counties, although positive impacts would accrue after an initial outlay for infrastructure improvements, the positive impacts would not offset the earlier losses for some time. Local governments might be able to finance the capital improvements with long-term bonds that could serve to alleviate this problem in some counties. In other counties, the redistribution of revenue from the state government or from other local governments experiencing net increases could offset these negative impacts.

5.1.8.5 Quality of Life/Social Well-Being

This assessment of SSC-related impacts on quality of life and social well-being is tailored to the unique characteristics of the SSC program. The project's size, combined with the rigorous siting requirements used in the selection of BQL sites, has resulted in seven potential host SSC regions that share important characteristics. In particular, each region contains a relatively large and dominant urban area, and the project extends in each region to cover large expanses of rural land. This commonality between study regions facilitates consistent treatment of potential social impacts.

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Table 5.1.8-7

NET SSC-RELATED CHANGES IN STATE GOVERNMENT REVENUE[1]
(Difference in proposed action and no-action, or current trend)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	(millions of 1988 dollars)											
Arizona	$1.5	$6.0	$10.8	$11.2	$9.6	$10.2	$8.5	$7.0	$3.3	$3.9	$4.3	$4.4
Colorado	1.6	6.2	11.1	11.4	9.7	10.2	8.3	6.7	3.3	4.0	4.3	4.5
Illinois	1.4	5.0	9.9	10.9	9.8	10.0	7.7	7.2	4.3	5.2	5.8	6.0
Michigan	1.6	6.2	11.6	12.4	11.1	11.5	9.2	7.4	3.4	4.1	4.4	4.6
North Carolina	2.2	8.1	14.7	15.2	13.3	14.0	11.7	9.9	6.2	7.4	8.2	8.4
Tennessee	1.4	5.6	10.5	11.1	9.7	10.4	8.7	7.2	4.2	5.0	5.5	5.6
Texas	0.8	3.0	5.5	5.8	5.2	5.5	4.6	4.0	2.3	2.8	3.1	3.2

1. Net impacts are expected SSC-related revenue gains over baseline conditions.

Table 5.1.8-8

SSC-RELATED CHANGES IN PUBLIC FINANCE CUMULATIVE TOTAL FOR LOCAL GOVERNMENTS[1] IN PRIMARY IMPACT COUNTIES

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	(millions of 1988 dollars)											
Arizona												
Maricopa Co.	($7.9)	($16.8)	($21.5)	$5.0	$4.8	$4.9	$3.8	$3.0	$2.8	$3.3	$3.6	$3.7
Colorado												
Adams Co.	(1.5)	(3.3)	(2.5)	1.6	1.5	1.3	0.5	0.3	0.3	0.3	0.4	0.4
Morgan Co.	0.1	2.0	6.0	9.9	8.5	9.2	7.9	6.5	6.0	7.2	7.8	8.1
Washington Co.	(0.0)	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
Illinois												
DuPage Co.	(1.3)	(2.0)	(3.9)	0.8	1.6	1.8	1.5	1.3	1.2	1.5	1.7	1.7
Kane Co.	(1.7)	(3.7)	(2.3)	2.8	3.9	4.1	3.3	2.8	2.6	3.2	3.5	3.6
Kendall Co.	(0.0)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Michigan												
Ingham Co.	(1.3)	(2.4)	2.6	3.0	2.6	2.4	1.4	1.0	0.9	1.1	1.2	1.2
Jackson Co.	0.0	0.6	0.5	2.4	2.2	2.3	2.0	1.6	1.5	1.8	2.0	2.0
North Carolina												
Durham Co.	(1.3)	(1.5)	(0.6)	3.6	3.6	3.7	2.9	2.3	2.1	2.5	2.7	2.8
Granville Co.	(0.3)	(0.5)	(0.4)	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4
Person Co.	(0.3)	(0.4)	(0.5)	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2

1. Net impacts are expected SSC-related revenue gains over baseline conditions minus expected SSC-related expenditure increases. Includes all local jurisdictions within the county, including county government itself. All values are in terms of millions of 1988 dollars; negative values are in parenthesis.

Table 5.1.8-8 (Cont)

SSC-RELATED CHANGES IN PUBLIC FINANCE CUMULATIVE TOTAL FOR LOCAL GOVERNMENTS

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	(millions of 1988 dollars)											
Tennessee												
Bedford Co.	(0.3)	(0.5)	(1.1)	(0.6)	0.0	0.0	0.0	(0.0)	(0.0)	0.0	0.0	0.0
Marshall Co.	(0.1)	(0.2)	(0.5)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Rutherford Co.	(1.1)	(1.2)	0.2	2.3	2.4	2.6	2.1	1.8	1.6	1.9	2.1	2.2
Texas												
Ellis Co.	(0.9)	(0.3)	1.9	3.4	3.3	3.5	2.8	2.3	2.1	2.5	2.8	2.9

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Supported in part by measurements of social indicators relating to characteristics of potential newcomers and those of resident populations and, in part, by concerns revealed in the course of scoping for the EIS, this qualitative assessment (structured according to guidelines offered by Flynn et al., 1983) focuses on the distribution of the effects among six key societal groups in each potential SSC region. Appendix 14 deals with these groups and their subgroups in more detail. These groups include:

(a) Suburban and rural residents whose property is required in fee simple for the SSC.

(b) Suburban and rural residents whose property is required in stratified fee for the SSC, and those living adjacent to SSC sites, as well as other rural nonfarm residents (including dwellers in small towns) for whom ties to their region's major cities are assumed to be somewhat less important, and for whom rural surroundings are assumed to exert a major influence on quality of life.

(c) Farm operators whose livelihood largely is derived by direct encounter with the rural environment and, like the second group, for whom quality of life is heavily dependent on characteristics of that rural environment.

(d) Early, short-term newcomers associated with SSC construction, including temporary in-migrants to the region, in response to SSC-related job opportunities, and their families.

(e) Longer-term newcomers associated with SSC operations and in-migrant workers and their families who would become permanent residents of the region.

(f) Urban and suburban residents who are also assumed to derive their livelihoods and life quality generally from activities in the urban and suburban portions of their region.

The people in group (a) above are those most directly affected by the SSC. They would have to sell their property and move. They have, for more than a year, been in a state of uncertainty and suspense about their future, and are concerned about whether they would get fair value for their property, among many other things. The overall impact of this in the various states is directly related to the number of residents and businesses to be relocated. Because the ROI's with the highest numbers of relocations are also those where similar accommodations are abundant, the impacts on the affected parties' quality of life may be minor (see Chapter 3, Table 3-6). Exceptions would be "homesteads," historical buildings, or other unique accommodations. Appendix 4 summarizes the compensation policies for relocated residences and buildings. These policies provide for mitigation in terms of compensation. When other considerations are also important, there would be a net adverse impact.

The people in group (b) above are the next most directly affected by the SSC. They would be strongly concerned about the effects of the presence of the SSC on their immediate environment. Their concerns are those addressed in this chapter having to do with noise during construction and operations (5.1.4), radiation (5.1.6), groundwater degradation (5.1.2), soil contamination (5.1.6), visual effects (5.1.10), etc.

In addition, they would be annoyed, particularly during construction, with the greatly increased number of spoils haul trucks on the previously little-traveled roads. At most sites, some roads would have to be temporarily or permanently cut or rerouted and new roads built; some backroads which have been little traveled would become connectors to various parts of the site. During construction, the general rural atmosphere would, to some degree, become more industrialized.

Small towns, particularly the Colorado communities of Brush and Fort Morgan and the Michigan village of Stockbridge, could experience SSC-related population impacts large enough to lead to "boomtown" conditions. Disruption of social networks and institutions, higher crime rates, escalating rents and other prices, deterioration of public services and facilities, and road congestion all are reported outcomes of some large project implementations in small rural communities. Unlike the typical boomtown syndrome, however, rapid growth in these SSC-impacted communities would not be soon followed by rapid declines in economic activities and population; SSC operations would continue for many years, allowing time for community residents and newcomers to adjust to one another and time to develop and maintain expanded services and social networks.

Group (b) persons would also have some positive impacts from the SSC. Many jobs would be available, both in construction and operations. There would be a general boom in the local economy which should mostly be beneficial. At Fermilab, as the scientists who were the newcomers to the communities became accepted, they actively participated in school, community, and social improvement programs. The same is expected to happen with SSC scientists.

Group (c) persons are least likely to be affected either positively or negatively by the presence of the SSC unless their property is in the fee simple or stratified fee areas. As in group (b), they would be concerned about local environment and truck traffic, but after a few years of living with the SSC would usually find that the adverse effects are negligible or nonexistent.

Group (d) persons would be concerned with the conditions already existing in the ROI--the level of service offered in the various communities. These people are in the area temporarily and would have more of an effect on the community than the community would have on them. For this group, the impact of the SSC would be positive as it would provide their livelihood for a number of years.

Group (e) persons include the scientists, engineers, technicians, and support staff not recruited locally. Their impact on the community lifestyle would be positive. Many of their salaries would be high compared to local salaries. Their average educational level would usually be higher than the local level. They would be strongly motivated toward maintaining high standards of secondary education and would be supportive of cultural, community, and technical projects in the areas in which they locate. This positive impact has occurred at Fermilab and would be expected in the case of the SSC.

Finally, those persons in group (f) are the ones most positively affected by the SSC. In addition to improvement in lifestyle from the effects of the group (b) people, new jobs and sources of income would be open for them. The net growth in the economy, from both direct and indirect employment, would also tend to improve their lifestyle.

Public concerns have been expressed, particularly in scoping meetings, about environmental degradation and health risks in connection with the SSC. These concerns are addressed in this FEIS, including impacts on:

- Air quality (Section 5.1.3)
- Water quality (Section 5.1.2)
- Water supply (Section 5.1.2)
- Soil contamination (Sections 5.1.5 and 5.1.6)
- Wildlife (Section 5.1.5)
- Noise (Section 5.1.4)
- Public health (Section 5.1.6)
- Traffic accidents (Section 5.1.6)
- Natural resources (Sections 5.1.1 and 5.6)
- Land use (Section 5.1.7)
- Prime farmlands (Section 5.1.7)
- Socioeconomics (Section 5.1.8)
- Cultural resources (Section 5.1.9), and
- Scenic and visual resources (Section 5.1.10)

5.1.8.6 <u>Transportation Systems</u>

This section provides an assessment of projected impacts to transportation systems resulting from SSC preconstruction, construction, and operations. It discusses modifications to the existing transportation systems and impacts on traffic potentially caused by SSC activities.

The approach to the transportation analysis is the following:

- Identification of the capacity and current utilization of existing transportation systems.

- Definition of the transportation demands of the SSC.

- Assessment of the ability of existing transportation systems to accommodate the SSC.

- Identification of potential mitigation strategies that would be considered during detailed design.

The transportation assessment focuses on peak SSC transportation demand periods during preconstruction, construction, and operations to assess worst-case impacts and to address the greatest need for mitigations.

The assessment for roads focuses on roads and highways providing access from the proposed campus to other site facilities, on roads and highways providing access to site facilities from nearby small cities and spoils disposal areas, and on major highways providing access to the site area from nearby metropolitan areas. The assessment for rail, air, waterways, and public transit systems focuses on those systems that directly serve SSC transportation demands.

Both direct and indirect impacts are assessed and defined as:

- Direct impacts - Impacts to transportation systems that result from the direct construction or operations of the SSC, directly by transportation of supplies to the SSC or wastes (mainly excavated material during construction) from the SSC, or directly by employees of the SSC.

- Indirect impacts - Impacts to transportation systems by the families of SSC employees, by other indirect population growth caused by the SSC, or by construction and/or operations of industrial or commercial facilities indirectly established to support the SSC.

Road system modification issues assessed include direct impacts to existing roads such as connection of new to existing roads, relocation of existing roads, disruption to existing roads because of construction, and closing of roads. Impact magnitude was subjectively estimated based on importance (current traffic carried by the existing roads and destinations served), amount of disruption to existing roads, and duration of the disruption. Road system modification issues dealing with new roads include the impact of new roads on existing traffic patterns. Impact magnitude was subjectively estimated based on the amount of change occurring in existing transportation patterns. In general, the new roads considered are the roads discussed in the proposal for each site.

Impacts resulting from construction and operations activities are compared among the proposed SSC sites in Tables 5.1.8-9 and 5.1.8-10, respectively. Additional information on environmental impact assessment methodologies and the assessment of impacts at each proposed SSC site are presented in Appendix 14, Section 14.2.1. There would be no impacts to transportation systems during preconstruction, except for the need for roads to drilling sites for geotechnical confirmation studies. A number of temporary dirt roads would be constructed to provide access to various geotechnical drilling and site monitoring activities. These roads would not appreciably increase traffic. The connection of these dirt roads to existing roads is not expected to result in impacts to the capacity or current utilization of existing roads.

A. Roads

Construction of on-site and off-site access roads includes the construction of new access roads to each SSC facility. Most of these would be two-lane paved roads that would be connected to the existing road network in the area. In many cases, improvements such as paving, widening, and replacement of bridges would be required to bring the existing network up to an acceptable level of service. Off-site access roads and highways would also be provided at a number of sites to provide access to the proposed campus area and to provide general site access.

These road improvement and construction activities would cause short-term disruption of traffic flow during direct road and bridge improvement activities and during the construction of intersections to connect access roads to the existing road network. In some cases, the construction of new, limited-access highways and SSC facilities would cut existing roads, disrupting their traffic flow for the duration of the project. Mitigations that would be evaluated during construction planning include scheduling major activities during off-peak hours of the day, maintaining at least one open lane past individual construction areas, establishing detour routes around construction activities, and using flagmen to direct traffic and maintain traffic flow.

Impacts resulting from construction and operations activities are compared among proposed SSC sites in Tables 5.1.8-9 and 5.1.8-10. New and improved SSC access roads might alter existing traffic patterns. In some cases, the access roads would improve transportation for existing residents of the area. In other cases, particularly where roads have been cut, existing traffic patterns might be adversely impacted. Mitigations that would be evaluated during detail design include the construction of frontage and bypass roads and intersections to limited access roads so that the existing residents can travel to their destinations in a reasonable manner.

Increased traffic on roads in the site area would result from construction workers commuting to and from work, transportation of equipment and construction supplies to the site, transportation of waste materials such as spoils from the site to disposal areas, and transportation of workers, equipment, and supplies from one SSC facility to another. Roads providing access to the campus and injector areas, individual service areas and intermediate access areas, and individual interaction points and experimental areas might experience an increase in traffic of up to 1,250, 300, and 200 vehicles per day, respectively. Increased traffic on roads in the region of influence would result from the increased population indirectly caused by the SSC construction. Several routes would be operating at a full capacity or higher level of service (LOS) if the SSC were located at that site. This represents an LOS of E or F. These are defined as follows:

Table 5.1.8-9

COMPARISON OF TRANSPORTATION IMPACTS DURING CONSTRUCTION AT PROPOSED SSC SITES[1]

Transportation Impact	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
1. Roads							
a. Road System Modifications[2]							
New 4-lane highway (mi)	15	0	4	1	25	6	5
New 2-lane highway (mi)	0	58	0	0	0	0	0
New 2-lane roads (mi)	37	34	3	7	12	4	22
Upgraded/resurfaced 2-lane roads (mi)	20	91	20	99	10	12	23
New 1-lane roads (mi)	8	2	1	2	2	3	4
New modified freeway/ tollway interchanges	No	No	Yes	No	Yes	No	Yes
Major road disruption	Potential[3]	No	No	No	No	No	No
b. Local Traffic Impacts on							
Lowest LOS on impacted 2-lane roads[4]	D	C	F	D	E	D	D
Disruption to Existing traffic patterns	No	Yes	No	No	Yes	Yes	No
c. Indirect Traffic Impact							
Increase in indirect traffic[5] (%)	0.4	14	1	1	3	4	3
2. Rail							
a. Rail System Modifications[6]							
Connection of new rail spurs/ sidings to existing rail lines	Yes	Yes	Yes	Yes	No	No	No
Length of new rail spurs/ sidings (mi)	7	20	0.8	0.5	N/A	N/A	N/A
Major rail disruption	Potential	No	No	No	No	No	No
Construction of existing rail line grade crossings[8]	Potential	Potential	Yes	Potential	Potential	Yes	Yes
Construction of existing rail line grade separation crossings[8]	Potential	Yes	No	No	Potential	No	No
b. Direct Traffic Impacts							
Trains per day serving the SSC site	<1	<1	<1	<1	<1	<1	<1

Table 5.1.8-9 (Cont)

COMPARISON OF TRANSPORTATION IMPACTS DURING CONSTRUCTION AT PROPOSED SSC SITES[1]

Transportation Impact	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
c. Indirect Traffic Impacts Increase in indirect traffic[9] (%)	0.4	0.4	0.1	0.1	0.8	1	0.3
3. Air							
a. Airport Modifications							
Major airport modifications	No	No	No	No	No	No	No
General aviation air field modifications[10]	No	No	Potential	Potential	No	No	Potential
b. Direct Traffic Impacts Average increase in number of flights per week	1	1	1	1	1	1	1
c. Indirect Traffic Impacts Increase in indirect traffic[9] (%)	0.4	0.4	0.1	0.1	0.8	1	0.3
4. Waterways Increase in waterway traffic	No change	No change	No change	No change	No change	No change	No change
5. Public Transit Increase in direct traffic	No change	No change	No change	No change	No change	No change	No change
Increase in indirect traffic[9] (%)	0.4	0.4	0.1	0.1	0.8	1	0.3

1. Construction impacts were evaluated for 1992, the peak construction year.
2. Road system modifications are based on SSC site proposals, with the exception of Arizona. See alternative plans as discussed in Appendix 14.
3. Major road disruption could occur temporarily if cut-and-cover tunnel construction cuts the Maricopa-Gila Bend Road.
4. LOS: Level of Service. A: Free flow with individual users virtually unaffected by the presence of others in the traffic stream. B: Stable flow but the presence of other users in the traffic stream begins to be noticeable. C: Stable flow but operations of individual users becomes significantly affected by interactions with others in the traffic flow. D: High density, but stable flow with speed and freedom to maneuver severely restricted, and the driver experiences a generally poor level of comfort and convenience. E: Unstable flow at near capacity level with speeds reduced; maneuvering difficult and extremely poor level of comfort and convenience. F: Forced or breakdown flow with traffic demand exceeding the capacity; unstable stop and go traffic.
5. Increase for county most affected by indirect SSC population growth.
6. Rail system modifications are based on SSC site proposals.
7. Major rail disruption could occur if cut-and-cover tunnel construction cuts the existing Southern Pacific main line tracks.
8. Existing rail line crossings are required in most cases. However, it is not clear from the SSC site proposals whether grade or grade separation crossings will be used.
9. Increase for the ROI.
10. Existing or proposed general aviation air fields are located in stratified fee areas.

Table 5.1.8-10

COMPARISON OF TRANSPORTATION IMPACT MAGNITUDES DURING OPERATIONS AT PROPOSED SSC SITES[1]

Transportation Impact	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
1. Roads							
a. Road System Modifications	None	None	None	None	None	None	None
b. Direct Traffic Impacts							
Lowest LOS on impacted highways[2]	D	C	F	D	E	D	E
Disruption to existing traffic patterns	No	Yes	No	No	Yes	Yes	No
c. Indirect Traffic Impacts							
Increase in indirect traffic[3] (%)	0.3	11	1	1	2	3	2
2. Rail							
a. Rail System Modifications	None	None	None	None	None	None	None
b. Direct Traffic Impacts	No change	No change	No change	No change	No change	No change	No change
c. Indirect Traffic Impacts							
Increase in indirect traffic[4] (%)	0.3	0.3	0.1	0.1	0.7	0.9	0.2
3. Air							
a. Airport Modifications	None	None	None	None	None	None	None
b. Direct Traffic Impacts							
Average increase in number of flights per week	1	1	1	1	1	1	1
c Indirect Traffic Impacts							
Increase in indirect traffic[4] (%)	0.3	0.3	0.1	0.1	0.7	0.9	0.2
4. Waterways							
Increase in waterway traffic	No change	No change	No change	No change	No change	No change	No change
5. Public Transit							
Increase in direct traffic	No change	No change	No change	No change	No change	No change	No change
Increase in indirect traffic[4] (%)	0.3	0.3	0.1	0.1	0.7	0.9	0.2

1. Operations impacts were evaluated for 2000, the year operation employment reaches a constant level.
2. LOS: Level of Service. A: Free flow with individual users virtually unaffected by the presence of others in the traffic stream. B: Stable flow but the presence of other users in the traffic stream begins to be noticeable. C: Stable flow but operations of individual users becomes significantly affected by interactions with others in the traffic flow. D: High density, but stable flow with speed and freedom to maneuver severely restricted and the driver experiences a generally poor level of comfort and convenience. E: Unstable flow at near capacity level with speeds reduced, maneuvering difficult and extremely poor level of comfort and convenience. E: Forced or breakdown flow with traffic demand exceeding the capacity, unstable stop and go traffic. F: Forced or breakdown flow with traffic demand exceeding the capacity, unstable stop and go traffic.
3. Increase for county most affected by indirect SSC population growth.
4. Increase for the ROI.

- E - Unstable flow at near capacity level with speeds reduced, maneuvering difficult, and extremely poor level of comfort and convenience.

- F - Forced or breakdown flow with traffic demand exceeding the capacity of the highway, unstable stop-and-go traffic.

The E and F LOS includes the following roads at each of the affected sites.

- Illinois - State Route 64; Kirk Road to Randall Road
  US Route 34; State Route 59 to State Route 31
  State Route 59; I-88 to State Route 56.

- North Carolina - US Route 501; US Route 158 to State Route 49.

- Texas - I-35E; I-20 to US Route 77.

Mitigations that would be considered during construction planning include the use of carpools, vanpools, and buses to decrease the peak traffic volume. In addition, SSC construction work-shifts could be staggered, taking into consideration work-shifts of other employers, to reduce peak traffic volume.

Mitigations that could potentially be implemented to reduce spoil disposal truck traffic impacts include the following: The use of state highways instead of local roads; direction of traffic away from residential areas and schools; use of traffic controls and speed limits; and the development of off-peak oriented disposal schedules to avoid normal urban congestion.

No modifications to road systems are forecasted during operations. In the event road improvements are needed, impacts and mitigations would be similar to those discussed above for construction.

Traffic pattern impacts resulting from the permanent closure of roads by limited access roads and SSC facilities would continue for the duration of operations. Mitigations implemented during construction would also mitigate operations impacts.

Increased traffic on roads in the site area would be incremental and reflects regional trends in traffic resulting from operations and maintenance workers commuting to and from work, transportation of operations equipment and supplies to the site, transportation of waste materials from the site to disposal areas, and transportation of workers, equipment, and supplies from one SSC facility to another. In addition, visiting scientists would commute to and from the site and travel from one SSC facility to another. Roads providing access to the campus and injector areas, individual service areas and intermediate access areas, and individual interaction points and experimental areas might experience an increase in traffic of up to 1,500, 25, and 150 vehicles per day, respectively. Increased traffic on roads in the region of influence would result from the increased population indirectly caused by SSC operations. Mitigations are the same as those discussed for construction.

B. Rail

During construction, a rail spur or siding might be required to be connected to an existing rail line and/or a road would be constructed across an existing rail line at some of the proposed sites. The connection of a rail spur or siding to an existing rail line may disrupt rail traffic for a short time while the switch is installed. The construction of an at-grade road crossing would also disrupt rail traffic while construction activities are occurring in the immediate vicinity of the track. The construction of a grade-separation road crossing is expected to result in only minimal disruption to rail traffic. Mitigations that might be examined by the carrier during construction planning include the scheduling of rail traffic around disruption periods, rerouting rail traffic over other railroads, scheduling construction work during periods of low rail traffic, and expediting construction work to minimize the duration of the disruption.

Increased rail traffic on existing rail lines might result from the transportation of construction materials, equipment, and nonfragile technical components to a new or existing rail spur or siding near the site. Mitigations might be examined by the carrier during construction planning and include the scheduling of rail service to the rail spur or siding to minimize delays to other rail traffic. Negligible impacts to rail lines and rail traffic are expected to result from operations.

C. Air

Construction and operations activities would not directly impact major airports. At least one general aviation airfield is located in a proposed stratified fee area. Three acres of the DuPage airport property in Illinois are located within the proposed fee simple lands in the near cluster. However, all facilities affecting airport operations are on proposed stratified fee areas. Impacts to these fields would be expected to be negligible because construction and operations activities would occur below ground in these areas.

Increased air traffic during construction and operations would be a direct result of the transportation of construction and operations personnel to and from the site and the transportation of mail, supplies, and equipment. Increased air traffic would also result from the increased population indirectly caused by SSC construction and operations. Most of these impacts would occur at the major airport in the site region.

D. Waterways

Some technical components, construction equipment, and supplies manufactured overseas would be shipped to ports and then transported to the proposed site by rail or truck. Other items manufactured near waterways in the United States might also be shipped by water. The likelihood of significant waterway use to support SSC construction and operations is very low at all sites.

E. Public Transit

Generally, public transit systems do not extend to the proposed sites and, therefore, would not be directly impacted by the SSC. Where public transit systems are present, they would experience direct impacts from the increased demand caused by construction and operations workers. Rental car services might experience increased demand during construction and operations. Public transit systems in nearby metropolitan areas would experience an increase in demand due to the increase in population indirectly caused by the SSC construction and operations.

5.1.8.7 Electricity

Various configurations of electric service have been proposed to serve the two SSC substations from nearby existing or proposed facilities (see Section 4.9.3). These have been chosen both to supply the necessary power requirements for normal SSC operations and to lessen the need for construction of additional transmission lines. Electric power would be brought on site via two transmission lines, with connections routed to each of the two SSC substations. The impacts felt here would be from the installation and routing of the transmission lines. These impacts might be mitigated to some extent by following standard power company construction techniques, by careful assessment of the planned routing, and, where possible, use of existing easements.

Both the Arizona and Colorado sites, being the most rural of the site alternatives, would require construction of a greater number of transmission lines. Again, if either of these sites were selected, the power company would need to provide mitigation to the extent possible by planned routing and construction techniques. Tennessee would also require construction of a fairly substantial amount of line. The remaining sites would need relatively short lengths of transmission line to connect Substations 1 and 2 to the electric power grid.

Electric power distribution around the booster rings and collider tunnel would be accomplished by routing power cables in the tunnel around the circumference of the ring. Electric power is planned to be distributed to the buildings by underground duct banks. Distribution of power lines in this manner would eliminate any visual impacts.

Construction power is generally available at each of the proposed sites and could be provided to contractors either by placement of a pole line, which may be removed when work is complete, or by planning early construction of permanent facilities in order to support construction work. For either scenario, impacts would be temporary and mitigation, to the extent possible, would be required of the contractor and appropriate power company.

Generally, the final location and placement of the proposed SSC facilities might require the relocation of several transmission lines in the vicinity. This might require some rerouting of existing transmission lines in order to maintain system continuity and customer service. These instances would need to be addressed on a site-specific basis as the need arose. Whether or not rerouting would be needed would depend on detailed design of the SSC. This issue will be addressed in the Supplemental EIS. However, typically, relocations would be over short distances and would be mitigated by following standard power company construction techniques.

5.1.8.8 Natural Gas

Each of the proposed sites is well served by an existing network of natural gas pipelines (see Section 4.9.3). With gas transmission lines on-site or in the immediate vicinity, the construction of new lines would be minimized. Providing service to the facilities would require constructing between 3 and 26 mi of new pipeline. Until detailed design of the SSC facilities exists and the precise location of existing pipelines is known at the selected site, no firm assessment of impact can be made. The use of proper construction techniques and carefully planned line routes would help to minimize impacts. The specific routes would be worked out after the site is selected during final design of the SSC.

During construction and preconstruction, it may be necessary to relocate several smaller pipelines. This might require the rerouting of existing lines to maintain continuity of service. These instances would need to be addressed on an individual basis as the need arose. However, relocations should be over short distances and should cause minimal and temporary impacts.

5.1.8.9 Telecommunications

Each of the proposed sites has existing telecommunications service in the general vicinity, but would require construction of new lines to service the SSC project. The exception would be Illinois, which currently provides similar service to Fermilab and has the necessary communications structure already in place.

During construction and preconstruction, on-site communications could be handled by commercially available two-way radios and walkie-talkies that are commonly used on construction sites.

Communications between the site and other locations could either be by connection to a local telephone system or by radio link to a system some distance away. Communications between tunneling operations and the surface would be via a hard-wired system on-site. For either case, there would be no environmental impact.

The final location of the proposed SSC facility might require the relocation of several communications lines in the vicinity. This would require some rerouting of the lines in order to maintain system continuity and customer service. Typically, this would be a relocation over a short distance, and specific routes would be worked out after the site is selected during final design of the SSC.

5.1.9 Cultural and Paleontological Resources

5.1.9.1 Cultural Resources

A. General Comparisons of Proposed Sites

Cultural resource assessments consider potentially adverse effects to significant archaeological sites and historic standing structures. Significant sites are those that would meet the eligibility criteria for listing on the National Register of Historic Places described in 36 CFR 60. Important cultural resources also include Native American sacred sites related to traditional religious beliefs and practices. The American Indian Religious Freedom Act (42 U.S.C. 1996) provides for the protection and preservation of sites identified or suspected to be sacred. Cultural resources are nonrenewable and could possess important scientific, educational, and heritage values. Cultural resources are potentially affected by SSC project activities performed during preconstruction, construction, and operations.

Data pertaining to known cultural resources were derived from information provided by the proposing States, data gathered through independent literature review, and consultation with the State Historic Preservation Officers (SHPO's).

Archaeological assessments involve identifying prehistoric and historic archaeological sites and verifying the locations of archaeological sites based upon archival information. Archaeological field surveys have not been completed at any of the proposed sites. Extensive field surveys have been undertaken at the Arizona and Illinois SSC sites, although several areas of potential impacts along the collider ring remain to be studied. Archaeological field surveys have not been performed at the Colorado, Michigan, North Carolina, Tennessee, and Texas sites. Surveys have not been performed of ancillary areas of construction activities such as access roads, utility rights-of-way, spoils deposition, etc. For any site selected for the SSC, further archaeological assessments would be necessary.

In Arizona, portions of the collider ring to be constructed by cut-and-cover, the campus areas A, B, and C, and buried beam access areas, have been extensively surveyed. At the proposed Illinois site, most of the locations of proposed facilities have been surveyed; however, others were not studied due to circumstances of poor visibility or limited access. A reconnaissance-level archaeological survey has been undertaken at the proposed Tennessee SSC site. No project-related archaeological field survey has taken place at the proposed Michigan, North Carolina, and Texas sites. A sample survey of proposed roadways to the site was performed in Colorado.

The extent to which historic surveys have been completed also varies. Cultural resource fieldwork pertaining to the proposed Arizona SSC collider ring included an historic building site survey. A total of five structures were identified, of which only one remains standing; other historic sites include three areas of historic refuse and two historic trail roads. In the area of the proposed Colorado site, local residents compiled a listing of known local historic resources. Further, in Colorado, portions of proposed roadways to the SSC site have been surveyed and significant historic sites have been identified. At the proposed North Carolina and Texas sites, some local studies have been completed. Significant historic structures are likely to be identified in both states. In Illinois, systematic, regional historic building surveys have been completed; these data provide a thorough database for assessing potential impacts to historic structures. In Michigan and Tennessee, intensive field inventories and evaluations of standing structures have been completed. Significant resources have been identified at both sites; other structures might require further evaluation. Historic cemeteries have been identified in areas of the proposed sites in Colorado, Illinois, Michigan, North Carolina, Tennessee, and Texas.

No Native American sacred sites have been identified at any of the proposed sites; although prehistoric burials have been previously recorded in the vicinity of the sites in Colorado, Illinois, Michigan, and Texas. The existence of prehistoric burials cannot be excluded at any of the sites. In response to Illinois State Museum inquiries, the Citizen Band Potawatomi Indians of Oklahoma have stated that Native American burials may be located in the general vicinity of the proposed Illinois SSC site but no specific locations were identified.

B. Descriptions of Known Resource Impacts at the Proposed Sites

Any of the seven known prehistoric sites within the proposed Arizona SSC project area could be eligible for the National Register. The significance of these prehistoric resources can be realized through appropriate data recovery programs emphasizing the recovery of botanical and faunal data from roasting pits, rock pile features, and buried cultural features in an attempt to document the procurement activities performed at these locations. A considerable part of the significant artifact assemblage at these sites may be surficial.

The construction of the SSC project in Arizona could impact a total of ten known historic sites. The Butterfield Stage Coach Line and the Juan Bautista de Anza Trail are important historical resources although neither has been placed on the National Register. The five historic structures (of which only one remains standing) and the three scatters of historic artifacts are slightly more than 50 years old. The significance of the historic sites has not been fully established.

It is anticipated that future archaeological and historical surveys conducted in Colorado may locate sites within the project area. Prehistoric sites are particularly likely along drainages such as Badger, Beaver, and Bijou Creeks. The known sites within the proposed project area have not been evaluated with regard to National Register criteria or specific potential project impacts. Similarly, the historic sites identified by local residents have not been thoroughly documented and evaluated. The precise locations of these sites are unclear with respect to proposed project facilities.

In addition, six historic sites considered eligible for the National Register have been identified and evaluated in Colorado along portions of the proposed SSC access roads; these are indicative of the nature of historic agriculture-related resources and vernacular architecture. Several of these could be directly impacted by the SSC.

Many of the proposed project construction areas at the proposed Illinois site have undergone intensive cultural resource surveys. Twenty-five prehistoric archaeological sites are on the Fermilab property; thirteen of these are currently being evaluated to determine if they are eligible for nomination to the National Register. Other known sites are located in potential impact areas of the collider ring. Additional surveys and evaluations are currently being completed by the Illinois State Museum.

A number of historic structures are located in potentially affected areas of the proposed collider ring in Illinois: 1) the near and far clusters, 2) the beam absorber easement areas, and 3) intermediate and service areas. The significance of these structures and potential impacts have not been evaluated. Eleven historic archaeological sites have been verified to date within the project area including four within the far cluster and four within the near cluster.

The historic structures survey of the proposed Michigan SSC site is complete. However, very little is currently known about the full range and specific locations of prehistoric archaeological sites in the proposed Michigan SSC project area. Most of the cultural history is represented by nearby recorded sites. Prehistoric sites are particularly likely in upland and wetland contexts. Predictive studies indicate that numerous prehistoric archaeological sites would be located during field surveys.

Three significant historic structures, the Cady Centennial Farm, Structure "R-516," and the Springman Centennial Farm, were identified in the area of the proposed Michigan SSC site. Other significant structures could be identified during future evaluations of the structures recorded.

Intensive surveys have not been completed in the proposed North Carolina SSC site area although extensive inventories of historic structures have been undertaken in Granville and Durham Counties. Detailed data are not available to predict numbers or projected locations of cultural resources. Those nearby resources which have been recorded indicate that the project area is likely to contain prehistoric and historic archaeological sites and historic structures which would be identified during field surveys.

Intensive archaeological surveys of the proposed Tennessee project area are not available. In addition, it is not possible to accurately predict numbers or projected locations of prehistoric and historic archaeological sites. Of the cultural resources which have been recorded at the proposed Tennessee site, only one historic archaeological site, the Spain Ranch, has been identified. One historic site, the Sanders Farm, could be eligible for the National Register.

Few archaeological studies have been completed in Ellis County, Texas, so data are not available at the proposed Texas SSC site to predict the numbers or projected locations of cultural resources. It is possible that previously unrecorded prehistoric and historic archaeological sites will be identified. Intensive historic buildings surveys could identify important structures.

C. Definitions of Impacts

Direct impacts would result from actual disturbance of a resource's structure, setting, and spatial configuration during construction or operations. Disturbances of this kind could occur within facility construction zones and areas of ancillary activities, such as access roads, utility rights-of-way, storage yards, parking areas, assembly areas, and project field offices. Disturbances of this kind occur to surface and subsurface elements of archaeological sites. The removal of historically or architecturally important structures are more obvious direct impacts.

Indirect impacts to cultural resources often result from the general intensification of land use activities in the area surrounding new development. Population growth and greater accessibility due to improved roads and other facilities may result in increased vandalism and other forms of disturbance and destruction. Further, patterns of land use on nearby public and private nonproject lands may change. The indirect impact area would thus vary with each proposed site, depending on site location and existing land use patterns. DOE does not control those factors that result in indirect impacts. Zoning and local land use plans are under the control of local governments.

Cumulative impacts to cultural resources often occur during periods of regional intensification of development. As a result, a nonrandom distribution of resources becomes vulnerable to disturbance and data loss.

Where there are appropriate state and local preservation plans backed by laws, regulations, and ordinances, the problem of indirect and cumulative impacts should be addressed. However, in those areas where there are no regional or local plans and regulations (or these are incomplete) cultural resources may be placed in danger of damage or destruction.

D. Mitigative Measures

After the SSC site is selected, the DOE would consult with the SHPO for the selected state and a Programmatic Agreement (PA) would be developed between the DOE, the SHPO, and the Advisory Council on Historic Preservation. Consultations with other Federal agencies such as the BLM and the Advisory Council on Historic Preservation would occur, as necessary. For the selected site, additional surveys and evaluations would be completed and, if needed, mitigation measures would be developed in accord with an PA.

In order to assure the protection of significant historical and archaeological resources at the selected SSC site, a mitigation program would be implemented consistent with the PA that provides for the identification, evaluation, and treatment of significant cultural resource properties that would be directly affected by the SSC project activities. Inventory and evaluation studies which supplement those already completed would be performed. If necessary, further archival research would be undertaken to establish data regarding properties that might occur in the selected project area.

To identify Native American sacred sites and other ethnographic locations, continued discussions may be needed with representatives of groups who have traditional or current ties to the areas affected within the selected project area, and who could identify concerns about the future management and treatment of those resources.

Proposed field studies of potential project impact areas would need to be completed. The objectives of field studies are twofold: to verify the existence and condition of previously recorded cultural resources, and to identify additional properties within areas affected by the project. Evaluations of archaeological properties are made in terms of established criteria of eligibility for the National Register and usually involve collection and analysis of data, using both surface materials and subsurface testing to establish the age, content, and horizontal and vertical extent and integrity of the deposit.

Evaluation of historic architectural and engineering properties including buildings, structures, and objects requires application of National Register criteria to establish eligibility. The evaluation process requires a detailed level of resource-specific investigation regarding age, ownership, historic associations, and documentation of condition, stylistic/functional traits, and integrity of contributing elements.

After significant cultural resources have been identified, each should undergo an assessment of potential impacts due to project implementation. Determinations can then be made of appropriate mitigative measures.

Avoiding significant historical and archaeological resources could be the most effective means of mitigating significant impacts. In locations where avoidance is not feasible because of technical, operational, regulatory, or cost considerations, alternative mitigation measures would be considered. Such measures would include: 1) recovery, analysis, and curation of data from significant sites; 2) documentation of historic structures prior to their removal or demolition; and 3) construction monitoring.

5.1.9.2 Paleontological Resources

Paleontological resources are defined as fossiliferous localities that provide important and unique data pertaining to sequences and circumstances of evolutionary biology and geological processes. Under the Antiquities Act (16 USC 431-433), the DOE has a responsibility for the protection of paleontological resources discovered during SSC preconstruction, construction, and operations, as prehistoric properties. Paleontological resources are nonrenewable and possess important scientific and educational values. Important resources are those whose scientific importance have been demonstrated in the scientific literature or those whose rarity, uniqueness, or other characteristics may make them the subject of future scientific study. In general, there are no Federal regulations that govern the management of paleontological resources.

Paleontological resources have been identified based principally on information provided in the state proposals. Data vary for each state depending on the level of research and recording previously undertaken within and near the proposed site. In some cases, further research may be desirable to assess the potential of certain geologic strata to produce important and unique fossil materials.

A. General Comparisons of Proposed Sites

The stratigraphic sequence within the proposed Arizona project area is not generally conducive to paleontological preservation. However, if fossils are present, they are most likely to occur in younger fanglomerate exposures. At the proposed North Carolina site, paleontological remains are not expected to be extensive in the project area and are unlikely to be encountered during construction of the SSC.

Paleontological resources are more likely to occur at the Colorado, Illinois, and Michigan sites. At the proposed Colorado SSC site, it is likely that paleontological materials would be discovered during construction activities; fossil materials have been found elsewhere in Colorado in many of the geological strata present within the project area. At the proposed Illinois SSC site, fossil remains are known to be present from the Quaternary strata. Many of the potential locations of paleontological materials at the site have been examined. At the proposed Michigan SSC site, there have been a large number of fossil discoveries within and near the proposed project area. Studies performed for the Michigan site proposal verified the existence of fossils in several stratigraphic contexts.

Little is known about the likelihood of encountering fossil remains at the proposed Tennessee and Texas SSC sites, although occasional fossils have been located in the geological strata present at these sites.

B. Definition of Impacts

Direct impacts could result from actual disturbance of an important and unique paleontological resource during preconstruction, construction, or operations. Disturbances of this kind could occur within facility construction zones and areas of ancillary activities such as access roads, utility rights-of-way, storage yards, parking areas, assembly areas, and project field offices.

Indirect impacts to important paleontological resources sometimes result from the general intensification of land use activities in the area surrounding new development. Population growth and greater accessibility due to improved roads and other facilities may result in nonprofessional excavations of fossil localities and other forms of disturbance and destruction. Further, patterns of land use on nearby nonproject lands may change. The indirect impact area would vary with each proposed site depending on site location and existing land use patterns. Zoning and local land use plans are under the control of local governments.

Cumulative impacts to paleontological resources sometimes occur during periods of regional intensification of development. As a result, a nonrandom distribution of fossils becomes vulnerable to disturbance and data loss. Intense development of a region can result in a disproportionate loss of fossil types and their concomitant data.

C. Mitigative Measures

Prior to construction at any of the proposed SSC sites, further paleontological field studies and evaluations should be completed, as necessary, for portions of the proposed project areas where paleontological localities are likely to occur. Paleontological evaluations could be included as part of the geological testing program during preconstruction.

Mitigation planning at the selected SSC site could provide for the identification of those construction areas which would require professional monitoring during ground-breaking and drilling procedures. Procedures would be developed for scientific recovery and documentation upon discovery of important and unique fossil materials.

Mitigation planning should allow the possibility that important and unique fossil remains may be uncovered during construction. Professional recovery of the materials and recording other scientific data might be necessary.

5.1.10 Scenic and Visual Resources

5.1.10.1 Introduction

Scenic and visual resource assessments for the seven proposed sites are presented in detail in Appendix 16 and are summarized below. The description of project features has been drawn from Appendix 1. The purpose of the assessments is to identify and evaluate the impacts on the aesthetics of the landscape at the proposed sites because of project preconstruction activities, construction, and operations. Table 5.1.10-1 shows the visual impacts associated with specific project facilities for the seven sites. Key terms for understanding this table are defined as follows:

- Visual impacts - Those impacts which occur when an action results in a physical change that, relative to the character of an area, appears out of place, discordant, and/or distracting.

- Significant - Visual impacts which result in a perceptible reduction of scenic/visual quality that lasts for more than 1 year and is seen from moderately to highly sensitive viewing positions.

- Negligible - Visual impacts which result in no perceptible reduction in scenic quality, as seen from moderately to highly sensitive viewing positions; those impacts lasting for less than 1 year; or those seen only from viewing positions low in sensitivity.

- Local scope - Those impacts on views from travel routes and areas primarily of local importance, such as city parks, residential areas, or locally designated scenic routes.

- Regional scope - Those impacts on views which are important to 1) the county or State, such as State parks, forest preserves, recreation areas, or county parks; or 2) the region, such as public lands managed by the BLM.

- National scope - Those impacts on views which are important at the national level, such as those from nationally designated parks, scenic trails, and designated wilderness areas.

Table 5.1.10-1

VISUAL IMPACTS

Specific Impact	Phase	AZ	CO	IL	MI	NC	TN	TX
Campus/Injector	Const/ Oper[1,2]	Sig[3] Reg[5]						
E3[8]		Neg[4] Reg[5]					Neg Reg	
E4	Const/ Oper	Neg Reg		Neg Local[7]	Neg Local	Neg Local		
E7	Const/ Oper	Sig Reg						
E8	Const/ Oper			Sig Local	Neg Local	Neg Local	Sig Local	
E9	Const/ Oper			Sig Local			Neg Local	
E10	Const/ Oper							Neg Local
F1[9]	Const/ Oper					Sig Local	Neg Reg	
F2	Const/ Oper	Sig Reg		Sig Local			Sig Local	
F3	Const/ Oper	Neg Reg			Sig Local			Sig Local
F4	Const/ Oper	Neg Reg		Sig Local		Sig Local		Sig Local
F5	Const/ Oper			Sig Local		Sig Local		
F6	Const/ Oper	Sig Reg						Sig Reg
F7	Const/ Oper	Sig Reg		Sig Local				

Table 5.1.10-1 (Cont)

VISUAL IMPACTS

Specific Impact	Phase	AZ	CO*	IL	MI	NC	TN	TX
F8	Const/ Oper			Sig Local			Sig Local	
F9	Const/ Oper					Sig Local	Sig Local	
K6[10]	Const/ Oper	Sig Reg						
Substation #2	Const/ Oper				Sig Local			
Cut/Cover[11]	Const	Sig Reg						

1. Const = Construction impact
2. Oper = Operations impact
3. Sig = Significant impact
4. Neg = Negligible impact
5. Natl = National scope
6. Reg = Regional scope
7. Local = Local scope
8. Intermediate access facilities
9. Sector service areas
10. Experimental halls
11. Cut-and-cover area

*No scenic or visual resource impacts would occur at the proposed Colorado site.

The assessments focus on the long-term visual impacts of the proposed project. Preconstruction activities important to scenic and visual resources are limited to test drilling which would result in visual impacts lasting a few weeks. Because of their transitory nature, these impacts are not discussed further.

Construction impacts include the appearance of cut-and-cover slopes; cleared areas before they are revegetated; excavated areas prior to construction; temporary roads and utilities; stockpiles of dirt, sand, and gravel; spoils disposal areas; equipment yards; and temporary construction buildings. Of these, only the clearing of vegetation and the disposition of spoils materials have the potential for long-term impacts on specific views. It is assumed, under a conservative worst-case scenario, that the intensity of impacts on specific views caused by construction would, though short term, be at least commensurate with the visual impact caused by the related surface facilities being built. Construction would be out of character within sensitive public views; vegetative clearing would be extensive, and the clearing could be fully utilized for laydown, equipment, and materials storage, temporary construction buildings, etc., and the movement of personnel and equipment, traffic, dust, etc., would further draw attention. Therefore, the intensity of impacts caused by construction and operations are considered approximately equal.

It is the operations phase of the project which has the greatest potential for long-term visual impacts. The features of project operation possibly affecting scenic and visual resources are those surface facilities occurring within moderately to highly sensitive public views. Many of these facilities would occur within lands to be acquired by the Federal Government as part of the land acquisition program (e.g., the campus, injector, and the near and far clusters). With acquisition of properties in such areas, many of those who would be affected are to be relocated and the question of local public sensitivity to visual impacts would be lessened. Except for the Arizona site, the buffer of acquired land for the campus and injector areas would be such that the nearest sensitive viewing positions would not include SSC structures within these areas. For the Arizona site, distant views from the crest and slopes of the southern Maricopa Mountains would include the campus and injector facilities.

Consequently, the analyses have concentrated mostly on the sector service areas (F sites), intermediate access facilities (E sites), experimental facilities (K sites), and transmission lines and substations, and cut-and-cover areas for the ring (only occurring at the Arizona site). In general, sector service areas and intermediate access facilities would be the project features of concern. These facilities would occur around the collider ring and their industrial appearance would be inconsistent in several contexts, such as residential and recreational areas.

5.1.10.2 Assessment Methodologies

The affected environment has been described in terms of the regional and local character of the physical settings in which the facilities are sited (visual character) as well as the levels of visual sensitivity ascribed to affected views. The visual impact of the project was assessed as to whether the project would appear uncharacteristic of its setting and, if so, how noticeable it may be.

The noticeability of a visual impact depends on project features, and their context and viewing conditions (angle of view, distance, primary viewing direction). Four levels of visual impact intensity may occur. These are termed "Visual Modification Classes" (VM Classes). Note that the VM Classes defined below are similar to, but modifications of, U.S. Department of Agriculture, Forest Service (USDA-FS) Visual Quality Objectives (VQOs) (U.S. Department of Agriculture, Forest Service 1974) and U.S. Department of the Interior, Bureau of Land Management (USDI-BLM) Visual Resource Management Classes (VRM Classes) (U.S. Department of the Interior, Bureau of Land Management 1978).

- VM Class 1 - Not noticeable: changes in the landscape are within the field of view but generally would be overlooked by all but the most concerned and interested viewers; they generally would not be noticed unless pointed out (inconspicuous because of such factors as distance, screening, low contrast with context, etc.).

- VM Class 2 - Noticeable, visually subordinate: changes in the landscape would not be overlooked (noticeable to most without being pointed out); they may attract some attention but do not compete for it with other features in the field of view. Such changes often are perceived as being in the background.

- VM Class 3 - Distracting, visually codominant: changes in the landscape compete for attention with other features in view (attention is drawn to the change about as frequently as to other features in the landscape).

- VM Class 4 - Visually dominant, demands attention: changes in the landscape are the focus of attention and tend to become the subject of the view; such changes often cause a lasting impression of the affected landscape; memorable.

Views of the following areas were considered to have high sensitivity:

- Designated areas of aesthetic, recreational, cultural, or scientific significance, including national, State, county, and community parks, recreation areas, and historic districts, such as the following:

- Nationally designated parks, historic sites, memorials, recreation areas, reserves, wilderness areas, scenic trails, wildlife refuges; points of scientific interest to the public (such as geologic sites); rest areas, visitor information centers, and scenic overlooks along Federal highways.

- State-designated parks, historic sites, reserves, recreation areas, coastal zones, beaches, points of scientific interest to the public, scenic overlooks, rest areas, and visitor information centers along State highways, and developed recreation sites.
- Designated county and regional parks, recreation areas, reservoirs, and beaches.

- Designated community and city parks, local picnic areas, botanic gardens, areas of local historic significance, open-space areas protected by local planning documents against visual modification.

o Areas or sites of cultural/religious importance to Native Americans (as defined in Appendix 15).

o Nationally or State-designated scenic highways or roads.

o Resort areas.

o Residential subdivisions (large- or small-lot), country estate subdivisions (lots greater than 1 acre).

o Travel routes, such as roads, rail lines, trails, bicycle paths, and equestrian trails, serving primarily as access to highly sensitive areas.

Views of the following areas were considered to be of moderate sensitivity:

o Segments of travel routes near highly sensitive use areas of interest, serving secondarily as access to those areas, but predominantly serving other destinations. Views seen while approaching an area of interest may be closely related to the appreciation of the aesthetic, cultural, scientific, or recreational significance of that destination.

o Rural residential areas and roads primarily serving as access to them.

o Undesignated but protected or popularly used or appreciated areas of aesthetic, recreational, cultural, or scientific significance at the local, county, or State level.

- Highways or roads locally designated as scenic routes, or informally designated as such in literature, road maps and road atlases.

- Travel routes, such as roads, trails, bicycle paths, and equestrian trails, that serve primarily as access to protected or popularly used undesignated areas important for their aesthetic, recreational, cultural, or scientific interest.

- Religious facilities and cemeteries.

- Travel routes serving secondarily as access to moderately sensitive areas.

- Farmsteads, or groupings of fewer than four residences.

- Industrial research/development, institutional, commercial, and agricultural use areas.

Conclusions about the potential visual impact of SSC facilities have been made by:

- Identifying key viewing positions. These are the moderate to highly sensitive viewing positions which would be affected by the project. Field analyses were conducted to identify which views would be most exposed to the project.

- Assessing project visibility relative to key viewing positions. Visibility has been assessed by field inspection. In most cases, whether or not project features would be visible was obvious. Where there was some uncertainty, line-of-sight analyses using U.S.G.S. topographic data were conducted. The effect of deciduous vegetation in screening project features is uncertain due to the analyses having been done in the late spring. Best professional judgment was used concerning screening during the winter.

- Assessing the VM Class for the impacts on the selected views. Photographs of facilities similar to those proposed by the SSC project served as the basis for assumptions concerning the character of the facilities, due to the conceptual level of the design to date. Also, field review of similar facilities was conducted. The assessment of VM Class was done according the best professional judgment based on such factors as viewing distance, angle of view, vegetative screening, and viewer orientation (primary direction of view).

5.1.10.3 Impact Assessment and Comparison of the Alternatives

The visual impacts expected at each site are compared in Table 5.1.10-1. Apart from the Arizona site, with few exceptions the visual impacts summarized stem from siting project facilities close to residential subdivisions or rural residential areas. In only two cases would recreational areas be impacted, while in four cases the visual setting for religious facilities (churches and cemeteries) would be altered.

The industrial-yard character and large scale of the sector service areas, buildings, and tank farms are incongruous with the character of residential neighborhood and country residences. In some cases, even the small intermediate access area building, which would appear similar to a warehouse or utility enclosure, would be inconsistent. This would be the case where this facility is sited in or near subdivisions, where residential character is relatively uniform and there is no mix of land uses. Rural residential areas, however, are often associated with outbuildings or are near farmlands and pastures where utility sheds are not uncommon. Here, the access areas would usually go unnoticed.

Concerning recreation areas, project facilities are inconsistent with the natural scenic qualities usually associated with outdoor recreation. Any structure can appear out of place in such a context.

Relative to religious facilities, stability, sense of peace, and a contemplative atmosphere are assumed to be key to their context. These qualities are often reflected in the visual character of their environs and would not be compatible with industrial features.

A. Arizona

Visual impacts stem from the fact that the site appears predominantly natural and any structures would seem out of place across most of the site. Not only do service areas and one experimental facility affect views, but the small buildings of the access areas may also affect views. In addition, the sparse vegetation, combined with the elevational differences across the site, yield open, distant, and panoramic views potentially capturing project facilities, even at substantial distances.

For this site, the sensitive views affected are those from dispersed recreation areas and trails within or adjacent to three BLM Wilderness Study Areas (WSA), the vicinity of one historic travel route, and informally designated camping areas. The impacts on views from the Wilderness Study Areas and the recreation sites and trails outside the WSAs would be regional in scope, because of the importance of these resources to residents of the greater Phoenix area.

The viewing positions considered key are those from which the project could be seen and, for the most part, which are moderately to highly sensitive. For the Arizona site, these are: the Butterfield Stage Route; the jeep trails and primitive roads that serve primarily as access to it; and the higher elevations of the Maricopa Mountains and interior canyons and wash areas traveled by off-road vehicle users and hikers.

The impacts for the Arizona site have been assessed relative to specific facilities, starting in the upper arc and moving counterclockwise.

F7: The potential visual impact is classified as VM Class 2, 3, and 4; highly sensitive views affected; potentially long-term significant impact; regional scope; mitigable to a level of insignificance, but possibly not before 5 years. A jeep trail that accesses the Butterfield Stage Route passes near this facility; brief views of F7 would be available from this trail, the facility appearing out of place and noticeable. Those hiking in the vicinity could not avoid seeing F7 and the paved access road, especially from higher points along the mountain slopes and ridges. The facility could draw attention to the point of being distracting (codominant, VM Class 3) or the focus of attention (dominant, VM Class 4).

Mitigation measures that should be evaluated during detailed design include the following: the access road alignment could be curved to prevent a line of sight along it toward F7. All of the road, or at least the part in view, could be paved with a material matching the sand-colored desert floor. A blending color should be chosen for the buildings, and landscaping and screening should be considered. The building could be sited below grade.

E7: The potential visual impact is classified as VM Class 2; low sensitivity for affected views; but inconsistent with BLM management direction; potentially long-term significant impact; regional scope; mitigable to a level of insignificance at project completion. A dirt road dead ends about a mile from the facility and the one-story building planned for the facility has potential for impact.

Mitigation measures may successfully mitigate the impact of E7 and should be evaluated during final design. These include siting below grade, landscaping, and berming.

F6: The potential visual impact is classified as VM Class 3; relative to the Butterfield Stage Route, high sensitivity; inconsistency with BLM management direction; potentially significant impact; regional scope. Relative to jeep trails to the west, low sensitivity but potentially significant impact because of inconsistency with BLM management direction; regional scope. Not mitigable to a level of insignificance. This facility could be visible from adjacent jeep trails near the Butterfield Stage Route.

As mitigation, the following are among the measures to be considered during final design to reduce the visibility of F6; these include several of those suggested relative to F7: providing for the first story of the buildings to be below grade; berming around at-grade facilities; using color effectively to blend the buildings with the monochromatic hills; and the avoidance of highly reflective materials. However, because of the elevation of the site, F6 may remain noticeable, but should be subordinate to natural features (VM Class 2). The impact, though lessened, would still have potential for significance.

E6: This area would have no impact. A jeep trail accessing the Butterfield Stage Route passes within 0.5 mi west of E6 at an elevation about 30 ft lower than this facility. The slope between the road and E6 is gradual, being about 1 percent, so appears essentially flat. There are no intervening landforms, but the relatively level line of sight to the one-story facility is blocked by shrubs. There would no visual impact.

K6 and Cut-and-Cover Area B: The potential visual impact is classified as VM Class 4; highly sensitive viewing positions; inconsistent with BLM management direction; potentially significant impact; regional scope not mitigable to a level of insignificance. A jeep trail connecting with Maricopa Road passes within 1,000 ft of K6 and crosses cut-and-cover Area B.

Specific measures should be considered during final design. K6 is so close to the trail that no measure could make it unnoticeable. The cut-and-cover area in time could feasibly be revegetated in this vicinity with the use of plants salvaged from the area prior to excavation, hydroseeding, and drip irrigation.

E5, F4, E4, F3, E3, F2, and E2: The potential visual impact is classified as VM Class 4; low-sensitivity viewing positions; inconsistency with BLM management objectives; significant impact; regional scope not mitigable. Facilities E2, E5, F4, E4, F3, and E3 would be in the general vicinity of Interstate 8 but would not be noticeable from Interstate 8 and would have no impact.

F2 is too close to the highway to completely mitigate its impact. Nonetheless, for this and the other facilities noted, design details, siting, selection of materials and colors, and screening should be considered in order to minimize visual impacts vis a vis views from the highway and nearby BLM lands. Specific measures to be taken should be evaluated during final design.

Campus and Injector: The potential visual impact is classified as VM Class 2 to 3; high sensitivity viewing positions; potentially significant impact; regional scope; not mitigable.

The campus and injector could be within views from the higher elevations of the southern Maricopa Mountains at distances ranging from 4.5 to 10 mi. From the northern Maricopa Mountains higher elevations, viewing positions would be over 10 mi away. Possibly, views from the closest ridges of the southern part of the range would be affected; the aggregate of the facilities would be distracting to dominant in the currently undeveloped setting (VM Class 3 to 4). Given the Wilderness Study Area (WSA) designation for these mountains, views from their flanks and ridges are considered highly sensitive. The impact would be significant but would affect very few recreationists. BLM visual resource management objectives for the campus and injector areas call for VRM Class IV (a high level of change in the landscape is permissible). Therefore, the campus and injector facilities are not inconsistent with BLM plans and policies.

The campus and injector facilities cannot be screened from view from elevated positions along the Maricopa Mountains. Architectural design and treatment and the choice of muted colors and nonreflective materials of construction to blend the structures with the desert should serve to reduce project contrast and noticeability. Measures to be taken should be evaluated during final siting and design.

Spoils: The potential visual impact is classified as VM Class 2 to 3; high-sensitivity viewing positions affected; regional scope; possibly mitigable in the long term.

Arizona has proposed four alternatives for disposal of spoils: Three of the alternatives would pose no visual impacts; these involve dispersal at distant mines or use as building material in the Phoenix area. However, one alternative is to spread the material across 1 mi^2 to a depth of 1 ft within the injector area. It is assumed that the material would be sterile and that plants would not grow there. The scar would, in this case, persist indefinitely. It would be seen from the southern Maricopa Mountains from points along the slopes and ridges. Alone the scar would be noticeable to distracting (VM Class 2 to 3). Coupled with the structures of the campus and injector, it would reinforce the dominance of the facilities. The affected views are highly sensitive and regionally important. The impact would therefore be significant and regional in scope.

As a mitigation, during detailed design, the feasibility of scraping the veneer of topsoil from the disposal site and stockpiling it should be considered. Subsequent to spoils disposal, spreading the topsoil over the site may facilitate revegetation. Eventually revegetation may reduce the impact to a negligible level.

B. Colorado

Colorado is shown as not being visually impacted by the proposed SSC because there are no moderately or highly sensitive views in the affected areas, i.e., there are no indications that the public would be appreciably concerned over the introduction to the landscape of features incongruous with the established agricultural character. The region is sparsely settled ranch- and farmland with no recreational sites or designated points of aesthetic, cultural, or scientific interest, residential areas, or scenic travel routes.

C. Illinois

In Illinois, the possibility of visual impacts on views from residential areas is particularly great because of the urbanization of much of the project site and its vicinity. Views from six subdivisions and one rural residential area would be adversely affected. The expected impacts would be important only at the local level. However, much of the site is characterized by such a mix of land uses that no identifiable character exists and there would be no visual impacts. Elsewhere, farmland prevails and sensitivity is low. The expected impacts for the Illinois site are assessed below starting with E1 and working clockwise to F9.

E1: There would be no visual impact. Views have been compromised by earlier land decisions.

E2: There would be no visual impact. Trees along the Virgil Gilman Trail block views of the facility.

F2: The potential visual impact is classified as VM Class 4; highly sensitive views affected; potentially long-term significant impact; local in scope; mitigable to a level of insignificance; indeterminate period before mitigation is effective.

This facility would occur in a field surrounded by an existing subdivision. A new residential development (a Planned Unit Development (PUD)) is going to occur in the same field, but it is the view from the existing homes that is of concern.

Mitigations are available. If the site is within the PUD and not between it and the existing residences, no further mitigation would be needed. It would be screened by the new homes. If not, earth berms, landscaping, selecting appropriate building materials and colors, and architectural treatment would be considered.

E3: This area has no impact because of industrial scale structures in the area.

E4: The potential visual impact is classified as VM Class 1; negligible impact; local scope.

Facility E4 would be about 400 ft south of a small cemetery on a partially wooded knoll. A farm is sited across the road to the west and there are extensive open fields to the north and south. The facility would be partially screened from view by fencerow plantings at the cemetery's southern edge, which help to partially enclose it, lending a sense of privacy and an inward orientation. The alignment of the road accessing the cemetery is east-west, which does not encourage views to the south toward E4. These factors suggest that E4 would not be especially noticeable from the cemetery. Moreover, if the structure should be glimpsed, there is a row of large lattice-structure transmission line towers directly south in line with views toward it from the knoll. These large industrial-like structures command attention and would dwarf the one-story building proposed, by comparison greatly overshadowing its impact. It is concluded that E4 would go unnoticed by most people visiting the cemetery (VM Class 1). This would be a negligible impact of local scope.

F4: The potential visual impact is classified as VM Class 4; moderately sensitive views affected; potentially long-term significant impact; local scope; possibly mitigable to a level of insignificance in the long term. This facility is located as close as 1,000 ft from an area of scattered rural residences (moderately sensitive).

As a mitigation, during final detailed project design, several measures should be evaluated. The use of landscaped berms could screen the facility from view, as per recommendations for concealing F2. Architectural treatment could provide structures compatible with the rural character of the area.

F5: The potential visual impact would be classified as VM Class 2 and 4; moderately sensitive travel route; highly sensitive public use area; potentially significant; local scope; impacts on residential views mitigable to a level of insignificance in the short term; impacts on road-based views may be mitigable in the short term.

The service area would be adjacent to Dauberman Road in a field and between two farms. The closest farm is less than 1/8 mi to the north; the other is about 1/3 mi to the south. Views from these farms are considered to be low in sensitivity. However, a subdivision lies to the north and northeast. Twenty-two of the homes in this subdivision would be within the fee simple area of the Far Cluster and families living there would be relocated. The remaining homes closest to the F5 site would be about 1/4 mi to the northwest. The facilities of this site, at the viewing distance involved, would not go unnoticed from the residences. It is assumed that the farms noted would be removed. Such removal would leave F5 more obtrusive than would be predicted than if they were to remain. The F5 facilities would be the only structures between the residences and Dauberman Road to the southwest.

Farms in the vicinity that would remain have structures that are substantially larger than those of the F5 facilities. At the viewing distance involved, and given the open sweep of the available views, F5 would probably be visually subordinate to other features (homes, farms) that are closer. The predicted visual impact would be VM Class 2, which, for the highly sensitive views affected, would be considered significant.

Views from Dauberman Road would also be affected. This road is a primary access to the subdivisions noted, although it serves other destinations as well. The turnoff to the subdivision is about 1/4 mi north of F5. Sensitivity for the part of Dauberman Road opposite the F5 site would be moderate, based on the criteria for sensitivity. Views toward F5 would be dominated by the facilities there (VM Class 4). The impact would be significant.

The impacts noted would be important to the residents in the immediate area and, therefore, are judged to be local in scope.

As mitigation, design measures described in relation to F2 and F7 should be considered during detailed project design. These measures could conceal the facility (landscaped berms, muted colors, etc.). The time required for screening to become fully effective would be substantial, relative to views from the residences, given the distance involved. The combination of berms and plantings would have to equal the height of the buildings. Views from the road could be more quickly screened, depending on the set-back from the road for the facility versus that for the planted berms. Therefore, it is estimated that impacts on views from the residences could not be fully mitigated by screening in fewer than 5 years (long-term impact), while those on views from Dauberman Road may be mitigable in the short term.

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If technically possible, it would be effective to site F5 closer to the existing farm 625 ft to the north and the farm structures left intact. The farm buildings may be sufficient in size to block many residence-based views of F5. In addition, architectural treatment, such as that suggested by the state of Illinois, might provide a barn-like appearance to the two-story structures, reducing the visual contrast of the F5 structures with their agricultural context. This latter measure may be most successful relative to the comparatively distant views from the residential area, rather than those from the road, which invite closer attention. If successful, the impact on residential views may be mitigated upon completion of construction. The success of architectural treatment relative to views from the road can only be assessed during final design.

E7: This area has no impact because it is already screened from view.

F7: The potential visual impact is classified as VM Class 4; highly sensitive public use area; moderately sensitive travel route; potentially significant; local scope; mitigable to a level of insignificance in the short term. This service area would be in a field directly across from a residential subdivision in an area where there are several such developments. Views from the adjacent subdivision and the road accessing it (Empire Road) are of concern. The road is the only access route to these homes, but serves other destinations as well; views from the road are considered to be moderately sensitive. The proximity of F7 to the road and the nearby residences is such that it would dominate the local views (VM Class 4). There is the potential for significance, but at a local level.

As mitigation, certain design measures described in relation to F2 should be considered during detailed project design. These measures could conceal the facility (landscaped berms, muted colors, etc.). The entire field in which F7 is located could be purchased as a buffer zone. Concerning the state's proposed architectural treatment of service areas to simulate farm structures, there are residual farms in the general area. Farm structures at this site would be compatible with the general context.

E8: The potential visual impact is classified as VM Class 4; highly sensitive public use area and road, moderately sensitive road; potentially significant; local scope; possibly mitigable to a level of insignificance, but not in the short term.

This intermediate access facility would be sited 0.2 mi from a development of new, expensive homes, the closest of which have been sold already. The one-story building would be fully in view from these homes, being 500 to 700 ft north of the entrance to the subdivision. Because it is near the entrance, it could not escape attention. It would be comparatively small but not compatible with the area features. However, at the viewing distance involved from the homes, the facility would be noticeable but subordinate to other features in view (VM Class 2). Those exiting the subdivision and turning north would pass by the facility at close range, and it would dominate views from the road (VM Class 4). Sensitivity for views from the homes and the interior subdivision road is high. For Denker Road, which also serves other destinations, sensitivity is moderate. There is potential for significance, but only at the local level (VM Class 4).

Mitigation, including screening with vegetation, should be evaluated during final project design. The structure should be set as far back from the street as possible and screened on all sides with dense evergreen plantings, mixed with deciduous species for variety. It is not certain that full screening would be possible because of its exposure to sensitive views on three sides. It would help to curve the site access road so that plantings could eventually cut off views directly along the road. It might require more than 5 years to achieve full screening.

F8: Potential visual impacts would be classified as VM Classes 2, 3, 4; moderately sensitive public views from travel routes affected; negligible and potentially significant; local scope; mitigable to a level of insignificance in the long term.

Facility F8 would be sited just east of the junction of Bolcum Road and Randall Road within a new subdivision currently under construction. Presently, only two of the homes in this project are occupied. The facility would also be in view from Bakers Acres, a new subdivision just under 1/2 mi to the southwest. Only two homes there are occupied. Subdivisions under construction with fewer than four homes occupied are considered to be low in sensitivity (Section 5.3.13.3.B).

Randall Road carries a considerable volume of traffic and serves secondarily as access to established subdivisions in the area, the closest of which abuts Red Gate Road on its south side near Randall Road. Portions of travel routes close to highly sensitive use areas serving secondarily as access to them are considered moderately sensitive. This classification would apply to views from Randall Road, approximately from F8 south to the rise 1500 ft south of Red Gate Road.

Similarly, views from Red Gate Road east of Randall Road would be moderately sensitive. That road secondarily serves as access to the established subdivision noted above and is considered to be moderately sensitive.

Due to heavy vegetation and structures, F8 cannot be seen from the referenced subdivision or from most of Red Gate Road east of Randall Road. From the Red Gate Road/Randall Road intersection, for 100 ft to the east on Red Gate Road, F8 would be visible at a distance of about 1/4 mi. At this distance, F8 would not be overlooked and would attract some attention. However, the facility would probably be subordinate to features closer at hand, such as the farm structures in the immediate foreground. Also, the direction of travel favors views to the east or west, not those to the north (in the direction of F8). The impact is expected to be a VM Class 2.

From Randall Road traveling north from Red Gate Road, facility F8 would be in view and would progressively dominate attention as one approached it. It would appear out of place, not being consistent with the scattered residential developments in the general vicinity. The visual impact would be VM Class 3 to 4, depending on proximity to F8. This impact on a moderately sensitive view would be significant.

The impacts noted would be important to the residents in the immediate area and, therefore, are judged to be local in scope.

Several mitigation measures should be evaluated during final detailed project design. Berms and plantings, as suggested relative to F2, would be ineffective for F8 in the short term given that the viewing positions include points that are 1/4 mi or more away and 10 to 15 ft higher than the facility. The combination of berms and plantings would have to be at least as high as the two-story structures to be concealed; i.e., the berms would have to be large and the plant materials mature. For close-in views, screen plantings and berms would be progressively more effective the closer the viewing position was to the facility.

Architectural design that alters the industrial appearance of the structures, making them more institutional in character, would reduce the impact. The zoning for the area is E3, which permits police stations, fire stations, and public and private schools, among other uses. Presumably, such uses are not incongruous with residential areas.

E9: The potential visual impact is classified as VM Class 4; highly sensitive public use area, moderately sensitive road; potentially significant; local scope; mitigable to a level of insignificance, but probably not in the short term. The proposed site for this facility would be seen on all four sides by residents in an established subdivision on Country Club Road. It would abut the road and not escape attention from those driving by. The impact would be the same as for E8.

As mitigation, the measures recommended for E8 would apply to E9 and should be considered during final design.

F9: No impact is projected. The facility would not be visible from the Great Western Nature Trail or State Highway 64. Further, the site is in an open field bounded by a light industrial park and 2,000 ft southwest of DuPage Airport.

Spoils are projected to have no impact. The State of Illinois proposes to dispose of spoils at four quarries. Therefore, no visual impacts would be associated with this activity.

D. Michigan

In Michigan, rolling woodlands and fence rows around small pastures and croplands substantially confine views. There are no subdivisions affected, and rural residences are scattered and comparatively few in number. No recreation areas or religious facilities are affected and there are no designated or informally classified scenic routes. The predicted visual impacts would be of local scope, only affecting several groupings of rural residences. Seven of the proposed SSC facility sites range from close to moderately to highly sensitive travel routes or public use areas. For three of these, the project either would be compatible with the immediate surroundings, or would not be visible to the point of being noticeable. Apart from the seven sites noted, the rolling terrain is sufficiently wooded to conceal the rest of the sites from any sensitive travel routes or public use areas.

E8: The potential visual impact is classified as VM Class 2; moderate sensitivity; negligible impact; local scope. This facility would be 500 ft or more east of Williamston Road in a flat, open field. Within a few hundred ft of the facility to the northwest along the road, there are several residences. This rural residential area is moderately sensitive. A gravel pit with existing stockpiles of gravel and associated heavy equipment are partially in view. A one-story building might be noticed, but would not draw much attention

F10 and K1: These areas are projected to have no impact. These facilities are of concern because of a potential equestrian trail about 500 ft to the southeast of F10 and about 800 ft northwest of K1. This trail traces the Grand Trunk Western Rail Line. In this vicinity the trail is depressed below adjacent fields and is lined by trees that confine views to the alignment of the trail. It is unlikely that the subject facilities would affect views from the trail; there would probably be no impact.

F1: This area is projected to have no impact.

The F1 facility would be sited 300 to 500 ft west of Dunn Road behind Lindsay's Wrecker Service. It is mentioned here because the Robinhood Sherwood Forest RV Campground is 1,500 ft to the east and, because it is a recreational facility, is considered highly sensitive. Although F1 would not be seen from the campground, it would be visible from Dunn Road just before the turnoff to the campground. Given that the wrecker service facilities are presently in the foreground of the affected views, it is unlikely that the SSC service area would be considered to be a visual impact. The clutter of car bodies and other junk already present compromises the scene.

F3: The potential visual impact is classified as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; mitigable over indeterminate period, possibly over the long term.

Six rural residences are in the immediate vicinity of F3, several homes being less than 300 ft away. Sensitivity is moderate. Given the proximity of the homes, the two-story buildings at the F3 site would dominate views from these residences (VM Class 4). The impact would be potentially significant to those living here (local scope).

The following mitigative measures should be evaluated during final detailed design: earth berms, landscaping, appropriate building materials and colors.

E4: This area is projected to have negligible impact of local scope.

Substation No. 2: The potential visual impact is classified as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; mitigable, possibly in the long term. This substation would be in the foreground view of several rural residences along Covert Road and at its intersection with Ridley Road. If the substation is similar in size and configuration to the one serving Illinois' Fermilab near its entrance, it would dominate attention (VM Class 4) and may be a concern to the immediate residents (local scope).

For mitigation, the following measures should be considered during final design. If there is flexibility in siting this structure, it could be located away from the road and behind a woodlot to the north. If not, plantings and/or planted berms could conceal it.

Spoils are projected to have no impact. The State of Michigan proposes to dispose of spoils by supplying it as material for commercial processing as aggregate fill at a quarry and by transport to existing landfills. No visual impacts would be expected.

E. North Carolina

At the North Carolina site, project features would affect views from two subdivisions, one rural residential area, roads accessing residential areas, a stream with recreational value, and a historic chapel. The affected views are locally important.

The proposed site is a substantially forested, sparsely settled, rural/agricultural area that is within 10 to 30 mi of urban areas lying to the south. The character of the site is consistently small-town, rural-residential, and agricultural. The industrial character of the SSC facilities would be incongruous in this setting.

None of the many travel routes through the site and its vicinity is formally or informally designated as scenic highways or roads. Several secondary roads serve subdivisions or rural residential areas; these are considered moderately sensitive (See Appendix 5). These are State Routes 1601, 1004, 1602, and 1736.

Concerning public use areas, most are subdivisions or rural residential areas. Views from these would be affected by F1, F9, E8, F7, F4, E4, and F3. Apart from residential areas, there are two other sensitive public use areas. Webb's Chapel would be displaced by F5 and separated from its aesthetic, historic context; and views from the Flat River, which supports some canoeing, may be affected by F1.

The expected impacts for the proposed site are assessed below starting with F1 and working counterclockwise to F3.

F1: The potential visual impact is classified as VM Class 4; highly sensitive views affected; potentially significant impact of local scope; mitigable, but not to a level of insignificance.

The Red Mountain subdivision is a cluster of expensive homes sited on a rise within 2,000 ft of the proposed site for F1 and somewhat higher. Because of the thick, deciduous forest surrounding the subdivision, views toward the facility are blocked for much of the year. During the winter, it may be possible to see the facility, but the views are likely to be substantially filtered by the trees nonetheless. It is expected that, if noticeable, the facility would probably attract little attention (VM Class 2). To a highly sensitive public, such an impact might yet be considered significant. It would, however, be an issue of local scope.

State Routes 1601, 1602, and 1736 pass within 700 to 1,500 ft of F1. These roads primarily serve rural residences and are considered moderately sensitive. The residences are tucked into the wooded settings and the views out are probably blocked in the summer and limited in the winter. However, it is expected that the facility would be visible from the area roads noted. The proposed site for F1 is on the side of a hill and above the subject roads, a factor tending to increase its visibility. A substantial clearing of vegetation would have to occur on the 6-acre site for construction of the facility structures as well as to create work space for other activities, such as tunnel construction. The clearing on the affected slope may render the facility highly visible to those passing by. In the winter, the facility would become substantially more visible. The industrial scale and appearance of the structures would be in glaring contrast to the small-scale rural residential character of the environs. There is the potential for this facility to attract and hold attention (VM Class 4). Within the moderately sensitive road-based views, such an impact could be significant to the local residents.

Similar to the impact on views from roads discussed, the impact on views from the Flat River could be significant. Local canoeists use the river (Hinton 1988) in the spring before vegetation has fully leafed out. They pass to within 2,000 ft of F1, and the facility and clearing might dominate attention (VM Class 4). The impact could be locally significant.

Mitigations. During detailed project design, the following measures should be evaluated. The primary mitigation recommended is to minimize the clearing of vegetation between the facility and sensitive viewing positions. In addition, landscaping with large-caliper evergreens to enhance screening could be effective. Lastly, design options such as choice of color and materials of construction to blend the structures with the background should be considered. These measures could substantially reduce project visibility; however the facility could still be noticeable from roads, residences, the Flat River, and the Red Mountain Subdivision. The residual magnitude of the impact on all views would be VM Class 2.

F9: The potential visual impact is classified as VM Class 2 and 4; moderately and highly sensitive views affected; potentially significant impact; not mitigable.

This facility is toward the end of a gravelled road solely serving a new subdivision called Raney Way. The facility would be in the midst of part of the subdivision, which consists of 21 parcels, some of which have been sold already. The subdivision and the gravel road are both considered highly sensitive. State Route 1004 is the main road accessing this area and is considered moderately sensitive (while providing access to the subdivision, it primarily serves other destinations). The facility would clearly dominate views from the gravel road and most of the future residences, some of which abut the site (VM Class 4). The visual impact from State Route 1004 may be classified as VM Class 2.

No mitigation is possible because the proposed site is in the midst of several affected viewing positions.

E8: This area is projected to have negligible impact. This facility would be 200 to 300 ft north of a road (State Route 1139) in the vicinity of a rural residential area (moderately sensitive). The affected views are so limited that the impact would be negligible.

F7: This area is projected to have no impact.

The facility would be about 500 ft north of State Route 1302 in a rural residential area. Presently there is a densely forested border along the road. It is assumed that the forest along the road could be left intact and clearing along the right-of-way for the access road held to a minimum. With this situation, the impact would be negligible.

F5: The potential visual impact is classified as VM Class 4; highly sensitive resource displaced; potentially significant impact; local scope; not mitigable. Webb's Chapel, a restored historic structure, would be displaced by F5 and presumably relocated. Views of the chapel and its surroundings, as well as views from the chapel, are considered highly sensitive. It is assumed that the chapel today is in its original location. Further, it is assumed that an historic structure and its setting are integrally related. Separating the structure from its context represents a substantial change in the visual character of the chapel regardless of where it is to be relocated. Replacing it with the facilities of F5 would, of course, represent a change of the greatest magnitude (VM Class 4). The impact would be potentially significant, but probably on the local level.

For mitigation, apart from displacing F5 several hundred feet, there are no measures that can be taken to mitigate the impact. Resiting F5 would require detailed technical considerations and can be considered only during final project design.

F4: The potential visual impact is classified as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; not mitigable. The proposed site for F4 is shown straddling a road and abutting, or being in close proximity, to a number of rural residences in an area of residual, small farms and pastures. One structure is a homestead dating to 1800, including its original tobacco sheds. Sensitivity is moderate and this facility would dominate views from the residences.

For mitigation, because of this proximity between the proposed site for the facility and the points from which the structures would be viewed, there are no feasible measures to conceal the buildings.

E4: The potential visual impact is classified as VM Class 2; moderately sensitive viewing position affected; negligible; local scope. Several rural residences are within 100 to 200 yds of the proposed site for E4. This facility would be 100 yds south of State Route 1536 in a field near an existing shed-like structure of similar size. Sensitivity is moderate. A light-industry-like building in this location might be noticed, but would not attract appreciable attention. Given the occurrence of a similar-sized structure nearby and given that both are relatively small, F4 is expected to be a subordinate feature in the landscape (VM Class 2). The impact would be of local scope and negligible.

E3: This area is projected to have no impact. The facility would be 1,200 ft south of U.S. Highway 158 in a rural residential area (moderate sensitivity). As sited now, it would be in a thick grove of trees and would not be visible, assuming that site clearing does not remove the trees affording the screening. Siting is critical. Based on current proposed siting, there would be no impact.

Spoils are projected to be nontoxic and would impact only those areas used directly for spoils disposal. The State of North Carolina proposes to dispose of spoils at 17 different locations. Fifteen of the sites would be 15 acres in size; the other two would each cover 20 to 45 acres. The actual acreage of spoils disposal area at each site would range from 3 to 5 acres. The intent is to provide a forested buffer around the spoils. This buffer, as planned, would preclude views of the spoils material, and there would be no visual impact.

F. Tennessee

At the proposed Tennessee site, an intermediate access facility would be close to homes at the edge of a small community, and service areas would affect views from rural residences. The impacts would be local in scope. However, running through part of the Tennessee site is a State-designated scenic highway. Past land use decisions have permitted mixed activities which have compromised the scenic qualities along this road (junk yards, commercial and industrial uses, residential developments). In this present context, the SSC facilities would not have an appreciable impact. However, siting industrial-like project features along the road would be inconsistent with the State's management objectives for the road, which call for not further degrading the views. In this case, the visual impacts would be regional in scope.

The expected impacts are assessed below starting with F9 and working counterclockwise to F1.

F9: The potential visual impact is categorized as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; not mitigable; long term. This facility would be sited to the west of Coleman Hill Road in a shallow hollow behind two houses in a rural residential area (moderate sensitivity). Other homes are on the east side of the road. The visual impact would be potentially significant to local residents (local scope).

If the two homes are not removed, the impact could not be mitigated and would be long term.

E9: The potential visual impact is categorized as VM Class 2; moderately sensitive views affected; negligible impact; local scope. Facility E9 would be sited against or behind a fencerow in a field less than 1,500 ft north of Coleman Hill Road/Patterson Road intersection. Several rural residences are in the immediate vicinity of this intersection and would be exposed to views of the facility (moderate sensitivity).

Mitigative measures are not required. The impact would probably not be greater than VM Class 2. Within moderately sensitive views, such an impact would be comparably negligible, but long term. The impact would be local in scope.

F8: The potential visual impact is categorized as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope mitigable in the long term. Facility F8 would be about 1,500 ft south of Tall Ferr Road and be in the midst of, or abutting, several rural residences (moderate sensitivity). The facility would clearly dominate views (VM Class 4). The impact would potentially be significant, but only to local residents (local scope).

Mitigation measures could include screening, berming, and architectural treatment.

E8: The potential visual impact is categorized as VM Class 2; highly sensitive viewing positions affected; potentially significant impact; local scope; mitigable in the short term. Facility E8 would be in a field about 500 ft behind a house at the northwest corner of College Grove Road and Drumright Road. Several homes in the small, rural community of College Grove are immediate to the site.

Mitigation measures could include architectural treatment similar to other outbuildings in the area, landscaping, and screening.

E3: The potential visual impact is categorized as VM Class 1; highly sensitive viewing position; negligible impact; long term. Facility E3 would be built along U.S. Highway 231/State Highway 10, a designated scenic highway. Sensitivity is high. No mitigation is necessary. Because of other structures in the area, the impact would be negligible, but long term.

F2: The potential visual impact is categorized as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; mitigable in the long term. This facility is in a rural area of pastures and fields and several homes. The preliminary siting is such that one or more of the homes abuts the boundary of the site.

Mitigation would include screening, berming, and landscaping.

F1: This area would have negligible impact.

Facility F1 is about 1,500 ft east of U.S. Highway 231/State Highway 10 and within views from that designated scenic parkway (highly sensitive). It is more apt to be seen by those traveling south than north because of a copse of trees to the south that probably would screen it from views from the northbound lane. F1 is in an area of unrelated views of an inconsistent landscape and would go undetected.

Spoils: One of the State's alternatives is to dispose of limestone spoils at 35 sites, each close to a surface facility. The impacts are analyzed below in the same facility order as for the preceding discussion. The range of mitigative measures available are presented at the end of this subsection.

F9, E9, E8, E3, F2, F1: These spoils areas would have no impact. No views would be negatively impacted.

F8: The potential visual impact is categorized as VM 4; moderately sensitive views affected; significant impact; local scope. Here the spoils would be readily seen from Tall Fern Road and nearby residences and would be in the immediate foreground. The site would, by itself, dominate views (VM Class 4), appearing as a devegetated scar next to the road.

Mitigations for spoils disposal to be evaluated during detailed design include: stockpiling area topsoil for distribution over spoils to facilitate revegetation; screening the spoils area with landscaping; and tinting concrete to lower contrast of retention pond dike (assuming concrete is used), or using an earthen dike.

G. Texas

At the Texas site, views from one subdivision, two rural residential areas, and a recreational area would be impacted. The scope of the impacts on views from the residential areas would be local in scope. However, one service area would adversely affect views from a lake serving as a regional recreation resource; the impact there would be regional in scope. The proposed SSC facility potentially would affect few views. Although many of the proposed facilities would be noticeable to dominant, as seen from secondary roads and isolated farm structures, few of the affected views are sufficiently sensitive for the effects to be considered an impact. The few cases where a visual impact merits consideration are discussed below, starting with the upper arc and moving clockwise.

F3: The potential visual impact is categorized as VM Class 2 and 4; highly sensitive views potentially affected; significant impact; local scope; mitigable; duration of impact indeterminate. The proposed site for F3 abuts the road across from and adjacent to several residences. The state proposes to acquire the land in this vicinity fee simple, which would make moot a discussion of sensitivity relative to these homes. However, there are a number of homes along the road serving F3 that are to the southeast; the views from several would include the facility. To the northeast there is a subdivision. Views from two of the residences and from the cul-de-sac at the end of the road serving the subdivision would include the proposed facility.

The situation can be mitigated. During detailed project design, several measures should be considered. The facility can be concealed from the residences to the southeast and the northeast, as well as from those driving along the road abutting the proposed site. Berming, landscaping, architectural treatment, and screening can be utilized to blend the facility into the surroundings.

E4: This area is projected to have no impact. This facility would be 2,000 ft west of State Highway 983 near a barn and within view of a number of residences to the south. The facility would probably not be noticed when viewed together with the barn structure.

F4: The potential visual impact is categorized as VM Class 4; moderately sensitive views affected; potentially significant impact; local scope; mitigable in the long term. Agricultural lands occur around this facility, with a few rural residences being about 1,500 ft southwest. An industrial-type facility in these lands is not consistent with the current land use.

As mitigations screening and architectural treatment could be employed. Berms would be out of place in this area.

K5: This area is projected to have no impact. Several rural residences are about 0.25 mi west of the proposed site for K5, which abuts the road serving these residences. Experimental facilities are about five stories high, with substantial parking and work areas around them. The structure would be readily seen from the residences noted, most of which are mobile homes. K5 will have no adverse impact.

F6: The potential visual impact is categorized as VM Class 3; highly sensitive views affected; potential for significance; regional scope; mitigable in the long term. Lake Bardwell and the stretch of State Highway 34 crossing the lake are highly and moderately sensitive, respectively. Facility F6 would be nearly 2 mi from the highway and nominally in views at nearly 90 degrees away from the direction of travel. It is unlikely that the facility would be noticed by those using the highway. Boaters could approach no closer than 2,000 ft to the facility, which would be on a peninsula.

Mitigation measures considered for F6 include berming and screening.

E10: This area would have negligible impact; local scope. This structure would be within view of a church and cemetery at a distance of about 1,000 ft. Because of the distance and the fact that the church and the cemetery are considered moderately sensitive, the impact would not be potentially significant, but it would be a negligible impact relative only to the local populace.

Spoils: Spoils would be categorized under the worst scenario as VM Class 4; possibly moderately to highly sensitive views affected; potential for significance; local scope; possibly mitigable. The state proposes that spoils consisting of chalk be used at a cement plant or as a material to be used in road construction. Marl spoils may be disposed of in quarries or placed in landfills at currently undefined locations. The landfills may be 15 ft high and could present a significant impact, depending on the location. Because of the uncertainties concerning location for the spoils disposal sites, a worst-case scenario is suggested: disposal in view of rural residences or subdivisions. Landfills 15 ft high in a flat landscape could dominate foreground views (VM Class 4). Views from residential areas are moderately to highly sensitive. Under the extremely conservative assumptions, the impact would be significant.

As mitigation, it is assumed a marl landfill could be landscaped. Screening by vegetation would then be feasible and should be evaluated during final design.

5.2 CUMULATIVE IMPACTS AT ALTERNATIVE SITES

Cumulative impact assessment includes both an analysis of the contribution of a project to regional trends as well as analysis of the contribution of a project to overall regional environmental conditions. Both have been included, where appropriate, in the detailed assessments of the effects of the project presented in Section 5.1 and further developed in Appendices 6 to 16. The following discussion highlights the major conclusions of these assessments as they related to cumulative impacts of the SSC project at the seven alternative sites.

5.2.1 Regional Population Growth

SSC-related regional population and housing impacts for each of the proposed sites are discussed in Section 5.1.8 of this volume and are summarized here as follows:

Site	Population % SSC-Related[1]	Housing Unit Demand[2]
Arizona	0.43	3,610
Colorado	0.38	2,290
Illinois	0.13	2,700
Michigan	0.14	1,830
North Carolina	0.83	4,070
Tennessee	1.12	3,990
Texas	0.28	2,700

1. SSC-related regional population increase as a percent of projected future baseline population in the region without the proposed project
2. Demand for housing in the region associated with in-migration

Impacts of the proposed SSC project on regional population growth are extremely small. Impacts on regional housing unit demand vary by small increments between sites. Local impacts are expected in Fort Morgan and Brush in Morgan County, Colorado, and in the village of Stockbridge in Ingham County, Michigan, based on the existing housing market.

5.2.2 Construction Materials

Approximately 1.3 to 1.8 million tons of high-quality aggregate would be consumed by construction of the SSC project. With the exception of the Colorado site, the proposed sites are located near, or have access to, abundant aggregate resources. However, aggregate resources in the Denver area are not abundant, and the existing permitted reserves are expected to be depleted in the first decade of the next century. The rapid expansion of the Denver area has both removed some resources from potential development and resulted in a large demand for aggregate in relation to the supply. The SSC will place an incremental increase in demand on this resource in the 1990's, and transportation of such material from outside the region may be required.

5.2.3 Water Use

The proposed SSC project would create an increased demand on water resources, both from direct project requirements and from indirect domestic water requirements due to regional population growth supported by the SSC project. Except as discussed below, the cumulative impact of SSC-related domestic water requirements would be proportional to the SSC-related population growth identified in Section 5.2.1. Long-term regional impacts to water use from SSC activities largely are dependent on the capabilities and capacities of existing systems, and the distribution in the region of water users. In Arizona, SSC direct water requirements will be met from groundwater resources that are largely undeveloped. Negligible impacts would result during construction; however, initiation of groundwater overdraft could result during operations depending on the extent of other use of the aquifer. In Colorado, SSC-direct water requirements would be partially met by purchases of existing surface and groundwater allocations. In Illinois, direct water requirements would be met primarily by groundwater supplies that have the capacity to support the project. A regional overdraft exists which would be incrementally increased primarily by indirect water uses associated with the SSC in Illinois. In Michigan, both direct and indirect SSC water requirements could contribute to localized groundwater overdraft. In North Carolina, SSC operations would use about 23 percent of the available excess capacity of Lake Butner. Water requirements from other water supply systems would be less than 4 percent of current excess capacities. In Tennessee, a number of small-to moderately sized existing systems relying primarily on surface water would meet both direct and indirect SSC water requirements. If all project requirements were met by these small to moderate existing systems, it could represent use of up to 22 percent of the available excess capacity of the Rutherford County system. Depending on other demands, system expansion could become necessary in several cases. In Texas, SSC-related water requirements would require only a negligible increased commitment of regional excess surface water supply capacity. A small increase to regional groundwater overdraft would also occur.

5.2.4 Air Quality

The mobile-source air emissions of the SSC project at any of the alternative sites would make a small, incremental contribution of a few percent (see Section 5.1.3) to regional air emissions. The contributions of the SSC to air emissions include particulates from construction activities and emission of combustion products from construction equipment and the vehicles of construction and operations workers. In addition, in-migration and secondary growth in emissions are due to a proportional increase in the number of automobiles operating in the region.

These sources make an incremental contribution to the air pollution of regions in which the NAAQS are exceeded. Proposed SSC sites in Illinois, Michigan, and Tennessee are within regions that are designated as non-attainment for ozone. Increases in pollutant emissions associated with the nonattainment status may result in a further degradation in air quality.

5.2.5 Radiation

Impacts from radiation produced by the SSC on the total population are small compared to existing background (in Michigan, for example, 0.25 person-rem/yr from the SSC as compared to 11,000 person-rem/yr for background). They thus contribute cumulatively to adverse genetic and carcinogenic effects at a level of some 0.002 percent.

5.2.6 Noise and Vibration

Impacts from noise generated during SSC construction and operations will be limited to the areas adjacent to the project facilities which are dispersed around the ring at such distances that the impacts from the individual areas would not be cumulative. Since the impacts from the noise sources are of limited extent and of little consequence at more than a mile from the source, the SSC would not contribute to general regional background noise levels. The impacts of the SSC on local residents will be most pronounced adjacent to service areas in rural or remote areas; and, if not mitigated, increased noise levels may result in expressions of public annoyance. In areas with existing sources of noise, the SSC-generated noise impacts will be less intrusive since the difference between ambient and SSC-generated noise will be less.

There are no known existing construction or quarrying activities in the immediate vicinity of any of the proposed sites which would interact in a cumulative manner with blasting impacts of SSC construction activities.

5.2.7 Wetlands

At all alternative sites except Arizona, wetland impacts could result from construction of surface facilities in fee simple areas proposed for immediate development and in areas slated for possible future expansion. construction of ancillary facilities could also affect wetlands. Without mitigation, these impacts would contribute, to varying degrees, to the national and regional destruction and degradation of wetland habitats. It is, however, DOE policy to avoid wetland impacts wherever possible and to mitigate wetland loss to the maximum extent practicable. Given the successful implementation of this policy, minimal impacts to wetlands could be expected to result from construction. In addition, some protection and preservation may be afforded to wetlands located within undeveloped fee simple areas and thus be a benefit of the project. The following discussion of cumulative impacts focuses on conservative estimates of wetland impact that could result from surface construction activities without mitigation.

5.2.7.1 Colorado

The Colorado site contains a number of small wetlands located largely in temporary stream courses and in the swales between the rolling hills. About 3.6 acres of wetlands could be impacted by construction at proposed surface facilities. An additional one acre of wetland habitat could be affected by construction of future expansion facilities.

The State of Colorado has proposed to construct an access road from the Denver area to the SSC site. The western end of the road would be located a few miles from Barr Lake. Barr Lake is used by migrating waterbirds, including the whooping crane, and also supports a breeding pair and a wintering population of bald eagles. The proposed access road could encroach upon close to 200 acres of wetlands, although with proper mitigation most wetlands could be avoided.

5.2.7.2 Illinois

The proposed Illinois project area contains a variety of wetlands. Approximately 199 acres of wetlands could be disturbed by construction of proposed surface facilities. An additional 294 acres of wetlands could be affected by construction of future expansion facilities. Approximately 200 acres of disturbance could be associated with construction of ancillary facilities but the impact of this development on wetlands is not known because locations have not been proposed. Impacts to wetlands would contribute to regional degradation and conversion of wetlands that is occurring as a result of expansion of the Chicago metropolitan area.

5.2.7.3 Michigan

Wetlands are abundant in the Michigan project area. Approximately 190 acres of wetlands could be impacted by construction of proposed surface facilities. An additional 319 acres of wetlands could be affected by construction of future expansion facilities. Approximately 250 acres of land could be disturbed by construction of ancillary facilities but the impacts of this development are not known because locations have not been proposed. Existing sources of impacts to wetlands occurring in the region include agricultural drainage and housing development. The proposed project would contribute to these other sources of impacts to wetlands.

5.2.7.4 North Carolina

Wetlands are common in the North Carolina project area. Approximately 41 acres of wetlands could be impacted by construction of proposed surface facilities. An additional 98 acres of wetlands could be affected by construction of future expansion facilities. About 850 acres of land could be disturbed by construction of ancillary facilities but the impacts of this development are not known because locations have not been proposed. Impacts from the project would contribute to degradation and conversion of wetlands due to expansion of regional urban areas.

5.2.7.5 Tennessee

Wetlands are common in the Tennessee project area. Approximately 38 acres of wetlands could be impacted by construction of proposed surface facilities. An additional 66 acres of wetlands could be affected by construction of future expansion facilities. About 340 acres of land could be disturbed by construction of ancillary facilities but the impacts of this development are not known because locations have not been proposed. Impacts to these areas would contribute to regional degradation and conversion of wetlands due largely to agricultural activities.

5.2.7.6 Texas

Wetlands are not common in the Texas project area. Approximately 3 acres of wetlands could be impacted by construction of proposed surface facilities. An additional 25 acres could be affected by construction of future expansion facilities. An additional 550 acres of land could be disturbed by construction of ancillary facilities but the impacts of this development are not known because locations have not been proposed. Impacts from the project would contribute to the regional loss of wetlands occurring from other sources of impact.

5.2.8 Prairies

There are seven prairie remnants in the 16 township area surrounding the proposed tunnel alignment in Illinois which contain examples of the original vegetation of northern Illinois. Those remnants which are on non-protected lands, including waste industrial lands, railroad right-of ways, and cemeteries, are under increasing threat of degradation or conversion due to urban growth. The Fermilab Prairie Restoration Natural Area is a 10-year-old, 675 acre prairie restoration project. The proposed location of the SSC project would avoid direct impacts to prairie remnants, and since modifications to the existing Fermilab facility would be concentrated in other areas, only incidental, minor impacts are expected to occur to the restored prairie. Incremental additions of the SSC project to regional impacts on prairie remnants would be limited to secondary impacts due to induced population growth.

The original vegetation of the Texas site was blackland prairie, which was developed into productive agricultural lands. Few, if any, remnants of the original vegetation remain in the proposed site region, and no remnants are known to occur at the proposed site. Should Texas be selected for the SSC, a survey would be necessary to determine the presence of any relict native prairie. Consideration would be given to relocating project facilities to avoid any prairies detected. Thus, the proposed SSC project at the proposed Texas site would not contribute to the regional decline of this resource.

5.2.9 Cedar Glades

Cedar glades are a distinctive ecological resource in the region of the Tennessee site. These communities, which are limited to the Central Basin, are openings on flat limestone outcrops in red cedar or red cedar-hardwood forests. For middle Tennessee, 12 endemic species are associated with cedar glades; many are state protected on Federal Status Review Species. Approximately 22 percent of the forested land area near the Tennessee site contains red cedar, and there are several glades in the vicinity of the proposed site. None of those known would be impacted by the project; however, during the preconstruction survey additional cedar glade areas could be identified and possibly impacted by construction of the project. These impacts would be an incremental addition to other regional impacts (i.e., tree harvest and stock grazing) on cedar glades.

5.2.10 Land Use

5.2.10.1 Arizona

SSC project development would probably be an important source of growth both in the southwestern region of Maricopa County and throughout the Phoenix metropolitan area. Regional and local planning agencies appear to be well-developed organizations, who, through their comprehensive planning efforts, are effectively guiding the character and direction of growth. It is expected that there would be some local competition for housing in the southwestern region, particularly as new housing developments come on line in the 1990's, should proximity to work be a major locational factor in housing choice determination. If not, it is expected that the regional housing supply would be adequate to handle both SSC workers as well as other newcomers. As a consequence, it may be difficult to separate the direct effects of SSC project development from the general pattern of regional growth.

5.2.10.2 Colorado

SSC project development would likely be the most significant source of growth in the northeastern Colorado region even if the Pawnee Generating Station, Unit II is constructed in the late 1990's. Land use patterns are expected to change dramatically and would challenge the regional and local planning agencies as they manage rapid growth. Nevertheless, there is considerable local professional planning experience in managing rapid growth generated by large-scale projects. Even though the Denver metropolitan region would be the major source of support for the project, given its distance away from the site, little in the way of land use effects would be attributable to the project.

5.2.10.3 Illinois

SSC project development would likely be an important, though not highly visible, source of growth in the urbanized Chicago region. Regional and local planning agencies appear to be well-developed organizations which, through their comprehensive planning efforts, are effectively guiding the character and direction of growth. It is expected that there would be some local competition for housing in the newly developing areas to the south and west of Fermilab, should proximity to work be a major locational factor in housing choice determination. If not, it is expected that the regional housing supply will be adequate to handle both SSC workers as well as other newcomers. As a consequence, it may be difficult to separate the direct effects of SSC project development on the region of influence from the general pattern of regional growth.

5.2.10.4 Michigan

SSC project development would likely be a significant source of growth in south-central Michigan. Regional and local economic development and planning agencies appear to be well-developed organizations, which, through their comprehensive planning efforts, are effectively guiding the character and direction of growth. It is expected that there would be a certain amount of revitalization to existing population centers, with some attendant new growth occurring. Given the site's unique reliance on three large urban centers, i.e., Ann Arbor, Lansing, and Jackson, plus a number of smaller communities, SSC project-related growth would be diffused throughout the region, thereby reducing to a minimum any singular development pressures.

5.2.10.5 North Carolina

SSC project development would likely be a major source of growth at the northern fringes of the Research Triangle Park area of the North Carolina Piedmont Region. State and regional planning agencies appear to be well-developed organizations, which, through their comprehensive planning efforts, are effectively guiding the character and direction of growth. It is expected that there would be some local competition for housing along the eastern and western borders of the SSC project, should proximity to work be a major locational factor in housing choice determination. If not, it is expected that the regional housing supply would be adequate to handle both SSC workers as well as other newcomers. As a consequence, it may be difficult to separate out the direct effects of SSC project development from the general pattern of regional growth.

5.2.10.6 Tennessee

SSC project development would likely be a significant source of growth in the middle Tennessee region. The area is currently experiencing rapid change and growth as major heavy industrial and other manufacturing projects are realized. Regional and local planning agencies are meeting these challenges through their comprehensive planning efforts so that the character and direction of growth can be guided effectively. It is expected that there would be a significant amount of local competition for housing along the northern and eastern borders of the SSC project, should proximity to work be a major locational factor in housing choice determination. If not, it is expected that the regional housing supply would be adequate enough to handle both SSC workers as well as other newcomers. As a consequence, it is likely to be easy to identify the direct effects of the SSC project locally, but more difficult to trace impacts at the Nashville-based regional scale.

5.2.10.7 Texas

SSC project development would likely be an important source of growth in the Dallas-Fort Worth metropolitan region. The region supports a reasonably well-diversified economy, but remains dependent on the internationally set price of oil as the economic driver. Given current low oil prices, the housing market is overbuilt as a result of recent downturns in the national economy. It is expected that there would be no local competition in the housing market generated by SSC project workers. Depending on the status of the local economy, the SSC project's direct effects may not be easily separated.

5.2.11 Prime, Unique, and Important Farmlands

The removal of prime, unique, and important farmlands to implement the proposed action will contribute to cumulative impacts at any site. However, the increments of removal of these soils are small with respect to the available soils of similar value within the regions of influence. There is no unique farmland that would be taken.

The DOE has conducted consultations with the U.S. Soil Conservation Service (SCS). SCS calculated the portion of prime and important farmlands which would be removed from the region's inventory if the project were implemented at the proposed site. The SCS also presented the acreage in the region which was estimated to be of comparable worth (based on FPPA criteria). These data are furnished in Table 5.2-1.

While there are appreciable acreages of prime and important farmlands proposed to be taken, in no state do they represent more than 1 percent of the inventory. The incremental increase in loss of prime and important farmlands is small and below the average lost per year by other development annually.

5.2.12 Socioeconomics and Infrastructure

5.2.12.1 Arizona

Two major construction projects currently under way in the Arizona region will be nearing completion about the same time that SSC construction would commence. The Central Arizona Project, a 320-mi aqueduct system of tunnels and canals, already brings water from the Colorado

Table 5.2-1

ESTIMATED INVENTORIES OF PRIME AND IMPORTANT FARMLANDS

State	Total in Involved Counties	Permanently Removed Acreages	Removed/Total
Arizona	0	0	0
Colorado	1,683,600	819	0.0005
Illinois	657,755	197	0.0003
Michigan	531,900	341	0.0006
North Carolina	572,444	955	0.001
Tennessee	425,817	606	0.0014
Texas	378,607	583	0.0015

Source: U.S. Department of Agriculture, Soil Conservation Service Consultation Letters

River to Phoenix, and when completed, will serve much of the Phoenix-Tucson corridor. The Palo Verde Nuclear Generating Station being built in central Maricopa County, is the largest nuclear power station in the United States and is expected to have the capability of serving up to three million residential customers. No new projects on the same scale have been proposed in the region. There are, however, two smaller scale dam construction projects slated to occur over the next 5 to 6 years. Both of these projects, the new Waddell Dam at Lake Pleasant and modifications to Roosevelt Dam at Roosevelt Lake, are upgrades of existing structures in northern Maricopa County and would lead to relatively minor socioeconomic impacts with or without concurrent construction of the SSC.

The most important regional factor with respect to cumulative impacts in the Arizona site region is the rapid expansion of the Phoenix metropolitan area. Large tracts of vacant land circling the urban area and ranging in size from 300 to 12,000 acres have been purchased by developers for future residential and commercial construction. The 38 large-scale developments identified in the Maricopa County Comprehensive Plan (Maricopa County Department of Planning and Development 1983) are estimated to have the capacity of accommodating over 400,000 residents. In the context of such extensive regional growth, SSC-related socioeconomic impacts would be comparatively small and easily absorbed.

5.2.12.2 Colorado

A number of major construction projects are planned for the Colorado site region in the next decade, with the peak cumulative construction activity occurring in the early 1990's. The most important of these projects include: a new airport, a new metro Denver beltway and upgrades to existing highways, a major water project, and cleanup of the Rocky Mountain Arsenal waste disposal site. The new airport, to be located northeast of Denver, is scheduled for peak construction between 1990 and 1994. At a total cost of $2 billion, the project is expected to employ from 2,200 to 2,900 construction workers annually. The major transportation project involves completing the remaining two segments of the Highway 470 beltway around metropolitan Denver: the first segment (E-470) is planned for construction beginning in the spring of 1989 at an estimated cost of $722 million; work on the second segment (W-470), expected to cost approximately $350 million, is not scheduled to begin until the year 2000. Another $54 million is budgeted for the first phase of construction of fast-track corridors dedicated lanes on existing highways for buses and high-occupancy vehicles. The Two Forks Water Project is proposed as a means of providing an adequate water supply for the area's future growth. The first phase of the project would be a dam located just below the confluence of the North Fork and the South Fork of the South Platte River. Construction is currently expected between 1990 and 1995 at a cost of $350 million. Finally, cleanup of the hazardous waste at the Rocky Mountain Arsenal could entail a project estimated at anywhere from $1 billion to $4 billion, depending on the cleanup option implemented.

In anticipation of these projects, as well as the possibility of building the SSC in Colorado, a special public-private task force was established to assess the possibility of shortages in critical materials and labor resulting from simultaneous development. The task force report--the "Strategic Resource Assessment Study"--concluded that labor, equipment, and critical resources should be readily available in the region unless construction activities were to escalate dramatically. Cumulative socioeconomic impacts in areas other than employment (such as housing, public services, and public finances) were not specifically addressed in the report, but at the regional level the same conclusion would hold for these resources as well. At the local level, however, adverse impacts in some of the small communities close to the site could be exacerbated by the cumulative impacts of other projects. For example, if the proposed (but postponed) expansion of the Pawnee Power Plant between Fort Morgan and Brush were to occur during construction of the SSC, these small towns would experience even greater difficulty absorbing the substantial impacts expected.

5.2.12.3 Illinois

Economic activity and development in the Illinois site region have been concentrated primarily in Chicago and Cook County, and this trend is expected to continue being led by two major city center projects to be completed in 1994 (estimated total $3 billion) and a proposed $1-billion office complex in suburban Des Plaines. Major transportation projects in the region include highway improvements expected to exceed $1 billion between 1988 and 1992 and a new $410-million rapid transit line. Outside of the Chicago metropolitan area, large construction projects include $800-million Chrysler plant expansion in Boone County (to the northwest) and a retirement community development in Will County (to the south).

In DuPage and Kendall counties, where it is expected that the socioeconomic impacts of building the SSC in Illinois would be the greatest, a number of development projects are planned. Most notably, projects are proposed in the growing communities along the Fox River and the western metropolitan-area suburbs such as Downers Grove and Wheaton. Almost all of these projects, however, are relatively small--less than $50 million--and cumulatively are not expected to compound substantially any potential SSC-related socioeconomic impacts.

5.2.12.4 Michigan

Economic growth in the Michigan site region has been and most likely will continue to be relatively slow. New projects proposed in the region are primarily located in the Detroit metropolitan area and the State Capital of Lansing. Michigan State Department of Transportation highway developments tend to be the largest construction projects currently foreseen in the region.

In the rural areas of Ingham and Jackson counties, adjacent to the proposed SSC site, there are no other major proposed projects. SSC-related socioeconomic impacts, which would be substantial in small nearby communities such as Stockbridge, would not be compounded by cumulative effects of other concurrent developments.

5.2.12.5 North Carolina

Initial construction of the Treyburn development, located between Durham and the proposed SSC site, is scheduled for completion during the summer of 1989, but build-out may not be realized for as long as 20 years. This combined residential, commercial, and industrial planned development thus would compete for labor and materials during SSC construction. During SSC operation, on the other hand, the Treyburn development likely would serve SSC-related population, housing some workers, and providing job opportunities for their dependents.

Other major projects currently proposed in Durham, Granville, and Person Counties would be farther from the SSC. These projects are considered to be within the normal baseline expansion of the region's economic activity and are not expected to adversely impact housing, public services, and public finance in the region, even in concert with SSC development there.

5.2.12.6 Tennessee

General Motors Corporation's Saturn Plant, a manufacturing and assembly complex south of Spring Hill in Maury County, is the largest project under way in the Tennessee site region. Construction of the plant should be completed by 1990, however, and thus would not compete with SSC construction for manpower or materials. Operation of the Saturn Plant would directly employ approximately 3,000 workers, nearly as many as the SSC, and to the extent that these workers are in-migrants to the region, SSC-related impacts on regional public services and public finances would be compounded. This cumulative impact would be most evident in the relatively large Davidson and Williamson counties, where the impacts could best be absorbed. The cumulative impact probably would not be felt in the smaller Bedford, Marshall, and Rutherford counties due to their distance from the plant.

Other proposed projects in the region, nearer the SSC, include facility expansion at the Bridgestone Tire Company north of LaVergne in Rutherford County and a set of commercial and residential developments near Franklin in Williamson County. All of these construction projects should be completed before peak SSC construction in 1992, and would not compete with the SSC for labor or materials. Impacts of these projects would fall within expected baseline expansion of the region's economic activity, so that cumulative impacts in conjunction with SSC operation would be minimal.

5.2.12.7 Texas

The rapid development in the past 15 years in the Texas site region has slowed dramatically since the collapse of world oil prices in 1986. The resulting decline in economic growth, as well as recent excess building in the real estate sector, has led to the delay of a number of proposed residential, commercial, and community developments. Nevertheless, many new construction projects are planned for the region--mostly concentrated in the Dallas-Fort Worth metropolitan area. From 1988 through 1995, $5 billion in state highway construction projects are scheduled in the ROI. In addition, the DART rail system, a $2.8 billion rapid transit project, is expected to begin construction in the next few years. Major private developments include a $208 million office complex being built primarily for tenancy by an IBM work force of 5,000 in Tarrant County (near the Dallas-Fort Worth airport) and numerous other buildings and facilities throughout the region. In Ellis County, several highway projects are planned as well as a $5 million expansion of the Waxahachie Water Plant and a $3.3 million Waxahachie/Midlothian Airport expansion.

In light of the recent downturn in economic growth in the region, development and operation of the SSC in Texas would provide needed economic stimulus to the region. Cumulative impacts would be minor at the regional level, but more substantial in Ellis County. However, many of the planned projects in Ellis County are for infrastructure expansion which would complement SSC development by increasing the local capacity to absorb SSC-related impacts.

5.2.13 Secondary Impacts of Ancillary Facilities

There are numerous ancillary facilities associated with the SSC. These are largely those in the service areas and in the campus/injector areas. Ancillary facilities, however, are also associated with the general development of the SSC site, access, utility easements, and transmission corriders. Although the direct effects of ancillary facilities provided for in their impacts evaluations (much of which is covered in NEPA review of power transmission lines, etc), the SSC would result in secondary impacts in the resource areas affected by these developments. The ancillary facilities of the site alternatives can be summarized in terms of the expected acreage and miles affected even though the configuration and design are conceptual.

For purposes of this discussion, six ancillary facilities will be examined: roads, railroads, power lines, natural gas lines, water supply, and sewage treatment services. The nature and extent of these ancillary facilities are typical of those associated with the development of light industry, except in the amount of power required, which is somewhat higher and more related to heavier industrial development. Table 5.2-2 summarizes the expected acreage and distance associated with the ancillary facility development at the site alternatives.

Table 5.2-2

ANCILLARY FACILITIES

State	Type	Length (miles)	Area (acres)
Arizona	Roads	121	891
	Railroad	6	55
	Power lines	52	465
	Natural gas	26	0
	Water supply	11	7
	Sewage (No. of plants)	0	0
Colorado	Roads	185	2,115
	Railroad	20	250
	Power lines	99	1,530
	Natural gas	21	0
	Water supply	138	360
	Sewage (No. of plants)	0	0
Illinois	Roads	28	16
	Railroad	1	5
	Power lines	2	6
	Natural gas	4	0
	Water supply	7	0
	Sewage (No. of plants)	0	0
Michigan	Roads	109	120
	Railroad	1	5
	Power lines	6	0
	Natural gas	10	0
	Water supply	3	10
	Sewage (No. of plants)	1	50

Table 5.2-2 (Cont)

ANCILLARY FACILITIES

State	Type	Length (miles)	Area (acres)
North Carolina	Roads	49	42
	Railroad	0	0
	Power lines	16	72-482 (depends on which utility)
	Natural gas	21	0
	Water supply	14	0
	Sewage (No. of plants)	6	0
Tennessee	Roads	25	250
	Railroad	0	0
	Power lines	32	24
	Natural gas	15	0
	Water supply	12	0
	Sewage (No. of plants)	6	0
Texas	Roads	54	65
	Railroad	0	0
	Power lines	5	70
	Natural gas	12	30
	Water supply	16	55
	Sewage (No. of plants)	0	0

Impacts of these ancillary facilities are discussed in Section 5.1.8.6 through 5.1.8.9. Secondary impacts of these ancillary facility construction and operations are discussed by resource affected in the paragraphs below.

Secondary impacts on earth resources would be minimal and would consist of minor changes in local topography due to road grading and utility corridors. No economic resource impacts would be anticipated. No geological hazards would be expected at the shallow depths utilities would be buried. Surface features such as waste treatment facilities would not significantly impact geological resources.

Secondary impacts on water resources would be the incremental increase of water use and the incremental increased use of municipal waste treatment facilities. In areas of low population densities, as in the service areas, a slight incremental increase in water use in households would occur and new service industries would develop to serve the additional population. To the degree that increased effluents result from utility support of the SSC and incremental additions to sewage treatment, water quality degradation might result as a secondary impact.

Secondary impacts on air resources would largely result from increased general air emissions from vehicular sources and access to the area. Another secondary impact would be increased air emissions from utilities furnishing power and natural gas to the SSC. The secondary impact would be the increment the SSC added to utility service requirements. All of the proposed sites have utility services which have sources of electricity derived from a variety of energy sources including fossil fuels, hydroelectric, and nuclear power. To the degree that the emissions are increased due to the incremental power consumption, secondary impacts would occur.

Secondary impacts would also increase noise around utility corridors and access roads due to maintenance of transmission lines and utility corridors.

Secondary impacts to waste management facilities would also occur. These impacts would be incremental increases in landfill loading rates from municipal solid waste generated by ancillary facilties and activities supporting these. It is anticipated that beneficial impacts would also result from easier access to disposal and recycling facilities. Neither hazardous waste nor radiological waste management in the region would be secondarily impacted.

Secondary impacts to ecological resources would include an incremental increase in the potential for disturbing threatened and endangered species' habitats due to increased land usage. If Tennessee is the selected site, a potential for secondary impacts to the Snail Shell Cave system, including dust introduction, increased openings to portions of the caves, and altered water quality may occur. Wetlands could experience secondary impacts of increased degradation due to changes in surface water usage and incremental increases in land development.

Secondary impacts to public health would include slightly increased probability of exposure to Valley Fever spores due to increased activities in maintenance or construction of ancillary facilities and due to in-migration if Arizona were the selected site. Similarly, there would be a slightly increased probability of exposure to (or damage from) fire ants if Texas were the selected site.

Secondary impacts on land resources are incremental increases in lands developed due to ancillary activities and those activities supporting them. The impacts would include incremental increases in converted prime and important farmlands, zoning changes, land use changes through land commitment to utility corridors, easements, and by increased access. It is expected that secondary impacts of ancillary activities would not be significant.

Secondary impacts on socioeconomics from ancillary facility construction and operations are difficult to measure or differentiate from those induced by aggregate development in the seven site alternative locations. Impacts could result in five areas: (1) economic activity, labor force, and income, (2) demographics and housing, (3) public services, (4) public finance, and (5) quality of life and social well-being. These measures of socioeconomic impacts are likely to not be measureably impacted by the secondary impacts of ancillary facility development. Quality of life would be perceived to be altered incrementally by any increase in landfill size, traffic, or many other local conditions (see discussion in Section 5.1.8.5). Small incremental impacts might also result in utility rates, school expenditures, and other public services especially early in the development of the SSC and its ancillary facilities. No significant impacts would be expected in income, labor force or demographics from ancillary facility development.

Secondary impacts of ancillary facility development on cultural resources would be those associated with increased growth and access due to the SSC. These are expected to be largely mitigated by actions taken during SSC final design and specific facility placement (see discussion on flexibility of design and site alternatives in Chapter 3, Section 3.6.1).

Secondary impacts on scenic and visual resources would be incremental due to power lines, utility corridors, sewage treatment plants, and roads/railroads. The perceived degradation of scenic and visual resources from development of ancillary facilities would be expected to be one of the more important secondary impacts of the SSC, in general.

Comparatively, the site alternatives can be evaluated with respect to secondary impacts from ancillary facilities. Resources which would be anticipated to be differentially impacted at the sites are summarized below:

- Arizona - Due to the more extensive infrastructure requirements, waste management, water resources, and air quality; ecological and regional resources because of their relative richness in the area of the proposed site.
- Colorado - Similar to conditions in Arizona from the perspective of infrastructure development impacts; access to the area would be greatly increased due to the new roads; conversion of lands in agriculture.
- Illinois - Secondary impacts would primarily be those associated with competition for resources in an area with rapid growth rate and increasing densities of residences and businesses.
- Michigan - Similar to conditions in Illinois except a more probable secondary impact on wetlands and sensitive habitats/communities.
- North Carolina - Secondary impacts are most likely to occur in the areas of water quality and supply.
- Tennessee - Secondary impacts might occur in the area of water supply, ecological resources, especially karst ecosystems such as the Snail Shell Cave System.
- Texas - Secondary impacts would be associated with increasing rates of service industry development and land use changes from agricultural and rural to suburban.

5.3 IDENTIFICATION OF IMPACTS OF THE NO-ACTION ALTERNATIVE

The impacts associated with implementing the no-action alternative, that is, not constructing and operating the SSC, are discussed from two standpoints. These are 1) the impacts of the SSC project not being implemented and 2) the impacts of the SSC project not being implemented at one of the alternative sites. These impacts are discussed below.

5.3.1 Impacts of SSC Project Not Being Implemented

The impacts associated with not implementing the SSC project are "the costs of lost opportunities." These are difficult to estimate because the values of any large research and development project cannot be predicted. Unexpected technological developments from R&D projects such as the space program are becoming commonplace (e.g., teflon). In addition to the loss of as-yet undefined technological gains, other impacts are: 1) loss of high energy physics knowledge, and 2) loss of U.S. leadership in high energy physics research, although research in this field at the Fermilab and SLAC would continue.

Secondary impacts of not implementing the SSC include impacts that reflect the use of the SSC-designated funds to other public works projects. These impacts cannot be assessed since there are no public works projects directly competing for funding with the SSC, and the DOE policy is that development of the SSC will not be pursued at the expense of other ongoing high energy research facilities and programs.

The impacts of delaying the project are similar to those impacts associated with not implementing the project at all. The delay might result in the SSC, when implemented, not being substantially better than one developed outside the U.S. Delaying the project in order to take advantage of new superconducting media is not feasible since the development time for these materials is unknown but exceeds the time targeted for SSC implementation.

5.3.2 Impacts Associated with No Action at Alternative Sites

The impacts of implementing the no-action alternative at any of the alternative sites would be a continuation of the current and projected conditions of those sites (see Chapter 4). These are evaluated in each of the alternative sites.

5.3.2.1 Arizona

The Arizona proposed site is the least developed of the seven site alternatives. The site, in the absence of the SSC, would remain a popular multiple use recreational area in the Sonoran desert. The wilderness study areas (WSA) would continue being used for selected studies. There would continue to be limited grazing of livestock. Development of the region for housing in connection with the growth of the Phoenix metropolitan area would continue. In addition, a separate issue is whether portions of the site will be Congressionally designated as wilderness. Pending before the Congress is an action to designate portions of Arizona as wilderness. The BLM recommendation is that the WSA portions remain in their current status for multiple use. The Arizona Wilderness Coalition has recommended inclusion of all three WSA areas in the wilderness designation. Congress will address this issue whether or not Arizona is designated as the preferred SSC site.

5.3.2.2 Colorado

The Colorado proposed site, without the SSC, will remain a dryland farming dominated economy. The growth rate in the area is expected to remain negligible except for small increases in the towns of Fort Morgan and Brush. The patterns of irrigated agriculture, the production of beef cattle, and the portions of the proposed site which are in prairie are expected to remain approximately at the current levels. Market drivers on agriculture production will remain the primary reasons for changes in the region of the site. Direct access routes to the area from Denver will remain limited.

5.3.2.3 Illinois

The Illinois proposed site will continue its rapid growth rate, especially in the east and north of the site, without the SSC development. The agricultural production trends in the area are declining and may continue to as a result of pressure toward suburbanization from the east.

Wetlands will continue to face encroachment from suburbanization. The operation of Fermilab is expected to continue regardless of the presence or absence of the SSC.

5.3.2.4 Michigan

The Michigan proposed site is also expected to remain in conditions similar to those existing, including light industrial and suburban uses. Reduced agricultural trends will be impacted by market drivers in farm prices. Timber production will not substantially increase. Wetlands will continue to face encroachment in specific local areas near the site. Suburbanization of the region will continue at the current measurable rates.

5.3.2.5 North Carolina

The Piedmont region will continue to develop slowly, primarily by the development of large-tract single-family residences. There will continue to be substantial timber and some agricultural production. The economy of the region will continue to be dependent largely on the service sector around the Research Triangle Park (RTP) area. Road access would continue to be minimally developed.

The watershed importances of the drainages of the site will continue to be important in terms of water supply, water quality, and biological resources.

5.3.2.6 Tennessee

The central basin of Tennessee will continue to develop at a steady or possibly increasing level. The immediate area of the site is in the

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more slowly developing portion of the central basin. Tennessee walking horse breeding, minimal timber and small scale agriculture in the form of family farms and truck/vegetable-fruit farms will remain in the area.

5.3.2.7 Texas

The region of the proposed Texas site will continue to develop responding to the suburbanization from the Dallas-Fort Worth area. The immediate area of the site will continue rapid development in the residential, service companies, and light industrial areas. Easy access to the metropolitan area will increase this pressure.

Agriculture is expected to remain important, especially in the southern portion of the proposed site. Biological resources will remain diverse though becoming spatially more patchy.

5.4 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts are those impacts that are not realistically mitigable. These are presented in summary form below. The detailed identification of impacts, including those that are mitigable, are presented in Section 5.1. Mitigations for those impacts that can be mitigated are summarized in Section 3.6.

Unavoidable adverse impacts would be:

- Loss of up to two producing quarries in Illinois, Michigan, and North Carolina.

- Loss of water wells within the SSC footprint: only a limited number of wells within this total area will need to be abandoned because of the project; however, prior to final siting and design decisions being made, an accurate estimate of the actual number of wells is not practical.

- Local water level decline and/or aquifer overdraft in Arizona (potential overdraft), Illinois, Michigan, and Texas.

- Increased ambient noise levels around some service areas that have human and/or wildlife populations.

- Potential loss of some habitat (although no designated critical habitat) of one or more threatened or endangered species:

  - Tumamoc globeberry in Arizona
  - Prairie brush clover in Illinois
  - Tennessee purple coneflower in Tennessee
  - Black capped vireo in Texas
  - Indiana bat in Tennessee and Michigan.

- Loss of wetlands (this is a conservative estimate that does not consider wetland mitigation. The acreages also do not consider wetlands that could be impacted at future expansion facilities or at ancillary facilities):

  - Arizona: No loss of wetlands

  - Colorado: Maximum 4 acres in the areas for B and E1 (wetlands also located in future sites C and J6)

  - Illinois: Maximum 215 acres in the areas of A and B (in Fermilab), F4, F8, F9, F10 (wetlands also located in future sites C [in Fermilab] and J5)

  - Michigan: Maximum 252 acres in areas for A, B, E1, E4, E5, F1, F9, F10, K2 (wetlands also located in future sites C, J1, J2, J3, J5, J6, K4)

  - North Carolina: Maximum 44 acres in areas for A, B, E2, E3, F7 (wetlands also located in future sites C, J1, J2, J3, J4, J6)

  - Tennessee: Maximum 38 acres in areas for A, B, F1, K2, K6 (wetlands also located in future sites C, J1, J2, J5, J6)

  - Texas: Maximum 3 acres in areas for A, B, K6 (wetlands also located in future sites C, J2, J3, J4, J6)

- Increased traffic and traffic accidents in the construction period are projected to increase accidents as follows:

  - Arizona - 40 injury accidents/yr
  - Colorado - 10 injury accidents/yr
  - Illinois - 10 injury accidents/yr
  - Michigan - 16 injury accidents/yr
  - North Carolina - 6 injury accidents/yr
  - Tennessee - 3 injury accidents/yr
  - Texas - 8 injury accidents/yr

  In Arizona, it is projected that there would be approximately one fatality/yr increase due to construction accidents; in all other states, it is estimated to be much less than one fatality/yr increase.

- Land use in Arizona and Colorado would be substantially altered.

- Estimated prime and State-important farmlands withdrawals (permanently developed):

  - Arizona 0 acres
  - Colorado 819 acres
  - Illinois 197 acres
  - Michigan 341 acres
  - North Carolina 955 acres
  - Tennessee 606 acres
  - Texas 588 acres

- Relocations:

  - Arizona 6
  - Colorado 23
  - Illinois 219
  - Michigan 221
  - North Carolina 180
  - Tennessee 128
  - Texas 175

- Scenic and visual impacts are of a regional scope in Arizona and a local scope in Illinois, Michigan, North Carolina, Tennessee, and Texas around specific surface facilities. There are no anticipated scenic and visual impacts in Colorado.

5.5 RELATIONSHIP OF SHORT-TERM USES TO LONG-TERM PRODUCTIVITY

The proposed action would constrain uses of specified resources during the 6- to 7-yr construction period and the 25- to 30-yr operations period. In general, these "short-term" uses of the resources will not permanently impact the long-term productivity of the host environment. However, impacts such as those from acreages that are removed from prime and important farmlands are considered to be permanently converted and removed from the regional inventory.

For the periods of construction and operations, the following constraints and resource impacts would result:

- Loss of land use in the fee simple areas, although it is DOE policy to allow multiple land uses as long as they are compatible with the mission of the facilities; upon decommissioning, these lands could be returned to public use.

- Removal of wetlands in the surface facility construction sites.

- Loss of habitat for migratory populations or loss of habitual migration trails in the area of surface facilities; loss of habitat for endemic and relic species.

- Where used as a source of project water supply, local surface or groundwater removals may result in a significant depletion of existing excess capacity or local groundwater overdrafts. Water would be available for other uses once project water withdrawals cease.

- Spoils disposal in some areas would remove some prime and important farmlands from production in the area of the site.

- Disposal of solid, radioactive, and hazardous wastes would utilize and thereby decrease the existing capacity of selected landfills, and LLRW- and RCRA-permitted facilities; these decreases would be a small fraction of current capacity.

- Residual radioactive contamination of materials left in the tunnel following decommissioning would increase total radioactive inventory in the tunnel; this increase would be a small percentage of naturally occurring radioactive materials underground at tunnel level, and would have no impact on long-term productivity of the host environment.

- Indirectly, via in-migration, there would be an increase in public services requirements, in housing demand, and public finance which would be expected to be sustained following the decommissioning of the SSC even though the employment sources would be altered following shutdown.

- Land use would not necessarily be permanently altered by the project; however, the secondary development, such as service industry, increased housing, and development of transportation and infrastructure supporting the SSC make the possibility of reconversion of land use to preproject status unlikely.

- Conversion of prime and important farmlands would be permanent if the surface of the earth is covered by buildings, parking lots, or other impervious surfaces.

- Paleontological resources encountered in the tunnel boring operations would be irretrievably lost; a portion of those that might be encountered in shaft drilling and tunneling would be lost depending on the excavation methodology employed.

- Scenic and visual resources would be altered through the life of the project at specific locations; these might be altered in the long-term depending upon land use post-decommissioning.

Many of the short-term uses of the regional resources committed to construct and operate the SSC are reversible in the long term. A preliminary evaluation of decommissioning is provided in Volume IV, Appendix 3. In general, it is feasible to decommission the facility removing the components, radioactive materials and sealing the tunnel access. Surface facilities could be removed selectively, converted to other uses, or removed entirely. Assuming complete decommissioning, long-term productivity of the host environment could largely be restored. If selected land use continued to use surface facilities, it is expected that productivity would continue to be a function of the rate of urbanization of the areas in general rather than specifically the result of the SSC project's implementation.

5.6 NATURAL AND DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL

This section on natural and depletable resources covers the following:

- The natural and depletable resource requirements for the generic SSC design.
- Generic potential for conservation.
- Natural resources precluded from development at the seven BQL sites.
- Comparison of natural resource requirements and availability among the sites.

The term "natural and depletable resources" in this context is broadly interpreted. It includes obvious natural and depletable resources such as sand, gravel, and aggregate; materials that are derived from natural and depletable resources such as cement, gypsum, glass, steel; and electric power, which is presumed to be derived from natural and depletable resources. Resources that may be required to construct facilities that are related to, but not part of, the SSC project, such as SSC-induced growth in housing and infrastructure are excluded. Water and land are discussed in detail earlier in this chapter and are mentioned only briefly in this section.

5.6.1 Natural and Depletable Resource Requirements

This estimate of natural and depletable resource requirements is based on the conceptual SSC design described in Volume IV, Appendix 1, Section 1.1 (Summary of Conceptual Engineering Design).

5.6.1.1 Technical Facilities

Construction materials required for the SSC technical facilities are all procurable without significant impact on U.S. supplies.

In 1984, world niobium demand was approximately 15,000 ton/yr increasing by 6 percent yearly (mostly supplied from Brazil). A peak annual SSC demand of 100 ton/yr represents less than 1 percent of world demand in 1984.

The impact of the SSC on the titanium market is difficult to assess because figures for titanium demand have been withheld from publication since 1982. However, at that time, U.S. demand was 3,750 ingot ton/yr. Thus, the SSC peak demand of 100 ton/yr represents 2.7 percent of the U.S. market some 6 years ago when figures were last available.

The helium cryogenic system will be charged with 57 Mft^3(std) of helium. The increase in helium requirement from 52 Mft^3(std), as stated in the Conceptual Design Report (CDR), to 57 Mft^3(std) is due to changes in the line sizes in the dipole cryostat made after issue of the CDR. Helium will be delivered to the site as liquid in 15,000-gal tank trucks (15,000 gal equals 1.4 Mft^3(std)). Expected losses of helium from the SSC are 52,500 l/mo, or 472,500 l/yr for 6,000 h/yr of operation. This is 14 Mft^3(std), or approximately 25 percent of the total inventory of 57 Mft^3(std). Since the total annual sales of helium in the U.S. are about 1,147 Mft^3(std), the annual SSC consumption represents only 1.2 percent of the U.S. market.

5.6.1.2 Conventional Facilities

For construction of conventional facilities (see Table 5.6-1), materials would be primarily obtained from local suppliers. None of the quantities of conventional building materials are large enough to have a significant impact on a regional market when consumption is spread over the 6-yr construction period, with the possible exception of the supply of aggregate in Colorado.

Total water requirements for construction of the technical and conventional facilities is estimated to be 111.5 million U.S. gal (343 acre-ft), broken down as shown in Table 5.6-2. Peak annual consumption during construction is estimated to be 28.6 million gal (88 acre-ft), or an average of 238 gal/min for a 2,000-h year. Peak demand during the 8-h construction workday will be several times this average flow, up to a maximum of 1,000 gal/min. As noted in the DOE's ISP, peak consumption of industrial water during operations is estimated at 2,200 gal/min (3,550 acre-ft/yr) for climatic conditions that allow the use of evaporative cooling, and potable water consumption is estimated at 250 gal/min (400 acre-ft/yr). Cooling water requirements for sites with significantly different climatic conditions will vary. If air cooling is used, cooling water requirements may be as low as 500 gal/min (800 acre-ft/yr). An annual industrial water requirement of 1,775 acre-ft/yr (1,100 gal/min) has been assumed for this EIS.

As shown in Table 5.6-1, for construction of the conventional facilities, estimated electric power consumption is 42.6 million kWh. Natural gas consumption, primarily for heating of work areas until permanent heating facilities are available, is small in comparison to consumption of electrical energy. Figures for operation of the conventional facilities are shown in Table 5.6-1.

Table 5.6-1

NATURAL AND DEPLETABLE RESOURCE REQUIREMENTS
CONVENTIONAL FACILITIES

Resource	Construction Quantity*	Construction Unit	Operations Quantity*	Operations Unit
Construction Materials				
Steel including rebar	30,000	tons		
Cement	100,000	tons		
Sand	100,000	yd^3		
Gravel (roads and concrete)	600,000	yd^3		
Fill, stone bedding	200,000	yd^3		
Wood forms	1,000,000	board-feet		
Concrete pipe, blocks	500,000	tons		
Glass	100,000	ft^2		
Water				
Industrial	266	acre-ft	1,775	acre-ft/yr
Potable	77	acre-ft	400	acre-ft/yr
Land				
Disturbed (facilities and infrastructure)**	494-3,395	acres	227-1,327	acres
DOE title (fee simple and stratified fee)	15,830	acres	15,830	acres
Energy				
Electric Power	42.6×10^6	kWh	888×10^6	Kwh/yr
Natural Gas			55	MBtu/h

* The quantities listed are order-of-magnitude estimates of major construction resources. These estimates are based on a conceptual design at a generic site with assumed geology, topography, and infrastructure.

**For the site specific details, see Table 3-2.

Table 5.6-2

CONSTRUCTION WATER SUMMARY
1989 - 1995

Use	Volume: Million U.S. Gal	Volume: Acre-ft
Personal use, technical facilities, management and engineering	18.2	57
Personal use, conventional facilities	6.9	21
Concrete	26.9	83
Backfill moisture control	12.8	39
Dust control	15.3	47
Landscaping	2.6	8
Access roads	20.6	63
Contractors' area	2.6	8
Spoils area	5.6	17
	111.5	343

During construction of the technical and conventional facilities, a total of 494-3,395 acres will be disturbed depending on which site is selected. Of this, 220-1,327 acres will be permanently disturbed.

The DOE requires land title to a maximum of 15,830 acres assuming fee simple estate for the upper and lower collider arcs (total of 3,790 acres) and for the abort/external beam arcs (total of 4,550 acres), i.e., a total of 8,340 acres. The DOE has indicated its willingness to accept a stratified estate arrangement for these areas that would reduce land requirements by all or part of 8,340 acres, thus reducing the total requirement to 7,490 acres.

5.6.2 Potential for Conservation

This section describes potential for non-site-specific conservation. Site-specific conservation potential is discussed in Section 5.6.4.

5.6.2.1 Minimizing Requirements

The requirements of the SSC R&D program have been extensively studied. Building materials are most affected by the type of construction that will, in turn, be determined by the site selected.

Projected water use during construction is 111.5 million gal. The major uses are for concrete (26.9 million gal), access road construction (20.6 million gal), water use by personnel (18.2 million gal), and dust control (15.3 million gal). Water requirements for concrete are based on an assumed 560,000 yd^3 of concrete and 35 gal/yd^3. In addition, 7.25 million gal is assumed for operation of the on-site precast concrete plant.

Water for access roads is based on 1,030 acres of access roads at a total requirement of 20,000 gal/acre throughout the construction period. This acreage of roads is comprised of 68 mi of dirt roads and 4.5 mi of HEB open excavation. Widths range from 100 to 180 ft. This water requirement will be dependent on the materials available for construction of the roads and the length required. Existing roads will be used wherever possible.

Personnel water use for the technical facilities (technical systems and management/engineering) is based on a total of 9,974 person-years throughout the construction period, which includes water for both drinking and personal cleanup. These requirements will not be influenced greatly in a generic way by the type of construction, but more by the climate of the actual site.

Dust control water requirements will be influenced by the site location, climate, soils, and type of construction. Dust control water requirements for cut-and-cover excavations will be substantially greater than for tunneling or drill and blast operations, because of the much larger area of disturbed ground. In this estimate, a total of 1,530 acres will require dust control. This excludes requirements for dust control of access roads.

In general, water use can be reduced by ponding surface runoff from disturbed areas and using this water for backfill moisture control, construction, and dust control, i.e., where potable water is not a requirement.

Construction laydown areas would be located at the sites of, for example, parking areas, so that they become part of the committed land resource.

It is the policy of the DOE to allow multiple land use to the maximum extent compatible with facility operations.

Energy requirements are heavily dependent on the geology and type of construction used for the SSC collider ring. Electric power consumption for constructing the tunnel is expected to range between 12 kWh/ft for cut-and-cover to about 400 kWh/ft for tunnel boring operations.

Depending upon location, it may be possible to save energy (power and gas) by cogenerating power and space heating/cooling. Campus facilities would use both and, depending on the cost of natural gas fuel and the avoided cost of the cogenerated power, there could be economic benefits from the installation of combined-cycle cogeneration systems. An engineering evaluation of cogeneration would be needed for the selected site during detailed design of the SSC.

5.6.2.2 Recycling and Resource Recovery

Recycling water for lower grade uses may be possible depending on quality and demand. For example, some 150 gal/min of cooling tower blowdown is estimated to be generated during operation. Part of this can be stored and used for irrigation purposes after suitable chemical treatment. Another portion can be concentrated into brine and higher grade water which could be used to reduce the SSC demand for water by blending. The brine would be wasted to a treatment plant or evaporation pond.

Certain recyclable materials can be used for construction to reduce the use of building materials. One example is fly ash from coal-fired electric power generation, which can be used as a fill material, as a raw material in cement, as an ingredient in the final grind of cement, or as a filler in concrete or concrete blocks. By recycling this waste material, a portion of the fill requirements may be met. This must be balanced by economic considerations, among which will be the proximity of the SSC to a suitable coal-fired power plant and the existence of excess fill material from the tunnel construction.

5.6.3 Resources Precluded from Development

The development of certain natural and depletable resources would possibly be precluded during the life of the project because of possible disruptive effects on SSC construction or operations. These resources are ones whose extraction methods are capable of causing vibration, and include: mining; drilling of oil or water wells; construction of major projects, roads, etc. Resources possibly precluded from development among the seven sites are summarized in Table 5.6-3.

As noted in the SSC ISP, because of the potential for disruptive vibration, no railroad line should pass within 3,000 ft of an interaction point, and major public roads should be no closer than 300 ft to an interaction point. Further, there is a restricted zone extending 150 ft horizontally and 35 ft vertically from the tunnel centerline, within which even existing activities will require DOE approval for operation.

With the possible exception of water wells, Table 5.6-3 shows that the natural and depletable resources possibly precluded from development as

Table 5.6-3

NATURAL AND DEPLETABLE RESOURCES POSSIBLY PRECLUDED FROM DEVELOPMENT

	Arizona	Colorado	Illinois	Michigan	North Carolina	Tennessee	Texas
Earthen resources	None - abundant sources in area	None - abundant in area, but competition for materials may occur	None - abundant sources in area.	2-5 aggregate producers near ring; some may be temporarily affected.	None - abundant sources in area.	None - abundant sources in area.	None - abundant sources in area.
Energy resources	No oil, gas, coal, or lignite in area. Suspect possible uranium occurrence; quality and quantity not known.	Approximately 30 oil wells within 1 mile of SSC; fewer than 20 oil wells may be affected. Uranium, coal remote from site, not affected.	No coal, oil, uranium, peat in economic deposits in area.	Fewer than 10 oil wells may be affected.	No known deposits of oil, gas, coal, uranium.	No economic deposits of oil, gas, coal, uranium.	No known economic deposits of oil, gas, coal, lignite, uranium.
Metallic resources	Copper, gold, silver, manganese, tungsten in small, uneconomic deposits.	No known economic deposits.	No known deposits.	No known deposits.	Copper in small, uneconomic deposits, with gold and silver.	Zinc exploration, but no known economic deposits. 2 abandoned barite and fluorite mines in vicinity.	No known economic deposits.
Other resources				Peat and clay in vicinity but not affected.	Pyrophyllite deposit, but not economic.	Phosphate reserves, but mined outside SSC area and not affected.	

a result of the SSC are not significant. Indeed, in two cases, the SSC project would result in development of a natural resource that may not otherwise take place. In Illinois, the excavated tunnel material (dolomite and dolomitic limestone) would be suitable for sale as a landfill liner or other commercial use; and in Texas, about half the excavated tunnel material is Austin chalk, which can be used for cement manufacture.

5.6.4 Comparison Among Sites

For the technical facilities, the requirements of natural and depletable resources would not vary among sites. For the conventional facilities, a comparison of natural and depletable resource requirements and availability among the seven sites is shown in Table 5.6-4. Impacts of the SSC on natural and depletable resources used to develop SSC conventional facilities (Table 5.6-4) and possible mitigation measures are discussed below.

5.6.4.1 Arizona

There would be no appreciable impact on earthen resources at the Arizona site due to high local availability. No prime or important farmlands would be converted to develop the SSC.

Slightly more than 10,800 acres of wilderness study areas could be impacted by the indirect loss of wilderness character. However, BLM has recommended these areas be maintained in multiple use status rather than being designated wilderness.

The major impact of the SSC project on natural resources would be on the groundwater in North Vekol Valley, which is discussed in detail in Section 5.1.2. This impact could be mitigated by practicing good water conservation measures, such as reuse of cooling tower blowdown, during construction and operation. The use of brine concentrators to produce a product water (to blend and reduce groundwater consumption) and brine waste (to evaporation ponds) from cooling tower blowdown would reduce groundwater withdrawal.

There are negligible economically viable metallic resources in the site area. There is the possibility of partially offsetting consumption of both electric power and natural gas by development of solar power (up to 15 MW) and solar cooling. Arizona has the greatest total cooling degree-days per year of the seven sites (3,000 degree-days--see Table 4-5). It should be noted that the requirement for natural gas was based on a coldest month of 900 degree-days used in the CDR. Since Arizona's coldest month corresponds to a peak monthly heating of 474 degree-days, natural gas consumption, even in the absence of any solar heating, will be a little more than half of 55 MBtu/h.

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Table 5.6-4

NATURAL AND DEPLETABLE RESOURCES REQUIRED COMPARISON AMONG SITES

	Arizona	Colorado	Illinois	Michigan
1. Earthen resources				
High quality aggregate	1,800,000 tons	1,800,000 tons	1,500,000 tons	1,300,000 tons
Mid quality aggregate	150,000 tons	188,000 tons	13,000 tons	189,000 tons
Stone bedding	63,000 tons	38,000 tons	38,000 tons	38,000 tons
Cement	99,000 tons	99,000 tons	143,000 tons	99,000 tons
Availability/Impact	Plentiful locally - no impact.	SSC uses 0.64% of permitted aggregate reserves - impact minor.	Plentiful locally - no impact.	Plentiful locally - no impact.
2. Land resources				
Fee simple area[1]	15,830 acres	7,690 acres	10,508 acres	7,885 acres
Prime farmland	0 acres	0 acres	185 acres	205 acres
Important farmland	0 acres	819 acres	12 acres	136 acres
Wilderness/parks	1,818 acres wilderness study area	0 acres	0 acres	0 acres
3. Water resources[2]				
Construction	343 acre-ft groundwater	343 acre-ft groundwater	343 acre-ft groundwater	343 acre-ft groundwater
Potable	400 acre-ft/yr groundwater	400 acre-ft/yr groundwater	400 acre-ft/yr groundwater	400 acre-ft/yr groundwater
Industrial	1,775 acre-ft/yr groundwater	1,775 acre-ft/yr groundwater	1,775 acre-ft/yr groundwater	1,775 acre-ft/yr groundwater
Availability/Impact	Operational use of industrial water may exceed groundwater recharge but impacts considered negligible.	Groundwater available; may require purchase of existing water rights - impact not significant.	SSC will increase current overdraft slightly - impact not significant.	SSC will increase current localized overdraft slightly - impact not significant.
4. Other resources				
Electric power[2] for operations	888 million kWh/yr	888 million kWh/yr	888 million kWh/yr	888 million kWh/yr
Cooling Index (annual)[3]	3	0.7	1.0	0.7
Heating Index (monthly)[4]	0.5	1.3	1.3	1.3

Table 5.6-4 (Cont)

NATURAL AND DEPLETABLE RESOURCES REQUIRED COMPARISON AMONG SITES

	North Carolina	Tennessee	Texas
1. Earthen resources			
High quality aggregate	1,600,000 tons	1,500,000 tons	1,500,000 tons
Mid quality aggregate	32,000 tons	13,000 tons	118,000 tons
Stone bedding	38,000 tons	38,000 tons	38,000 tons
Cement	149,000 tons	141,000 tons	149,000 tons
Availability/Impact	Aggregate plentiful locally - no impact. Cement from outside NC - minor impact.	Plentiful locally - no impact.	Cement plentiful locally - no impact. Aggregate transported 90 miles - minor impact.
2. Land resources			
Fee simple area[1]	7,950 acres	7,750 acres	8,650 acres
Prime farmland	630 acres	415 acres	430 acres
Important farmland	325 acres	191 acres	158 acres
Wilderness/Parks	0 acres	0 acres	0 acres
3. Water Resources[2]			
Construction	343 acre-ft surface water	343 acre-ft } mostly	343 acre-ft } mostly
Potable	400 acre-ft/yr surface water	400 acre-ft/yr } surface	400 acre-ft/yr } surface
Industrial	1,775 acre-ft/yr surface water	1,775 acre-ft/yr } water	1,775 acre-ft/yr } water
Availability/Impact	Uses only portion of excess surface water capacity in area - no impact to groundwater.	F7 and F8 will use groundwater - impact negligible. Balance is surface water; uses only portion of excess surface water capacity in area.	Far cluster and 8 service areas require groundwater. Impact measurable but not significant. Surface water available.
4. Other resources Electric power[2] for operations	888 million kWh/yr	888 million kWh/yr	888 million kWh/yr
Cooling Index (annual)[3]	1.5	1.8	2.5
Heating Index (monthly)[4]	0.8	0.9	0.7

1. Does not include land required for ancillary facilities.
2. Estimates of water and electric power use are not sufficiently refined to allow site-by-site comparisons.
3. Cooling Index was calculated as the total degree days per year (Table 4-5) divided by the CDR assumed value of 1,000 degree days per year (95°F design basis)
4. Heating Index was calculated as the peak monthly heating degree days (Table 4-5) divided by the CDR assumed value of 900 degree days (25°F design basis)

5.6.4.2 Colorado

An impact of the SSC project on natural resources in Colorado would be on the local supply of aggregate. The SSC will consume 0.64 percent of all currently permitted aggregate reserves in the area, foreshortening the projected life of such reserves by less than 1 year from 2001. This impact could be partially mitigated by use of fly ash from nearby coal-fired power plants in a portion of aggregate. Western coals produce a fly ash that is typically high in calcium, which makes the ash pozzolanic and a beneficial fill material for concrete, but these coals are also high in alkalis that have a deleterious effect on concrete. Therefore, chemical balances and compliance with concrete specifications would need to be confirmed prior to use of fly ash. Even without the use of fly ash, the impact of the SSC on aggregate supply would be minor.

No prime farmlands would be converted; 819 acres of important farmlands would be disturbed.

Colorado has a peak monthly heating of 1132 degree days, slightly greater than the value used in the CDR of 900 degree days. The total cooling degree days per year is 700, the least among the seven alternative sites and slightly in excess of the 1000 degree days annual cooling assumed in the CDR.

The State of Colorado has also estimated that, because of low summer wet bulb temperatures, required flow of cooling water will be an average of 921 gal/min (1,485 acre-ft/yr).

5.6.4.3 Illinois

The proposed fee simple area of 10,508 acres includes 6,800 acres of Fermilab, including prime and important farmlands that are in production and are leased to local farmers. This demonstrates potential for conservation of farmland and enhancement of natural prairie and wetland habitats.

No impacts would be detected on earthen resources. Approximately 185 acres of prime farmlands and 12 acres of important farmlands would be converted.

Groundwater overdraft would be aggravated by SSC development, a small incremental cumulative impact.

5.6.4.4 Michigan

During final design, alternative sitings of facilities and other mitigations will be evaluated.

The Michigan site also would have a potential impact from acidic leachate from pyritic spoils from tunnel excavation. Mitigation measures are available, and are discussed in full in Section 5.1.11 and in Volume IV, Appendix 10.

The State of Michigan proposal states that the climate is colder than the referenced climatic conditions used in the CDR, 1,260 degree-days vs 900 degree-days. This means that the expected demand for natural gas in Michigan will increase from 55 MBtu/h to 69 MBtu/h. (Table 4-5 shows a peak monthly heating requirement of 1,181 degree-days). Cooling requirements are only slightly greater than that assumed in the CDR and the lowest among the seven site alternatives.

5.6.4.5 North Carolina

There would be minimal impacts are earthen resources associated with bringing cement from outside the region. No other earthen resources would be impacted.

Approximately 630 acres of prime farmlands and approximately 325 acres of important farmlands would be converted.

There would be a small incremental impact to surface water use (a portion of excess capacity of local utilities), a cumulative impact. No significant impacts would be anticipated on groundwater.

Heating during the peak month is less than the assumed CDR requirement (See Tables 4-5 and 5.6-4). Cooling would require 1.5 times that assumed in the CDR annually.

5.6.4.6 Tennessee

There would be no appreciable impacts on earthen resources due to SSC development. Approximately 415 acres of prime farmlands and 191 acres of important farmlands would be coverted.

Tennessee's coldest month is 778 degree-days (see Table 4-5), so that the SSC's consumption of natural gas in Tennessee will be less than the 55 MBtu/h projected for 900 degree-days. Cooling requirements (peak month) are more than twice as large as those assumed in the EIS.

5.6.4.7 Texas

Texas offers potential for development of a natural resource as a result of the SSC. Limestone from the tunnel excavation is Austin chalk and may be suitable for making cement. There are cement plants in the area that use this type of raw material. Therefore, this resource may be productively used to offset consumption of other natural resources to produce the cement for the SSC.

Approximately 430 acres of prime farmlands would be converted; 158 acres of important farmlands.

The major impact of the SSC in Texas will be on the level of groundwater at remote locations. The far cluster and eight service areas will require a total of 490 gal/min, which is to be supplied by groundwater. This issue, and possible mitigation measures, are discussed in detail in Section 5.1.2 and Volume IV, Appendix 7.

Cooling requirements at peak would be 2.5 times that assumed in the CDR; heating, however, would be only 70 percent of that assumed during the peak month.

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CHAPTER 6

FEDERAL PERMITS, LICENSES, AND OTHER ENTITLEMENTS

CHAPTER 6 FEDERAL PERMITS, LICENSES, AND OTHER ENTITLEMENTS

TABLES

CHAPTER 6 FEDERAL PERMITS, LICENSES, AND OTHER ENTITLEMENTS

6.1 INTRODUCTION

This chapter identifies Federal permits, licenses, and other entitlements that may be required in implementing the SSC proposal in each state.

Various Federal environmental statutes impose environmental protection and compliance requirements upon Federal agencies, including requirements for Federal agencies to comply with certain State and local regulatory programs. It is DOE policy to conduct its operations in an environmentally safe and sound manner in compliance with applicable environmental statutes, regulations, and standards.

DOE Order 5480.4 lists Federal environmental requirements applicable to DOE projects (see Section 6.3). The Order was reviewed to identify those authorities applicable to the SSC project. Further, those authorities were then assessed to determine which state and local environmental authorities are also applicable. Applicable Federal requirements are discussed in Section 6.2.

The National Environmental Policy Act (NEPA) of 1969 (42 USC 4321 et seq.) establishes broad national environmental policy. NEPA, as amended, requires all Federal agencies to prepare an EIS for proposed major Federal actions significantly affecting the quality of the human environment.

This EIS has been prepared in accordance with the Council on Environmental Quality's regulations on implementing NEPA (40 CFR 1500-1508) and DOE guidelines for compliance with NEPA (52 FR 47662), December 15, 1987.

6.2 FEDERAL REQUIREMENTS

The major Federal environmental requirements that may be applicable to the construction or operation of the SSC project are discussed in this section.

6.2.1 The Clean Water Act, as Amended (33 USC 1251 et seq.)

The objective of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

The CWA requires all branches of the Federal government involved in an activity that may result in a point source discharge or runoff of pollutants to waters of the United States to comply with applicable Federal, State, interstate, and local requirements respecting the control and abatement of water pollution to the same extent as any nongovernment entity.

National Pollutant Discharge Elimination System (NPDES). The Environmental Protection Agency is the permitting and enforcement agency for NPDES permits issued to facilities that discharge to surface waters unless authority has been delegated to the states. The states of concern in this EIS with delegated authority for NPDES permits are Colorado, Illinois, Michigan, North Carolina, and Tennessee.

Potential discharges to surface waters are indicated in Table 6-1. Should a site be selected in which discharges to surface water are proposed, the DOE would consult with the EPA or the designated state authority concerning requirements for NPDES permits.

Dredge and Fill Permits. The CWA, Section 404, establishes a permit system for the dredge and fill material in waters of the United States, which is administered by the U.S. Army Corps of Engineers. This permitting requirement applies to navigable waters including their wetlands. The only State to which authority has been delegated under Section 404 of the CWA is Michigan. Construction of certain SSC facilities may occur in wetlands (see Table 6-2). Should a site be selected for which facilities are proposed in wetlands, the DOE would consult with the Corps of Engineers or designated state authority regarding 404 permits.

Antidegradation. The water quality management plans of all of the States of concern in this EIS include antidegradation provisions, to protect the existing quality of waters in accordance with 40 CFR 131.12. The antidegradation policies of the states rely on the "best technical judgment" of their staff and/or radiation and chemical concentration limits. There are differences among states in the implementation of the policies and the extent to which they allow variances. Before project operations are initiated, potential contamination would have to be evaluated against the relevant antidegradation policy and any standards in effect at that time.

6.2.2 Executive Order 11988: Floodplain Management (May 24, 1977)

This Executive Order requires Federal agency procedures to ensure that the potential effects of any action undertaken in a floodplain consider flood hazards and floodplain management and avoid floodplain impacts to the extent practicable. DOE regulations at 10 CFR 1022 establish procedures for DOE compliance. Proposed sites that may have facilities affecting floodplains are identified in Table 6-3. Assessment of SSC project actions proposed in floodplains is contained in Chapter 5.

6.2.3 Executive Order 11990: Protection of Wetlands (May 24, 1977)

This Executive Order requires all Federal agencies to consider wetland protection in decision-making and to avoid impacts to wetlands to the extent practicable. DOE regulations (10 CFR 1022) establish procedures for DOE compliance for actions which may affect a wetland, and require the DOE to assess the effects of the action on the survival, quality, and natural and beneficial values of the wetlands and to avoid impacts to wetlands to the extent practicable. These assessments have been included in Chapter 5 of this EIS. Proposed sites that may affect wetlands were identified in Table 6-2.

Table 6-1

POTENTIAL POINT SOURCE DISCHARGES WHICH MAY REQUIRE NPDES PERMITS

State		Direct Discharge	Affected Major Streams or Lakes
Arizona			
Near STP	-	Waterman Wash	Gila River
Far STP	-	Bender Wash	Gila River
Colorado			
Near STP	-	Badger Creek	South Platte River
Far STP	-	Beaver Creek	South Platte River
Illinois			
E1	-	Unnamed Tributary	Fox River
F1	-	Waubansee Creek	Fox River
E2	-	Waubansee Creek	Fox River
F2	-	Waubansee Creek	Fox River
E3	-	Unnamed Tributary	Fox River
F3	-	Blackberry Creek	Fox River
E4	-	Big Rock Creek	Fox River
F4	-	Big Rock Creek	Fox River
E5	-	Welch Creek	Fox River
K1	-	Unnamed Tributary	Fox River
K2	-	Unnamed Tributary	Fox River
K3	-	Welch Creek	Fox River
K4	-	Welch Creek	Fox River
F5	-	Welch Creek	Fox River
E6	-	Welch Creek	Fox River
F6	-	Virgil Ditch No. 1	Kishwaukee River
E7	-	Ferson Creek	Fox River
F7	-	Ferson Creek	Fox River
E8	-	Ferson Creek	Fox River
F8	-	Otter Creek	Fox River
E9	-	Unnamed Tributary	Fox River
F9	-	Unnamed Tributary	Fox River
E10	-	Kress Creek	DuPage River
F10	-	Unnamed Tributary	Fox River
Michigan			
E1	-	Unnamed Tributary	Huron River
F1	-	Portage River	Grand River
E2	-	Portage River	Grand River
F2	-	Portage River	Grand River
E3	-	Grand River	Grand River
F3	-	Tobin Snyder Drain	Grand River
E4	-	Unnamed Tributary	Grand River
F4	-	Unnamed Tributary	Grand River
E5	-	Unnamed Tributary	Grand River
F5	-	Perry Creek	Grand River
K3	-	Perry Creek	Grand River
K4	-	Perry Creek	Grand River
E6	-	Sycamore Creek	Grand River
F6	-	Talmadge Drain	Grand River
E7	-	Mud Creek	Grand River
F7	-	Deer Creek	Grand River
E8	-	Sweeny Drain	Grand River
F8	-	Doan Creek	Grand River
E9	-	Doan Creek	Grand River
F9	-	Doan Creek	Grand River
E10	-	Thornapple Creek	Grand River
F10	-	Thornapple Creek	Grand River
K1	-	Thornapple Creek	Grand River
K2	-	Unnamed Tributary	Huron River

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Table 6-1 (Cont)

POTENTIAL POINT SOURCE DISCHARGES WHICH MAY REQUIRE NPDES PERMITS

State		Direct Discharge	Affected Major Streams or Lakes
North Carolina			
E1	-	Dial Creek	Flat River
F1	-	Flat River	Flat River
E2	-	South Flat River	Flat River
F2	-	North Flat River	Flat River
E3	-	Unnamed Tributary to North Flat River	Flat River
F3	-	Marlow Creek	Flat River
E4	-	Mill Creek	Flat River
F4	-	Mayo Creek	Flat River
E5	-	Mayo Creek	Flat River
K3	-	Unnamed Tributary to Mayo Creek	Flat River
K4	-	Unnamed Tributary to Mayo Creek	Tar River
F5	-	Unnamed Tributary to Mayo Creek	Tar River
E6	-	Grassy Creek	Roanoke River
F6	-	Mountain Creek	Roanoke River
E7	-	Blue Creek	Roanoke River
F7	-	North Fork	Tar River
E8	-	Unnamed Tributary to North Fork	Tar River
F8	-	Owen Creek	Tar River
E9	-	Unnamed Tributary	Tar River
F9	-	Unnamed Tributary	Tar River
E10	-	Unnamed Tributary	Neuse River
F10	-	Unnamed Tributary	Lake Butner (Neuse)
K1	-	Unnamed Tributary	Lake Butner (Neuse)
K2	-	Dial Creek	Flat River
Tennessee			
Near STP*	-	West Fork Stones River	Stones River
E1	-	West Fork Stones River	Stones River
F1	-	Lytle Creek	Stones River
E2	-	Lytle Creek	Stones River
F2	-	Dry Fork Creek	Stones River
E3	-	Unnamed Tributary	Duck River
F3	-	Hutton Creek	Duck River
E4	-	North Fork Creek	Duck River
F4	-	North Fork Creek	Duck River
E5	-	Clem Creek	Duck River
K3	-	Clem Creek	Duck River
K4	-	Wilson Creek	Duck River
F5	-	Wilson Creek	Duck River
E6	-	Lick Creek	Duck River
F6	-	Wilson Creek	Duck River
E7	-	South Fork Flat Creek	Duck River
F7	-	Cove Branch	Harpeth River
E8	-	Overall Creek	Harpeth River
F8	-	Nelson Creek	Harpeth River
E9	-	Nelson Creek	Harpeth River
F9	-	Unnamed Tributary	Stones River
E10	-	Overall Creek	Stones River
F10	-	Armstrong Branch	Stones River
K1	-	Armstrong Branch	Stones River
K2	-	Unnamed Tributary	Stones River
Texas			
Near STP	-	Unnamed Tributary to Chambers Creek	Trinity River
Far STP	-	Cottonwood Creek	Trinity River

* Alternative

Table 6-2

SITES WITH FACILITIES PROPOSED IN WETLANDS

State	Wetland Locations[1]
Arizona	none
Colorado	B, E1
Illinois	Fermilab (A,B), F4, F8, F9, F10
Michigan	A, B, E1, E4, E5, F1 F9, F10, K2
North Carolina	A, B, E2, E3, F7
Tennessee	A, B, F1, K2, K6
Texas	A, B, K6

1. Wetlands occurring within future expansion facilities (area C, the J sites, and sites K3 and K4) are not considered here because these sites may not be developed (see Chapter 3, Section 3.7.3).

Table 6-3

SITES WITH FACILITIES ENCROACHING INTO FLOODPLAINS (INCLUDING FUTURE EXPANSION AREAS)

State	Floodplains
Arizona	none
Colorado	J2, E3, F3, K3, K6, E8, E1, F8
Illinois	K4, J3, J6, F5
Michigan	Campus (A, B, C) F1, F2, F6
North Carolina	Campus (B, C), E2, J6, K6, J5, J2
Tennessee	Campus (A, C) F1, E6, E1, J2, J4, F10
Texas	J2, J3, J4, E1, E9, J6

6.2.4 The Safe Drinking Water Act (42 USC 300f et seq.)

The purpose of the Safe Drinking Water Act (SDWA) is to set primary drinking water standards for owners/operators of public water systems and to prevent underground injection that can contaminate drinking water sources.

National Primary Drinking Water Regulations, 40 CFR 141. These regulations define maximum contamination levels in public water systems. The EPA has delegated authority for regulating public water supplies to the seven states where the site alternatives are proposed. Proposed sources of potable water for the SSC are indicated in Table 3-3, Section 3.4.

Underground Injection Control (UIC), 40 CFR 144,146. Under the SDWA, any planned disposal of fluids by well injection with the potential to contaminate groundwater that is an actual or potential source of drinking water requires a specific rule by EPA or a UIC permit.

The states which have been delegated authority to issue UIC permits are Illinois and Texas. Michigan has proposed reinjection as an alternative method for disposal of treated dewatering wastes. Such an activity would require consultation with the EPA regarding permit requirements.

6.2.5 Clean Air Act (42 USC 7401 et seq., as amended)

The Clean Air Act (CAA) sets national primary and secondary ambient air quality standards, requires that specific emission increases for major stationary sources and modifications thereto will be evaluated so as to prevent a significant deterioration in air quality, and provides authority to the EPA to set national standards for performance of new stationary sources of air pollutants and standards for emissions of hazardous air pollutants. As a result EPA has established several air permitting programs. The implementing regulations are described in the following paragraphs.

National Primary and Secondary Ambient Air Quality Standards (40 CFR 50). National primary ambient air quality standards define levels of air quality judged by the EPA to be necessary to protect public health; secondary standards, which are lower, protect the public welfare. Standards are promulgated for sulfur oxides, particulates, carbon monoxide, photochemical oxidants, hydrocarbons, and nitrogen oxides (NO_x). These standards are enforced by the states through State implementation plans. DOE will consult with the state whose site is selected as to permit requirements.

Prevention of Significant Deterioration of Air Quality (40 CFR 52). This policy was incorporated into the CAA to limit increases of pollutants in clean air areas to specific increments even though the ambient air standards are being met. Any stationary source with the potential to emit more than 250 tons/yr of regulated pollutants, including NO_x, requires a Prevention of Significant Deterioration (PSD) permit. Only Texas does not have regulatory authority from EPA for this program; thus the Texas site would be covered by EPA regulations.

As discussed more fully in Appendix 8, the SSC would not qualify as a major stationary source, therefore no PSD permit would be required for the facility. However, if the State-proposed incinerator option for solid waste disposal were implemented at the Illinois, Michigan, or North Carolina sites, the PSD permit process would apply to operation of an incinerator. If an incinerator were used, DOE would consult with the appropriate agency as to permit requirements.

National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61); National Emission Standards for Radionuclide Emissions from Department of Energy (DOE) Facilities (Subpart H). National Emission Standards for Hazardous Air Pollutants have been established for beryllium, mercury, asbestos, vinyl chloride, and other hazardous materials, including radionuclide emissions from DOE facilities. 40 CFR 61.92 establishes limits for annual radiation dose equivalents to members of the general public resulting from air emissions from DOE facilities. These annual limits are 25 mrem to the whole body and 75 mrem to the critical organ of any individual. Doses due to radon-220 and radon-222 and their respective decay products are excluded from these limits. The regulations also require DOE to notify and obtain approval from the

Administrator of the EPA prior to the start of construction on a new source of emissions or modification of an existing source of emissions of radionuclides.

The SSC project, at all site alternatives, may produce air emissions of hazardous materials, including radionuclides, in very small amounts. As discussed more fully in Appendices 8 and 10, air emissions of nonradioactive, hazardous materials may result from evaporative loss of volatile substances used in experimental areas and for site and equipment maintenance. Minuscule amounts of radioactive air activation products that are formed during SSC operating periods may be emitted during ventilation of the experimental halls. DOE will consult with the Administrator of the EPA (or appropriate state authorities) regarding any necessary approval procedures for the SSC facility.

6.2.6 Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments of 1984 (42 USC 6901-6987)

RCRA provides for protection of public health and the environment from activities associated with the use, handling, treatment, and disposal of solid and hazardous wastes. It sets forth requirements for generators and transporters of hazardous waste and also establishes a specific permit program for treatment, storage, and disposal of hazardous wastes.

Subpart D of RCRA provides for the development of state plans for solid waste disposal and resource recovery. The objectives of Subpart D are to assist in developing and encouraging methods for solid waste disposal that are environmentally sound, maximize the recovery of valuable resources from solid waste, and encourage resource conservation. Solid waste is defined by the Act as any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

The EPA has promulgated guidelines to assist in the development and implementation of State solid waste management plans. These include criteria for the operation of landfills. If an on-site landfill alternative is selected, as proposed by the States of Arizona, North Carolina, and Colorado, consultation with the appropriate regulatory agency would be initiated to assure consistency with the state solid waste plan.

The EPA has promulgated regulations to implement RCRA Subpart C for treatment, storage, and disposal (TSD) of hazardous waste in 40 CFR 260-270. The hazardous waste regulations contain interim status standards applicable to TSD hazardous wastes or constituents from solid waste management units at a TSD facility. The EPA has authorized the seven states to conduct portions of the RCRA hazardous waste interim status and final status permit program for hazardous wastes.

All seven states have authority to implement the base RCRA permit program. Also, only Colorado has an approved program including regulations recently issued by EPA under the Hazardous and Solid Waste Amendments of 1984.

Generally, all generators must provide documentation (a "manifest") of the creation of the waste, and the waste must be tracked from generation through treatment, storage, and/or final disposition. The RCRA regulations also require that Department of Transportation (DOT) regulations for packaging, labeling, and transporting hazardous materials and wastes be followed. These are found in 49 CFR 100-199.

Two states, Arizona and Colorado, are in the process of constructing a RCRA-permitted disposal facility each within 5 mi of the State's proposed SSC location. In-state disposal facilities available for accepting SSC wastes are located in Texas, Illinois, and Michigan. Hazardous waste generated in North Carolina or Tennessee by the SSC would be shipped to disposal facilities out-of-state.

For mixed wastes, that is, those containing both hazardous waste and radioactive waste components, the hazardous waste components are subject to RCRA regulations. Mixed wastes generated by any of the proposed activities would be treated, stored, and disposed of in accordance with applicable EPA and state requirements. Only Colorado has the authority to regulate mixed radioactive and hazardous wastes. Mixed wastes are not expected to be generated at the SSC. However, if this expectation is wrong, these wastes would be disposed of in accordance with the requirements of RCRA.

The low-level radioactive waste (LLRW) would be disposed of in solid form consistent with the provisions of DOE Order 5820.2A or 10 CFR 61, as applicable. Texas is in the process of developing a low-level radioactive waste site in Hudspeth County, which is about 700 miles from the proposed site. Colorado, North Carolina, and Tennessee are in the regional LLRW compacts which have access to the existing commercial LLRW disposal sites. Although the current plan is to dispose of LLRW from the SSC at a DOE facility in Richland, Washington, these sites may accept SSC wastes.

6.2.7 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9601 et seq., as amended)

CERCLA provides for funding and enforcement authority, cleanup, and emergency response authority for releases of hazardous substances into the environment as defined in CERCLA. The DOE will comply with all reporting requirements for releases of hazardous substances into the environment and take appropriate action to respond to these releases.

6.2.8 Emergency Planning and Community Right to Know Act of 1986 (EPCRA) (42 USC 11001 et seq.)

EPCRA establishes requirements for emergency planning, spill reporting, and inventory reporting for specified classes of hazardous substances at commercial facilities or workplaces with an inventory of toxic/hazardous chemicals. The Act requires State and local emergency planning committees to be established to prepare plans to respond to releases of "Extremely Hazardous Substances" listed by the EPA. Owners and operators of facilities must immediately notify the local and State committees of releases beyond facility boundaries of reportable quantities (initially set at one pound) of substances reportable under CERCLA Section 103(a). In the unlikely event of an unpermitted release of hazardous substances, the DOE would comply with notification requirements and initiate appropriate remedial action. Consistent with EPCRA, the DOE would also provide appropriate SSC project chemical inventory information to state and local emergency planning and response commissions.

6.2.9 Noise Control Act of 1972 (42 USC 4901 et seq.)

Section 4 of the Federal Noise Control Act directs all Federal agencies "to the fullest extent within their authority" to carry out programs within their jurisdiction in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes public health or welfare. While no standards or EPA regulations have been promulgated under this Act, some states and local committees have issued noise-limiting requirements. Activities associated with the SSC which would increase ambient noise levels include: 1) construction of surface facilities and access shafts, experimental areas, and the tunnel; 2) delivery of cryogenic materials during operations; and 3) operation of access shaft ventilation fans. The noise impacts of the proposed project at the site alternatives are discussed in Chapter 5 and Appendix 9, along with mitigative measures which would be considered during the site-specific final design.

6.2.10 American Indian Religious Freedom Act (AIRFA) (42 USC 1996)

AIRFA provides the policy of the United States to protect and preserve the rights of American Indians to believe, express, and exercise tribal religious beliefs. Sites identified or suspected to be sacred to one or more tribes might be present on the proposed sites. To date, consultation with tribes and nations has not identified any sites of religious significance at the proposed sites. However, there is a potential for burial areas at all sites, as discussed in Chapter 5 and Appendix 15. During project activities, consultation would continue if any such areas are encountered.

6.2.11 National Historic Preservation Act (NHPA), 16 USC 470 a-470w-6; Executive Order 11593, Protection and Enhancement of the Cultural Environment; Archaeological and Historic Preservation Act, 16 USC 469-469c; and Historic Sites Act, 16 USC 461-467

Pursuant to these Acts and Executive Order 11593, DOE must provide an opportunity as appropriate for comment and consultation with the Advisory Council on Historic Preservation.

After selection of the SSC site, the DOE would consult with the Advisory Council on Historic Preservation and SHPO and attempt to negotiate a

Programmatic Agreement (PA) pursuit to 36 CRF Section 800.13 with the Council and the SHPO. Compliance with this PA would satisfy all Section 106 responsibilities for individual undertakings carried out in accordance with the agreements (see Section 4.9). Planned preconstruction activities include surveys necessary to validate the cultural resource assessments.

6.2.12 Archaeological Resources Protection Act (ARPA) (16 USC 470aa-470ll) and the Antiquities Act (16 USC 431-33)

ARPA is designed to protect archaeological resources on Federal and Native American lands by providing criminal and civil penalties for the unauthorized excavation and removal of these resources. ARPA enlarges and further defines requirements under the Antiquities Act. ARPA also requires consideration of the provisions of AIRFA.

ARPA provides for the excavation and removal of archaeological resources that may be required during a cultural resources management plan and prior to surface-disturbing activities, and provides a process by which Native Americans can become involved in the consideration of tribal religious or cultural sites that may be impacted by archaeological investigations.

Permitting requirements are included in ARPA with waiver provisions.

ARPA requires a permit from the Department of the Interior (DOI) for any excavation or removal of archaeological resources from public or Indian lands. Excavations must be undertaken for the purposes of furthering archaeological knowledge in the public interest. On Indian lands, consent must be obtained from the Indian tribe prior to issuance of a permit by the Bureau of Land Management (BLM), DOI, and the permit must contain all terms and conditions requested by the tribe.

None of the site alternatives include Indian lands; however, more than 60 percent of the Arizona site is situated on public lands. Should excavation or removal of archaeological remains be necessary on public lands at the Arizona site, DOE would consult with DOI regarding permit requirements.

Under the Antiquities Act, the DOE is also responsible for the protection of paleontological resources as prehistoric properties. It should be noted that some resources, e.g., petrified wood, can be taken in limited amounts in recreational activities which wood increases as a result of increased access to the area developed for the SSC.

6.2.13 Endangered Species Act (16 USC 1531-1543)

The Endangered Species Act establishes a Federal policy to conserve endangered or threatened species of fish, wildlife, and plants. The DOE must determine whether any listed or proposed endangered or threatened species or their habitats would be affected by project activities. If a listed species or critical/proposed-critical habitat may be affected by the project, DOE must consult with the Regional Director, U.S. Fish and Wildlife Service (USFWS), DOI, and follow the USFWS procedures.

In accordance with requirements in 50 CFR 402, the DOE has initiated consultation for all seven proposed sites with the USFWS. Results of that consultation have been documented in Appendix 11, which also contains an assessment of threatened and endangered species at the proposed sites. Biotic surveys at the selected site would be performed during preconstruction in order to verify the assessments.

6.2.14 Bald and Golden Eagle Protection Act (16 USC 668-668(d))

The Bald and Golden Eagle Protection Act affords protection to bald and golden eagles by establishing penalties for the unauthorized taking, possession, selling, purchase, or transportation of eagles, their nests, or their eggs. The USFWS has the authority to issue permits for the taking or disturbing of eagles or their nests or eggs for certain purposes. If SSC activities would disturb bald or golden eagles or their nests, the DOE would initiate informal discussions with the USFWS regarding mitigation measures.

At all proposed sites, except Colorado, eagles are known to occur only as migrants. In Colorado, bald eagle nesting and roosting habitats are adjacent to an access road the State proposes to construct between the Denver area and the SSC site. This activity would require Colorado to consult with the USFWS.

6.2.15 Migratory Bird Treaty Act (16 USC 703-712)

The Migratory Bird Treaty Act affords protection to many species of migratory birds by prohibiting the pursuit, hunting, taking, capture, possession, or killing of such species or their nests and eggs. It is possible that some migratory birds or their nests or eggs could be impacted by activities associated with construction and operation of the SSC at all seven proposed sites. Although no permit for this project is required under the Act, the DOE is required to consult with the USFWS regarding impacts to migratory birds and to evaluate ways to avoid or minimize these effects in accordance with the USFWS mitigation policy.

6.2.16 The Wild Free-Roaming Horses and Burros Act of 1971 (16 USC 1331-1340)

This Act declares wild horses and burros to be "living symbols of the historic and pioneer spirit of the West." It protects wild horses and burros from capture, branding, harassment, or unlawful death. It provides for the protection and management of wild horses and burros on public lands administered by the Secretary of the Interior through the BLM or by the Secretary of Agriculture through the Forest Service. A few wild burros are present on public lands in the vicinity of the Arizona site. The DOE would consult with BLM concerning protection of these animals.

6.2.17 The Fish and Wildlife Coordination Act (FWCA) (16 USC 661-666c)

This law requires consultation with the USFWS to consider fish and wildlife resources when water bodies, including wetlands, are to be modified, controlled, or impounded. It then requires action to be taken to prevent loss and damage to these resources and to provide for their development and improvement.

All alternative sites except Arizona contain wetlands. Wetlands assessments are provided in Chapter 5 and Appendix 11. Planned preconstruction activities include wetland surveys to validate the assessments, determine the need for consultation with the USFWS under the FWCA, and incorporate appropriate mitigation into final project design.

6.2.18 The Wilderness Act of 1964 (16 USC 1131-1136)

The Wilderness Act of 1964 instructs Federal land management agencies to inventory their lands to determine the suitability of such lands for inclusion in the National Wilderness Preservation System. FLPMA applies these requirements to public land (see Section 6.2.20). It also prohibits numerous activities on designated wilderness areas. These activities include commercial enterprises, permanent and temporary roads, motorized travel, boats, aircraft, structures, and installations.

At the Arizona site, several project facilities would be located in three Wilderness Study Areas (WSA's) administered by the BLM. A discussion of the relationship of the SSC to acquisition of public lands for the SSC and the WSA's is incorporated in Section 4.8.

6.2.19 The Farmland Protection Policy Act (FPPA) (7 USC 4201-4209)

The FPPA would apply to the SSC if the selected site would require taking any farmlands. This Act requires Federal agencies to minimize or eliminate the unnecessary and irreversible conversion of farmland to nonagricultural uses and to assure that Federal programs, to the extent practicable, are compatible with state, local government, and private programs to protect farmland.

Construction of the SSC at any of the site alternatives, except in Arizona, would affect farmland. The DOE has consulted with the Soil Conservation Service regarding farmlands which would be converted by the SSC project at the site alternatives. Assessment of farmland conversion is presented in Chapter 5 and Appendix 13.

6.2.20 The Federal Land Policy and Management Act (FLPMA) of 1976 (43 USC 1701-1782)

FLPMA gave the BLM a mandate, among other charges, to: 1) manage public land according to land use plans developed with public participation and involvement; 2) maintain an inventory of the public lands and their resource values; 3) establish a policy of requiring fair market value for the use of public lands; and 4) authorize the establishment of citizen's advisory councils.

FLPMA also provides for withdrawals of public lands for specific uses. The Arizona proposal includes provisions that 6,748 acres of public lands administered by the BLM be made available to the DOE for the SSC project. At present, no firm plan for transfer has been agreed to. A combination of withdrawal and rights-of-way is currently under consideration. No other site alternative includes lands administered by the BLM.

6.2.21 The Uniform Relocation and Real Property Acquisition Policies Act (42 USC 4601 et seq.)

This law provides for uniform and equitable treatment of persons displaced from their homes, businesses, or farms by Federal programs. It also establishes uniform and equitable land acquisition policies for Federal and Federally assisted program.

The Invitation for Site Proposals (ISP) requires the proposer of the selected SSC site to comply with the requirements of this Act when these lands are acquired by the proposer for transferal to the DOE.

6.2.22 The National Trails System Act of 1968 (16 USC 1241 et seq.)

The law institutes a national system of recreation, scenic, and historic trails as a means to provide for the ever-increasing outdoor recreation need of an expanding population and to promote the preservation of public access to, travel within, and enjoyment and appreciation of the open-air, outdoor areas and historic resources of the nation.

Construction of the SSC in Illinois would affect a national recreation trail; however, it is expected that there would be only minimal disruption caused in its use as construction activities occurred in adjacent areas.

6.3 DOE ORDERS

The DOE exercises its responsibilities for protection of public health and safety and the environment through a series of DOE Orders. The DOE general environmental protection policy is set forth in the "Environmental Policy Statement," DOE Notice 5400.1, issued by the Secretary on January 8, 1986, and extended on January 7, 1987. It states the DOE's commitment to national environmental protection goals by conducting operations "in an environmentally safe and sound manner... in compliance with the letter and spirit of applicable environmental statutes, regulations, and standards." This Environmental Policy Statement also contains a departmental commitment to "good environmental management in all of its programs and at all of its facilities in order to correct existing environmental problems, to minimize risks to the environment or public health, and to anticipate and address potential environmental problems before they pose a threat to the quality of the environment or public welfare." Further, "it is DOE's policy that efforts to meet environmental obligations be carried out consistently across all operations and among all field organizations and programs."

The SSC would be constructed and operated as a Federally funded research and development center. The operating contract would include a clause in which the DOE elects to enforce health and safety requirements and which makes compliance with all relevant DOE health, safety and environmental orders a contractual requirement. The operating contractor would also be responsible for construction. The major DOE orders pertaining to the construction and operation of the SSC are briefly discussed below.

6.3.1 DOE Order 5440.1C, National Environmental Policy Act (NEPA)

This Order establishes responsibilities and sets forth procedures necessary for the DOE to implement NEPA, as amended.

6.3.2 DOE Order 5480.1B, Environmental Protection, Safety, and Health Protection Program for DOE Operations

This Order provides the organization, assigns responsibilities, and establishes the components of an environmental protection, safety, and health protection program applicable to all DOE operations. It is currently being revised (1988), and as a part of the revisions, its 14 chapters are being issued as separate DOE Orders in a 5400 series. While compliance with draft revisions (i.e., revisions not formally approved by the DOE) is not required, the SSC project would be designed to comply with the intent of these draft revisions.

Chapters XI and XII, which are currently in revision, have direct applicability to this EIS. Chapter XI provides, among other things, radiation-protection standards for occupational and nonoccupational exposures. It also provides radionuclide concentration guides for airborne emissions and liquid effluents. Chapter XI additionally sets forth monitoring requirements to ensure that these standards are met. Chapter XII establishes pollution and compliance with environmental protection laws and with Executive Order 12088.

The current draft revision to DOE Order 5480.1B, Chapter XI (DOE Order 5480.xx [March 31, 1987]) and draft DOE Order 5400.3, provide public radiation exposure limits and add a new section on environmental protection. Except under unusual circumstances, the radiation dose limit to a member of the public is 100 mrem/yr. The derived concentration guides (DCG's) for members of the public who are not "occupational workers" are based on input from various national and international organizations (primarily the International Commission on Radiological Protection (ICRP)). These DCG's establish allowable upper limits of radioisotope concentrations in air and water above natural background levels that would be a result of ingestion or inhalation. A more detailed discussion is presented in Appendices 10 and 12.

The requirements of the draft revision also implement regulations concerning the protection of soils, aquifers, natural waterways, and aquatic organisms against avoidable contamination by radioactive materials. Definitive radiological monitoring requirements have been established, and additional guidance on recommended procedures and activities has been developed. General requirements also are included concerning capabilities to detect and assess unplanned releases of radioactive material and radiological consequences.

6.3.3 DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards

Order 5480.4 specifies and provides "requirements for the application of the mandatory environmental protection, safety, and health standards applicable to all DOE operations." This Order lists both mandatory and reference standards that are applicable to the environmental protection, safety, and health program established by DOE Order 5480.1B.

6.3.4 DOE Order 5483.1A, June 22, 1983

This Order provides several requirements and procedures for the establishment of an occupational safety program at Government-owned contractor-operated facilities.

CHAPTER 7

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CHAPTER 7 PREPARERS AND REVIEWERS

Those who prepared this EIS for the SSC are identified below. The overall effort for the Department of Energy was led by Dr. L. Edward Temple, Jr., Executive Director, SSC Site Task Force, Office of Energy Research. Robert Selby, Director, Project Management and Engineering Division (PMED), Chicago Operations Office and Robert Wunderlich, Deputy Director, PMED, had direct responsibility for the development of the EIS.

Reviews of the analyses and draft materials for the Department of Energy were provided by staff from: Office of Energy Research; Office of General Counsel; Assistant Secretary, Environment, Safety, and Health; Assistant Secretary, Management and Administration, and the Chicago Operations Office. Staff contributing to the documents are listed below; their educational credentials and area of expertise are given when they are first listed:

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CHAPTER 8

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CHAPTER 8

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Mr. Lou N. Sutton
San Antonio, TX 78205

Mr. Jim Tallas
Sugar Land, TX 77478

Mr. M. A. Taylor
Waco, TX 76714

Mr. Frank Tejeda
San Antonio, TX 78221

Mr. Barry Telford
DeKalb, TX 75559

Mr. Garfield Thompson
Forth Worth, TX 76105

Mr. Senfronia Thompson
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Mr. Mike Toomey
Houston, TX 77084

Mr. Carlos F. Truan
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Mr. D. R. Uher
Bay City, TX 77414

Mr. Hector Uribe
Brownsville, TX 78520

Mr. Jack Vowell
El Paso, TX 79912

Mr. Tom C. Waldrop
Corsicana, TX 75110

Mr. Ralph Wallace, III
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Mr. Larry Warner
Port Isabel, TX 78578

Mr. Craig Washington
Houston, TX 77004

Mr. Richard Waterfield
Canadian, TX 79014

Mr. Gary Watkins
Odessa, TX 79761

Mr. Ed R. Watson
Deer Park, TX 77536

Mr. Foster Whaley
Pampa, TX 79065

Mr. John Whitmire
Houston, TX 77008

Mr. Richard F. Williamson
Weatherford, TX 76086

Mr. Doyle Willis
Fort Worth, TX 76102

Mr. John Willy
Angleton, TX 77515

Mr. Ron Wilson
Houston, TX 77033

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Denver, CO 80203

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Mr. Wynn Harris
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Washington, DC 20001

Mr. Rick Thornberg
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Springfield, IL 62701

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Springfield, IL 62706

Mr. Thomas Lay Burroughs
Springfield, IL 62777

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Geneva, IL 60134

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Champaign, IL 61820

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St. Charles, IL 60174

Mr. Gary R. Clark
Springfield, IL 62764

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Yorkville, IL 60560

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Hanover Park, IL 60103

Ms. Donna Daliesasse
Batavia, IL 60510

Mr. Michael Divine
Springfield, IL 62701

Ms. Marie A. Downey
Bartlett, IL 60103

Mr. William K. Durham
Sterling, IL 61081

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Geneva, IL 60134

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Springfield, IL 62701

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Springfield, IL 62704

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Springfield, IL 62706

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Champaign, IL 61820

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Mr. Bruce E. Towier
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Mr. Ed Murray
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Mr. Jimmy Naifen
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Ms. Karen Roberts
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Camp Verde, AZ 86322

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Mr. George Wahquahboshkuk
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Mr. David Mackety
Fulton, MI 49052

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Mt. Pleasant, MI 48858

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Mt. Pleasant, MI 48858

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Mr. White Hartley
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Mr. James Hendrickson
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Mr. William Houle
Cloquet, MN 55720

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Cass Lake, MN 56633

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Mr. Vernon Haddon
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Mr. Elmer Manatowa
Stroud, OK 74079

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Mr. Charles Norman
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III. Libraries

Arizona

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Phoenix Public Library
Phoenix, AZ 85004

Colorado

East Morgan County Library
Brush, CO 80723

Fort Morgan Public Library
Fort Morgan, CO 80701

District of Columbia

DOE Public Reading Room
Washington, DC 20585

Illinois

Aurora Public Library
Aurora, IL 60506

DOE Public Reading Room
Chicago Operations Office
Argonne, IL 60439

Illinois SSC Project Office
Batavia, IL 60510

Kaneville Township Library
Kaneville, IL 60144

St. Charles Public Library
St. Charles, IL 60174

West Chicago Public Library
West Chicago, IL 60185

Michigan

Ingham County Library System
Mason, MI 48854

Jackson District Library System
Jackson, MI 49201

North Carolina

Durham County Library
Durham, NC 27701

Roxboro Library
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Richard H. Thomton Library
Oxford, NC 27565

Tennessee

DOE Public Reading Room
Oak Ridge Operations Office
Oak Ridge, TN 37831

Linebaugh Public Library
Murfreesboro, TN 37130

Tennessee Department of Economic and Community Development Library
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V. Landowners and/or Interested Persons

A total of 13,933 copies of the EIS document were sent to landowners, industry, environmental groups, academia, and individuals known to be interested in, or affected by, the project in the region of each of the seven proposed alternative sites. (Reference Table 8.1 indicating requests by each alternative site.)

VI. News Media

A total of 1,086 copies of the EIS document were sent to the news media (including newspapers, radio, and television stations) in the region of each of the seven proposed alternative sites. (Reference Table 8.1 indicating requests by each alternative site.)

A complete distribution list is available through the U.S. Department of Energy, Freedom of Information Room, Washington, DC 20585.

VII. Other

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League of Women Voters of U.S.
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TABLE 8.1

ENVIRONMENTAL IMPACT STATEMENT DISTRIBUTION MATRIX

CATEGORY	ARIZONA	COLORADO	ILLINOIS	MICHIGAN	NORTH CAROLINA	TENNESSEE	TEXAS	NON-BQL SITES	SUB TOTAL
U.S. Senate	2	2	2	2	2	2	2	8	22
U.S. House of Representatives	4	4	8	5	3	3	4	8	39
Federal Agencies/ Departments	5	3	5	4	6	7	5	28	63
Governors/ Proposers	1	1	1	1	2	1	2	0	9
State Legislators	81	99	172	147	168	131	178	0	976
State and Local Officials	16	38	78	81	30	43	46	9	341
D.C. State Offices	1	1	2	1	2	1	1	0	9
Native Americans	14	3	0	5	5	0	0	33	60
Libraries/DOE Reading Rooms	2	2	6	2	3	3	2	1	21
Environmental Groups	16	39	21	87	28	20	16	17	244
Landowners and/or Interested Persons	269	229	7,864	1,653	1,157	1,099	946	716	13,933
News Media	113	67	223	143	124	99	310	7	1,086
Other	0	0	0	0	0	0	0	2	2
TOTALS	524	488	8,382	2,131	1,530	1,409	1,512	829	16,805

CHAPTER 9

PRINCIPAL REFERENCES

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CHAPTER 9 PRINCIPAL REFERENCES

CHAPTER 9 PRINCIPAL REFERENCES

9.1 DESIGN-RELATED REFERENCES

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GLOSSARY

GLOSSARY

AAHC	Arizona Agricultural and Horticulture Commission.
ACGIH	American Conference of Governmental Industrial Hygienists.
Ach	Air changes per hour.
ADEQ	Arizona Department of Environmental Quality.
ADOT	Arizona Department of Transportation.
AE	Accessible Environment.
AEA	Atomic Energy Act.
AE/CM	Architect-Engineer/Construction Manager.
AIP	Accelerator Improvement Projects.
AIRFA	American Indian Religious Freedom Act of 1978.
ALARA	As Low As Reasonably Achievable. A DOE policy to minimize the exposure of workers to ionizing radiation as much as practical. This is in addition to keeping exposures below mandatory guidelines.
ALI	Annual Limit of Intake.
ANL	Argonne National Laboratory (Argonne, Illinois).
ANSI	American National Standards Institute.
APHA	American Public Health Association.
ARPA	Archaeological Resources Protection Act of 1979.
ARRA	Arizona Radiation Regulation Agency.
ASTM	American Society for Testing and Materials.
AUI	Associated Universities Incorporated.
AZDOT	Arizona State Department of Transportation.

Absolute Zero — A hypothetical temperature characterized by the complete absence of atomic vibration; equivalent to approximately -273.16^{o}C or -459.69^{o}F. (see Centigrade, Fahrenheit)

Absorbed Dose — The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.

Absorber — In electromagnetic systems, a material that absorbs or reduces the intensity of radiation.

Absorption — In electromagnetic systems, the physical process by which the number of particles or photons entering a body of matter is reduced or attenuated by interaction with the matter. In acoustics, the physical process by which the intensity of acoustic waves is reduced by interaction with reactive surfaces. The process by which noise reduction occurs when surface acoustic treatment is used, or when outdoor noise propagates over vegetation or certain ground features.

Accelerator — An experimental physics device for imparting large kinetic energy to electrically charged atomic and subatomic particles such as electrons and protons. The path of the particles is controlled by magnetic fields while kinetic energy is typically imparted by radiowaves. If the particle path is linear, the device is called a Linear Accelerator or LINAC. If the particle path is circular or oval, the device is a cyclotron, synchrocyclotron, or synchrotron. The main collider ring of the SSC is a synchrotron (actually a variation of a synchrotron called a collider). The injector consists of a LINAC and three progressively larger synchrotrons (LEB, MEB, and HEB) that together will generate, accelerate, and inject protons into the main collider ring.

Acreage — An area of land comprising a number of acres.

Advection — The process by which a material (dissolved or suspended) in groundwater is transported by the bulk motion of the flowing groundwater.

Alluvial Fan — A fan-shaped deposit of alluvium made by a stream where it runs onto a level plain or meets a slower stream.

Alluvium	General term for all detrital sediments deposited as a result of the operation of modern rivers.
Alpha Particle	A particle consisting of two protons and two neutrons (equivalent to the nucleus of a helium atom) that is emitted from the nucleus of a radionuclide during radioactive decay.
Ammonide	An inclusive term for ammonites and related species.
Ammonite	An extinct animal found as a fossil. Ammonites looked like an octopus or squid inside a straight or curved conical shell. Specifically, a large group of extinct mollusks related to the living chambered nautilus.
Anadromous	Referring to animals that return to their birthplace for breeding. Most commonly used in connection with the migration of salmon and some species of trout that return up river to the same small stretch of stream or creek.
Ancillary	Subordinate, auxiliary.
Anhydrite	The mineral anhydrous calcium sulfate, $CaSO_4$, commonly found in evaporites.
Annunciator	An electrically controlled signal board or indicator.
Antiparticle	A particle that is identical to an ordinary particle except for having certain opposite elementary properties, such as electric charge.
Aquic	Of or pertaining to water.
Aquiclude	Saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.
Aquifer	A saturated, permeable geologic unit that can transmit significant (usable) quantities of water under ordinary hydraulic gradients.
Aquitard	Less-permeable beds in a stratigraphic sequence (relative to the aquifer).
Archaeology	The science investigating past human life and activities based on the study of material remains (fossils, relics, artifacts, monuments).

Archival	Relating to the preservation of records and documents, or constituting the place where the material is preserved.
Aridic	Of or pertaining to the lack of moisture.
Artificial Radioactivity	Radioactivity exhibited by man-made radionuclides produced as the result of particle bombardment or electromagnetic irradiation of a material; as opposed to natural radioactivity. (see Radioactive Decay, Radioactivity)
Atmosphere (of pressure)	The pressure exerted by the atmosphere under standard conditions. Equivalent to 14.66 $lb/inch^2$.
Atom	The smallest unit of a chemical element that has the chemical and physical characteristics of the element. Atoms consist of a central nucleus surrounded by orbital electrons. Protons and neutrons are found in the nucleus. The nucleus is held together by the strong force; the atom is held together by electromagnetic force. (see Electromagnetic Force, Ion, Isotope, Neutron, Nucleon, Nucleus, Proton)
Atomic Number	The number of protons in the nucleus of an atom.
Atomic Weight	The average relative weight of the atom of an element referred to an arbitrary standard. (A value of 12.000 is used for the atomic weight of oxygen.)
Attenuation	In electromagnetic systems, the process by which a beam of radiation is reduced in intensity when passing through some material. It is a combination of absorption and scattering processes and leads to a decrease in flux density of the beam when projected through matter. In acoustics, it is the reduction in sound level that results from the conversion of acoustic energy to heat energy through interaction of the particles of the conducting medium. (see Absorption)
BEA	Bureau of Economic Analysis (of the United States Department of Commerce).

BEIR	Biological Effects of Ionizing Radiation.
BLM	Bureau of Land Management (of the United States Department of Interior).
BLS	Bureau of Labor Statistics (of the United States Department of Labor).
BNL	Brookhaven National Laboratory (Upton, New York).
BQL	Best Qualified List; one of the seven site alternatives considered for location of the SSC by DOE.
Background Radiation	Naturally occurring radiation due primarily to cosmic rays and natural radioactivity.
Basalt	A dark grey to black, fine-grained igneous rock composed primarily of calcium feldspar and pyroxene, with or without olivine.
Beam	A unidirectional or approximately unidirectional flow of electromagnetic radiation or particles.
Bedrock	Any solid rock exposed at the surface of the earth or overlain by unconsolidated material.
Bel	The logarithmic expression of the magnitude of sound pressure, sound power, or sound intensity relative to a reference quantity. Loudness is related to the sound level in decibels but is not expressed in decibels. The loudness units, "sones" or "phons," are not used in this document.
Berm	A narrow shelf, path, or ledge typically at the top or bottom of a slope; also a mound or wall of earth.
Beta Particle	An electron emitted from the nucleus of a radionuclide during radioactive decay.
Betatron	An accelerator in which electrons (beta particles) are accelerated. (see Accelerator, Beta Particle)
Bicarbonate	The negatively charged ion HCO_3.
Biomass	The total mass or amount of living organisms in a particular area or volume.

Biota	The flora and fauna of a region.
Bivalve	Referring to an animal with a two-part shell, such as a clam.
Bog	A swamp; a wet spongy morass, composed chiefly of decaying vegetable matter or peat. A common term used in Scotland and Ireland.
Borehole	A hole bored or drilled in the earth.
Bosons	Current theory proposes that fundamental forces (strong force, electromagnetic force, weak force, gravitation) are carried or mediated by particles called bosons. There are currently postulated to be eight bosons of the strong force, which are called gluons; a single boson of the electromagnetic force, called a photon; three bosons of the weak force, called W^+, W^-, and Z^0 bosons; and a single boson of gravitation called a graviton.
Brachiopod	Marine, shelled animals in the phylum Brachiopoda. The animals have two unequal shells (bivalves) that are normally bilaterally symmetrical. Many species have a superficial resemblance to clams, which are members of the phylum Mollusca. Brachiopods are common fossils found in marine sediments.
Brecciated	Material composed of highly angular coarse fragments.
^oC	Degrees Celsius. (see Centigrade)
CAAC	Clean Air Act Codes. (computer codes)
CAP	Central Arizona Project.
CAT	Computer Aided Tomography.
CBT	Colorado - Big Thompson Project.
CDF	Collider Detector Facility (located at Fermilab).
CDG	Central Design Group - the technical group responsible for the current SSC program.
CDOT	Colorado Department of Transportation.
CDR	Conceptual Design Report for the SSC published in 1986.

CEBAF — Continuous Electron Beam Accelerator Facility (LINAC located in Newport News, Virginia).

CEQ — Council on Environmental Quality.

CERCLA — The Comprehensive Environmental Response, Compensation, and Liability Act, commonly referred to as "Superfund." CERCLA gives the Federal government power to respond to releases or threatened releases of hazardous substances that present a danger to human health and the environment. CERCLA established a Hazardous Substance Trust Fund (Superfund), available to finance responses taken by the Federal government instead of waiting to resolve questions of legal responsibility.

CERN — Centre Europeenne Pour La Recherche Nucleaire (Now called the "Organisation Europeenne Pour La Recherche Nucleaire"). The European Organization for Nuclear Research located in Geneva, Switzerland.

CFR — Code of Federal Regulations. A publication of the Federal government that contains the rules and regulations established by all Federal Agencies for regulating their areas of responsibility. Essentially the details of what is required to comply with the laws passed by Congress as interpreted by the Federal Agencies.

CGS — Colorado Geological Survey.

COE — United States Army Corps of Engineers.

COG — Council of Government.

CRCPD — Conference of Radiation Control Program Directors.

CRM — Cultural Resource Management.

Calcareous — Containing calcium carbonate ($CaCO_3$).

Caliper — A measuring instrument with two legs or jaws that can be adjusted to determine thickness, diameter, or distance between two surfaces or points.

Calorimeter — Any of several apparatuses for measuring thermodynamic properties of materials. In high energy physics, a detection device for trapping and measuring the energies of all particles emerging from particle collisions.

Carcinogen	A substance or agent that can produce or incite cancer.
Catchment	Something that catches water, or the amount of water caught.
Celsius	The unit of temperature in the Centigrade scale of temperature measurement. (see Centigrade)
Cenozoic	The era in the history of the earth from the extinction of the dinosaurs to the present. Often called the "age of the mammals," the era is estimated to be from approximately 65 million years ago to and including the present.
Centerline	A line equidistant from the surface or sides of something.
Centigrade	The thermometric scale in the metric system in which the interval between the freezing point and the boiling point of water, under standard atmospheric pressure, is divided into 100 units defined as degrees Celsius (abbr. ^{o}C). The freezing point of water is defined as $0^{o}C$, and the boiling point of water as $100^{o}C$.
CGS System	Centimeter-Gram-Second System. A system of units based on the centimeter as the unit of length, the gram as the unit of mass, and the mean solar second as the unit of time. A subset of the metric system. (see Metric System)
Chalcedony	A translucent quartz mineral that is commonly pale blue or grey with nearly waxlike luster.
Chalk	A very soft, unindurated (uncemented) limestone often containing the hard parts of microorganisms.
Chert	A variety of quartz.
Claystone	An indurated (cemented) clay. (see Shale)
Cohort	A group of individuals in a demographic study having a statistical factor in common (such as age or class membership).

Collider	A shortening of "Colliding Beam Storage Ring Synchrotron." A type of synchrotron in which two beams of particles orbit in opposite directions in concentric rings. The beams can be accelerated and stored independently until brought together. The SSC is a collider.
Collimator	A device used to "purify" a particle beam by absorbing off-axis particles.
Collision	An encounter between two subatomic energetic particles.
Compound	A chemical substance composed of two or more elements. Compounds have different chemical and physical properties than the individual elements. The basic unit of a compound is the molecule.
Conductivity	The quality or property of a material to transmit electricity. The reciprocal of electrical resistivity.
Confined Aquifer	An aquifer that is confined between two confining strata, i.e., aquitards or aquicludes.
Conglomerate	A cemented rock containing rounded pebbles and gravel.
Conventional Facilities	The normal buildings, structures, and utilities required to house and/or support the technical components of the SSC. (see Technical Components)
Cooldown	The time-period required to bring superconducting magnets from room temperature to their operating temperature.
Cooling Tower	A heat exchange device designed to transfer heat from a process to the atmosphere, either directly or through the use of an intermediate fluid. Alternative cooling methods transfer heat to bodies of water.
Cosmic Rays	Particles that bombard the earth from outer space. Cosmic rays are predominantly protons and electrons, but include, to a lesser degree, atomic nuclei of elements with atomic weights greater than hydrogen.

Craton	A relatively stable, immobile part of the earth's crust, generally of large size; a very large pluton or merged group of plutons.
Cretaceous	The last period in the Mesozoic Era in the history of the earth, estimated to have occurred from approximately 140 to 65 million years ago. The period is characterized by the culmination of the dinosaurs. At the end of the Cretaceous, the dinosaurs became extinct.
Crinoid	A group of marine invertebrates that look somewhat like a flower. Part of the phylum Echinoderma, a large group of marine worms.
Cryogenic	Of or relating to the production of very low temperatures; in particular, temperatures approaching absolute zero.
Cryostat	An apparatus for maintaining a constant low temperature; especially temperatures approaching absolute zero.
Crystalline	Of or pertaining to the nature of a crystal.
Cumulative	Summing of data or values of a random variable.
Cut-and-Cover	A construction technique where a cut trench is first excavated. After installation of components in the trench, the trench is then backfilled with the previously excavated material.
Cyclotron	An early accelerator design that used both a fixed magnetic field and fixed radiofrequency to accelerate charged particles in a spiral path. (See Accelerator, Relativistic Mass Increase, Synchrocyclotron.)
dB	Decibel.
DEIS	Draft Environmental Impact Statement.
DESY	Deutsches Electronen-Synchrotron. German Organization for Nuclear Research located in Hamburg, West Germany.
DO	Dissolved Oxygen. Refers to the amount of oxygen dissolved in water.
DOD	United States Department of Defense.

DOE	United States Department of Energy .
DOT	United States Department of Transportation.
DPF	Division of Particles and Fields (of the American Physical Society).
DRCOG	Denver Regional Council of Governments.
Daughter	In radioactive decay, the nuclide produced as the result of the decay; in high-energy physics, the nuclide or subatomic particle produced as the result of an interaction (collision).
Debris	The remains of something broken down or destroyed.
Decay Series	The parent and all daughter radionuclides to the stable daughter product.
Decibel	One-tenth of a bel; a measure of the magnitude of sound pressure, sound power, or sound intensity. (see Bel)
Deciduous	Referring to plants that lose leaves seasonally. Most commonly used in connection with trees that lose their leaves in specific seasons, such as autumn, or dry seasons.
Degrees F	Degrees Fahrenheit. (see Fahrenheit).
Demographics	The study of the dynamic balance of a population, especially with regard to density and capacity for expansion or decline.
Dendritic	An irregular branching pattern resembling a shrub or tree.
Detrital	Referring to material derived from the erosion of preexisting rocks.
Dewpoint	The temperature at which vapor begins to condense.
Diabase	A variety of basaltic rock.
Diorite	An igneous, plutonic rock composed essentially of sodium-rich feldspar and hornblende, the mica biotite, or pyroxene.

Dipole	In electromagnetic systems, a pair of equal and opposite electrical charges or magnetic poles of opposite sign separated by a small distance. In acoustics, a radiating body that has a specific phase relationship between two vibrating points. In accelerators, dipole magnets are used to bend beams of particles (similar to the way a prism bends light beams).
Dispersion	The process by which a material (dissolved or suspended) in water spreads during transport by the bulk motion of the flowing water. Results in the dilution of the material over a larger volume.
Dolomite	A calcium-magnesium carbonate mineral with the composition $CaMg(CO_3)_2$. Also a term applied to those sedimentary rocks that approximate the composition of the mineral.
Dose Equivalent	A quantity used in radiation protection. It expresses all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads and certain modifying factors. The unit of dose equivalent is the rem.
Dose Rate	The radiation dose delivered per unit of time.
Dosimetry	The theory and application of the principles and techniques involved in measuring and recording radiation doses. A practical aspect is concerned with the use of various types of radiation instruments with which measurements are made.
Drift	Rock material transported by a glacier and deposited by or from the ice or by or in water derived from the melting of the ice.
EDI	Engineering, Design, and Inspection
EIS	Environmental Impact Statement
E&M	Electrical and Mechanical
EMCS	Energy Management and Control Systems
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute

ER	Office of Energy Research (of the United States Department of Energy)
ESD	Elementary School District
EXACT	Computer code for the general analytical solution of the one-dimensional solute transport equation for zero-order production and first-order decay.
Ecosystem	The complex of a plant or animal community and its environment, functioning as an ecological unit in nature.
Ecotype	An association of plant and animal communities interacting within a specific spatial area, and adapted to the physical chemical conditions of that area.
Electromagnetic Force	A long-range force associated with electric and magnetic properties of particles. Current theory proposes that the electromagnetic force is carried by a boson called a photon.
Electron	An elementary atomic particle having a mass of 9×10^{-28} grams and a negative unit charge. The electron is classed as a lepton and has 1/1836 the mass of a proton.
Electron Volt	A unit of energy commonly used in particle physics, equal to the energy gained by an electron that is accelerated through a potential difference of one volt. It is used to express either the energy or the mass of the particle (in accord with the theory of relativity, which relates mass to energy by Einstein's famous equation, $E = mc^2$, where E is the energy of the particle, m is the mass of the particle, and c is the speed of light). Larger multiples of the basic unit are frequently referred to: keV for thousand or kilo electron volts, MeV for million or mega electron volts, GeV for billion electron volts, TeV for trillion electron volts.
Element	Chemical substance that consist of atoms of one kind; a substance all of whose atoms have the same atomic number.
Elementary Particle	A subatomic particle that has no apparent substructure, i.e., that cannot be subdivided into other particles.

Encroachment	Advanced beyond the usual or proper limits.
Endangered Species	Any species that is in danger of extinction throughout all or a significant portion of its range.
Endemic	Restricted or unique to a locality or region.
End Moraine	A moraine formed at the front end of a glacier.
English System	The system of measurement based on the foot as a unit of length, the pound as a unit of weight, and the gallon as a unit of volume. The system commonly in use in the United States of America.
Eolian	Applied to the erosive action of the wind and the deposits that are due to the transporting action of the wind (e.g., sand dunes).
Ephemeral	Lasting only a few days. An ephemeral stream is one that has flowing water present only immediately after a rain.
Epiclastic	Textural term applied to deposited sediments consisting of weathered, rounded detrital material. (As opposed to brecciated.)
Epoch	In geology, a division of geologic time; a subdivision of the period.
Era	In geology, the highest-order division of geologic time. The eras now generally recognized are the Precambrian, Paleozoic, Mesozoic, and Cenozoic.
Erosion	The action or process of being worn away.
Esker	Serpentine ridges of gravel and sand taken to mark channels in glaciers through which streams washed finer material, leaving the coarser gravel.
Eustatic	Of or pertaining to worldwide sea level.
Eutrophic	Generally used in reference to a shallow body of water, rich in dissolved nutrients, that has good primary production of vegetation.
Evaporite	A sedimentary rock deposited from aqueous solution as a result of extensive or total evaporation of the water.

Evapotranspiration	Loss of water from the soil both by evaporation and by transpiration from plants growing in the soil.
Expenditure	The act or process of paying out.
FAA	Federal Aviation Administration.
FEIS	Final Environmental Impact Statement.
FEMA	Federal Emergency Management Agency.
FHBM	Flood Hazard Boundary Map.
FHLB	Federal Home Loan Bank.
FHWA	Federal Highway Administration.
FIRM	Flood Insurance Rate Map.
FLPMA	Federal Land Policy and Management Act (of 1976).
FM	Factory Mutual (Approval Guide).
FNAL	Fermi National Accelerator Laboratory (Fermilab, located in Batavia, Illinois).
f.o.b.	Free on board.
FPPA	Farmland Protection Policy Act.
FR	Federal Register. A document published daily that summarizes the actions of Congress and proposed actions of Federal Agencies.
FTE	Full-Time Equivalent.
FY	Fiscal Year.
Fahrenheit	The thermometric scale in the English system in which the unit of measure is defined as degrees Fahrenheit (abbr. ^{o}F). Under standard atmospheric pressure, the boiling point of water is at 212 degrees above the zero of the scale, and the freezing point of water is at 32 degrees above the zero of the scale. The zero point approximates the temperature produced by mixing equal quantities by weight of snow and common salt. At the time the scale was developed, this was the lowest temperature obtained.

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Fanglomerate	A rock formed by the cementing of deposited material in an alluvial fan.
Farmland of Statewide Importance	Land, in addition to prime and unique farmland, that is of statewide importance for the production of food, feed, fiber, forage, and oil-seed crops. Criteria for defining and delineating this land are determined by appropriate state agencies.
Fauna	The animal species characteristic of a region, time period, or special environment.
Fee Simple	A real estate transaction in which the purchaser receives the property without any limitations or restrictions.
Feldspar	A common rock-forming, aluminum-silicate mineral. Three end members occur: calcium rich (anorthite), sodium rich (albite), and potassium rich (microcline or orthoclase, depending on the structure). However, any composition between the calcium-rich and sodium-rich members and the sodium-rich and potassium-rich members can be found. The actual chemical composition found in a rock an indicates how the rock was formed and is used to classify it.
Fen	Swamp; low land covered wholly or partly with water.
Feral	Wild; not domesticated or cultivated.
Floodplain	That portion of a river valley that becomes covered with water when the river overflows its banks at flood stage.
Flora	The plant species characteristic of a region, time period, or special environment.
Forbs	Herbaceous plants that are not grass.
Friable	Easily crumbled (indicating the material is poorly cemented).
Fungal Spores	A primitive reproductive body produced by fungus.
GeV	Billion electron Volts.
GNP	Gross National Product.

GPE	General Purpose Equipment.
GPO	United States Government Printing Office.
GPP	General Purpose Plant (construction)
Gamma Rays	Electromagnetic radiation whose wave lengths are shorter than those of X-rays, and hence are of higher energy.
Gastropods	Snails; specifically, a class of the phylum Mollusca, which includes snails.
Gauss	The unit for magnetic field strength in the cgs system. The strength of the Earth's magnetic field at the land surface at the latitudes of the U.S. is approximately 1/2 gauss.
Geodetic	Related to the precise measurement of position on the surface of the earth.
Geology	The science that studies the earth, the rocks of which it is composed, and the changes that it has undergone or is undergoing.
Geomorphology	A branch of both physiography and geology that deals with the surficial form of the earth, the general configuration of its surface, and the changes that take place in the evolution of landforms.
Glacial	Pertaining to, characteristic of, produced by, deposited by, or derived from a glacier.
Granite	A light colored plutonic rock consisting essentially of sodium and/or potassium feldspar and quartz.
Gravitation	The weak but long range force that affects all matter but is manifested only in macroscopic objects. The force manifested by acceleration toward each other of two bodies. The force of gravity.
Gypsum	A hydrated calcium sulfate mineral with the composition $CaSO_4 \cdot H_2O$.
HEB	High Energy Booster (one of the synchrotrons in the injector of the SSC).
HEPAP	High Energy Physics Advisory Panel. This panel reviews U.S. high energy programs and makes

	recommendations to the DOE on matters of high energy physics policy.
HERA	Hadron Electron Ring Accelerator (at DESY).
HTM	Hazardous and Toxic Materials.
HUD	United States Department of Housing and Urban Development.
HVAC	Heating, Ventilating, and Air Conditioning.
HW	Hardware.
Habitat	Where a species lives.
Hadron	Subatomic particles that are composed of quarks and are affected by the strong force. Protons and neutrons are classified as hadrons.
Herbivore	A plant-eating animal.
Herpetofauna	Reptiles.
Holocene	The most recent epoch in the Quaternary Period in the history of the earth, estimated to be from approximately 11,000 years ago to and including the present time. The epoch is characterized as the time since the end of the last continental glaciation and the presence of continental glaciers and ice sheets.
Hornblende	A mineral; generally rod shaped and dark in color.
Hydraulic Conductivity	A measure of how fast water will flow through a rock. Defined as the volume of water that will move in a unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. The hydraulic conductivity is a basic property of the rock. The "transmissivity" is a derived property of an aquifer that depends both on the hydraulic conductivity and the thickness of the aquifer.
Hydraulic Gradient	The slope of the water table.
Hydric	Relating to or containing hydrogen.
Hydrology	The branch of earth science dealing with the properties, distribution, and circulation of water primarily on the land surface, in the

soil, and in the underlying rocks. Also a branch of engineering that studies the flow of fluids.

ICFA	International Committee on Future Accelerators.
ICRP	International Commission on Radiological Protection.
IDOC	Illinois Department of Conservation.
IDOT	Illinois Department of Transportation.
IEEE	Institute of Electrical & Electronics Engineers.
IFWIS	Illinois Fish and Wildlife Information System.
INEL	Idaho National Engineering Laboratory (Idaho Falls, Idaho).
ISC	Industry Supplied Components.
ISCST	Industrial Source Complex Short Term.
ISGS	Illinois State Geological Survey.
ISP	Invitation for Site Proposals. A DOE document requesting states to submit proposals for the siting of the SSC project. Issued April, 1987.
ISQ	Intrinsic Soil Quality.
ISR	Intersecting Storage Rings, specifically the CERN storage rings.
ISWS	Illinois State Water Survey.
Igneous	Referring to a rock formed from the solidificatiion of molten or partly molten material (magma), in contrast to sedimentary rock.
Important Farmland	Farmland classified as prime farmland, unique farmland, and additional farmland of statewide importance.
Indurated	A rock rendered hard due to heat, pressure, and/or cementation.
Infrastructure	The basic facilities, equipment, and installations supporting the function of a system.

In-migrate	To move into or come to live in a region or community; especially as part of a large-scale and continuing movement of population.
Interface	To serve as the place at which independent systems meet and act on or communicate with each other.
Invertebrate	Of or relating to animals lacking a backbone (spinal column).
Ion	An atom or molecule having an electric charge. The charge can be positive or negative. (see Ionization)
Ionization	The process of creating ions by adding or removing one or more electrons from atoms or molecules. (Ionization can be caused by high temperatures, electrical discharges, or radiation.)
Ionizing Radiation	Radiation with sufficient energy to produce ions in a material.
Isotope	Atoms (of the same element) having the identical number of protons in the nucleus, but a different number of neutrons. Isotopes have the same atomic number, but different atomic weight. Because of the slight difference in atomic weight, isotopes have slightly different chemical and physical properties. Different isotopes of the same element may exhibit significantly different radioactive behavior.
Javelina	A species of wild pig found in the desert southwest.
K	Degrees Kelvin. (see Kelvin)
keV	Kilo Electron Volts (1,000 electron volts).
Kame	A low, step-sided conical hill of stratified gravel or sand formed in contact with glacier ice.
Karst	A type of topography formed over limestone, dolomite, or gypsum rocks by dissolution of the rock by the percolation of rain water and/or the movement of groundwater. The terrain is characterized by closed depressions or sinkholes, caves, and underground drainage.

Kelvin	The thermometric scale on which the unit of measurement, defined as degrees Kelvin (abbr. K) equals the centigrade degree and according to which absolute zero is 0^oK, the equivalent of -273.16^oC.
Kettle	A depression in glacial drift made by the melting of a detached mass of glacier ice. The ice may have been either wholly or partly buried in the drift.
Kinetic Energy	The energy associated with the motion of any object.
Klaxon	An electronically operated horn or warning signal.
Klystron	An electron tube in which bunching of electrons is produced by electric fields; used for generating and amplifying ultra high frequency electric currents.
Kyanite	An aluminum-silicate mineral; a group of three aluminum-silicates with the same chemical composition but different structures. Occurring in metamorphic rocks, they are used to indicate the degree of metamorphism.
LANL	Los Alamos National Laboratory (located in Los Alamos, New Mexico).
LBL	Lawrence Berkeley Laboratory (located in Berkeley, California).
LCC	Life Cycle Cost.
L_{dn}	Day/Night Equivalent Sound Level; a single-number measure which expresses the magnitude of sound as a level obtained by averaging the energy equivalent of the A-weighted sound levels representative of specific area over a 24-hour period. Levels occurring after 10:00 p.m. and before 7:00 a.m. are weighted by adding 10 dB to account for increased human sensitivity to sound during normal sleeping hours. The value is expressed in dB (optionally in dBA). (After US EPA, 1971)
LEB	Low Energy Booster (one of the synchrotrons in the injector for the SSC).

LEP	Large Electron-Positron Collider (under construction at CERN).
LET	Linear Energy Transfer.
LHC	Large Hadron Collider. A collider proposed by CERN which would utilize the tunnel being built for LEP.
LINAC	Linear Accelerator. (see Linear Accelerator)
LLD	Lower Limit of Detection.
LLNL	Lawrence Livermore National Laboratory (located in Livermore, California).
LLRW	Low-Level Radioactive Waste.
LLWF	Low-Level (radioactive) Waste Facility.
LOS	Level of Service (the ratio of government employment in a particular sector to the total regional population. This term is also used to describe highway usage).
LSA	Low Specific Activity. A United States Department of Transportation classification for radioactive waste below a specific level of radioactivity.
Labor-hour	Equivalent to man-hour.
Lacustrine	Pertaining to, produced by, or formed in a lake or lakes.
Leachate	The solution formed after percolation through a material. The composition of the solution has changed due to the dissolution of soluble substances from the material.
Lentic	Of, relating to, or living in still waters such as lakes, ponds, or swamps.
Lepton	Current theory proposes leptons as any of six particles that experience the weak force but not the strong force. Known leptons include the electron, muon, tau, their three associated neutrinos (electron neutrino, muon neutrino, tau neutrino), and their corresponding antiparticle forms.

Linear Accelerator	An accelerator designed to accelerate electrically charged atomic and subatomic particles in a straight line. Particles are accelerated in one direction only and collide with a fixed target at the end of the path. (see Accelerator)
Limestone	A bedded sediment rock consisting chiefly of the calcium carbonate mineral, calcite ($CaCO_3$).
Lithology	The physical character of a rock.
Loess	A loose, sedimentary deposit consisting predominantly of silt and commonly of eolian origin.
Lotic	Of, relating to, or living in flowing waters such as rivers and streams.
Luminosity	A measure of the number of potentially interacting particles available in two colliding beams.
MAG	Maricopa Association of Governments (Arizona).
MCCOG/DD	Mid-Cumberland Council of Governments/Development District (Tennessee).
MCQWD	Morgan County Quality Water District (Colorado).
MDA	Minimum Detectable Activity.
MEB	Medium Energy Booster (one of the synchrotrons in the injector for the SSC).
MeV	Million or Mega Electron Volts (one million electron volts).
MI	Municipal and Industrial.
MILS	Minerals Industry Locations System.
MLM	Mound Laboratories - Monsanto (Ohio).
MOA	Memorandum of Agreement.
Marl	A calcareous clay or intimate mixture of clay with particles of calcite or dolomite, usually occurring as fragments of shells.

Marsh — A shallow, stagnant body of water. In the temperate zone, marshes are filled with rushes and reeds.

Mass — The material equivalent of energy. Different from weight in that it neither increases nor decreases with gravitational force.

Maxwell — The unit for electromagnetic flux in the cgs (centimeter-gram-second) measuring system. A Maxwell is equal to the flux per square centimeter of normal cross section in a region where the magnetic field strength is 1 gauss.

Median — The middle value of a set of data ordered by magnitude.

Mesic — Characterized by a moderate amount of moisture.

Meson — A class of short-lived composite particles that have a mass between that of the electron and a proton. Mesons are commonly produced as secondary particles by the collision between cosmic rays and atoms in the atmosphere and in collisions produced by accelerators.

Mesozoic — The era in the history of the earth known as the "age of the dinosaurs." The era is estimated to be from approximately 230 to 65 million years ago. Three periods are identified in the Mesozoic. The earliest is the Triassic (230 to 185 million years ago); the middle period is the Jurassic (185 to 140 million years ago); the final period is the Cretaceous (140 to 65 million years ago). Dinosaurs first appeared in the Triassic, and they became extinct at the end of the Cretaceous.

Metamorphic — Referring to rocks that have been altered in composition, texture, or internal structure as a result of increased pressure, temperature, or introduction of new chemical substances.

Metavolcanics — Metamorphosed volcanic rocks; volcanic rocks that have been altered as a result of increased pressure, temperature, or introduction of new chemical substances.

Meteorology — The science that deals with the atmosphere and its phenomena, especially with weather forecasting.

Metric	Of or relating to the metric system.
Metric System	The system of measurement based on the meter as a unit of length. The gram and the kilogram (1000 grams) are units of weight, and the liter is a unit of volume (equal to 1/1000 of a cubic meter).
Mica	A mineral group with a flat, platelike structure.
Micaceous	Containing mica minerals.
Microbial	Relating to microscopic, living organisms.
Millirem	One-thousandth of a rem.
Mississippian	A period of the Paleozoic Era in the history of the earth, estimated to be from approximately 350 to 310 million years ago. The period is characterized by the abundance on land of simple plants and early trees that have been fossilized as thick beds of coal in the United States.
Mitigate	To reduce an impact to make less severe or painful.
Mitigation	Methods used to reduce the significance of or eliminate an anticipated adverse environmental impact.
MKS System	Meter-Kilogram-Second System. A system of units based on the meter as the unit of length, the kilogram as the unit of mass, and the mean solar second as the unit of time. A subset of the metric system. (see Metric System)
Molecule	The smallest unit of a compound having the chemical and physical characteristics of the compound; the smallest combination of atoms that will form a given chemical compound. A molecule consists of two or more atoms and has properties that differ from those of the individual atoms.
Mollusca	The phylum that includes the classes gastropods (snails), pelecypods (clams), and cephalopods (squids and octopi).
Mollusk	Clam; specifically, a member of the Mollusca.
Monochromatic	Radiation having a single wavelength on energy.

Moraine	Glacial drift having the form of a ridge, deposited around the perimeter of a glacier.
Morphology	A branch of biology that deals with the form and structure of animals and plants.
Muon	An unstable lepton that has the same charge as an electron but 207 times the mass. At rest, it decays in seconds into an electron and a neutrino.
NAAQS	National Ambient Air Quality Standard.
NAS/NAE	National Academy of Science/National Academy of Engineering.
NCALG	Northern Colorado Association of Local Governments.
NCRP	National Council on Radiation Protection and Measurements.
NCTCOG	North Central Texas Council of Governments.
NEPA	National Environmental Policy Act.
NEPA Review	A formal review process required of certain federal and federally funded projects that involves the identification and analysis of potential environmental impacts and mitigation measures made pursuant to the NEPA.
NERC	National Energy Reliability Council.
NFPA	National Fire Protection Association.
NIOSH	National Institute for Occupational Safety and Health.
NIPC	Northern Illinois Planning Commission.
NPDES	National Pollutant Discharge Elimination System.
NPL	National Priorities List. A list that is part of CERCLA ("Superfund"), which ranks hazardous waste sites.
NRC	United States Nuclear Regulatory Commission.
Natural Radioactivity	Radioactivity exhibited by naturally occurring radionuclides. (There are more than 50 naturally occurring radionuclides.)

Nautiloid	An animal in the class Cephalopod. Nautiloids look like a squid or octopus in a conical shell. The shell has a series of chambers and can be either straight or coiled.
Neutrino	Any of three uncharged, apparently massless leptons, each associated with one of the charged leptons (electron, muon, tau).
Neutron	An uncharged particle found in all atomic nuclei except that of ordinary hydrogen. The mass of a neutron is almost identical to that of a proton. The neutron was previously believed to be an elementary particle, but current theory and experimental evidence indicates the neutron is composed of quarks.
Neutron Skyshine	Neutron radiation emerging more or less vertically from a shielded enclosure and scattering from air molecules to produce radiation seen at ground level locations that are not along the line of sight.
Nuclei	Plural of nucleus.
Nucleon	A proton or neutron; especially in the atomic nucleus.
Nucleus	The dense, central core of an atom, composed of protons and neutrons and held together by the strong force.
Nuclide	Generally used to refer to atoms of a specific isotope.
ORNL	Oak Ridge National Laboratory (Oak Ridge, Tennessee).
OSHA	Occupational Safety and Health Administration.
OSWER	Office of Solid Waste and Emergency Response (of the United States Environmental Protection Agency).
Omnivores	Those animals consuming both animal and plant food.
Ordovician	A period in the Paleozoic Era in the history of the earth estimated to be from approximately 490 to 420 million years ago. The period is characterized by an abundance of marine life with calcareous shells. The shells are

	preserved as fossils in thick accumulations of limestone rock.
Ostracods	Tiny, bivalve animals found in both marine and freshwater environments.
Overdraft	In hydrology, to remove more groundwater (by pumping) than is being replaced by natural processes. The result is generally a decline in the water table.
PBX	Private Automatic Branch Exchange.
PEC	Provident Energy Company.
PEL	Permissible Exposure Limit.
PEP	Positron-Electron Project. A collider for positrons and electrons added at the end of the SLAC LINAC.
PET	Positron-Emission Tomography.
PL	Public Law.
PPV	Peak Particle Velocity.
PSAR	Preliminary Safety Analysis Report.
PSD	Prevention of Significant (Air Quality) Deterioration.
PUD	Planned Unit Development.
PVNGS	Palo Verde Nuclear Generating Station.
Paleontology	A branch of geology that studies the plants and animals in past geological ages. It is based on the study of the fossil remains of organisms.
Palustrine	Pertaining to material deposited in a swamp environment.
Parcel	A tract or plot of land with a recorded title.
Parent	In radioactive decay, the initial, unstable nuclide; in particle physics, the initial nuclide or particle.
Pedogenesis	The formation and development of soil.

Pelecypods — Clams. Specifically, a class of bivalve mollusks in the Mollusca phylum.

Pennsylvanian — A period of the Paleozoic Era in the history of the earth, estimated to be from approximately 310 to 275 million years ago. The period is characterized by the abundance on land of plants and trees on land that have been fossilized as thick beds of coal in the United States.

Percolate — To pass or move through fine interstices; to filter.

Period — A division of geologic time; a subdivision of the era.

Permeability — A measure of the capacity of a material to transmit a fluid.

Photon — A particle of light (a quantum of electromagnetic radiation). Current physical theory views electromagnetic radiation as having the characteristics of either a wave or a particle, depending upon the measurement being made.

Phylum — One of the primary divisions of the animal and plant kingdom; a group of closely related classes of animals and plants. ("Class" is the next lower division.)

Physiography — The study of the genesis and evolution of land forms. Physical geography.

Piedmont — Lying or formed at the base of mountains; the area at the base of mountains.

Piezometer — An instrument or device for measuring pressure, pressure change, or compressibility; especially one for measuring the hydrostatic pressure in a body of groundwater.

Pleistocene — The epoch in the history of the earth estimated to be from approximately 600,000 to 11,000 years ago. The earlier of two epochs in the Quaternary Period, the Pleistocene is characterized by the presence of continental glaciers and ice sheets covering large portions of North America and Europe. The Ice Age.

Pluton — A large body of once molten rock that formed beneath the surface of the earth.

Porosity — The ratio of the volume of openings in a rock to the total volume of the rock.

Potable — Water suitable for drinking.

Prairie — Widespread areas of grasslands, with a predominance of grass species and forbs.

Precambrian — The era in the age of the earth from the formation of the planet to the appearance of abundant animal life having hard shells. Estimated to be from approximately 4,600 million to 600 million years ago.

Predator — An animal that preys on other animals for food.

Prey — A animal taken by a predator as food.

Prime Farmland — Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses (urban areas are not included). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods.

Progeny — Radionuclide decay product. (see Daughter)

Proterozoic — A proposed separation of the Precambrian Era into two new eras. The Proterozoic Era is that portion of the history of the earth from the first evidence of simple forms of life to the appearance of abundant animal life having hard shells at the beginning of the Cambrian Period of the Paleozoic Era.

Proton — A positively charged particle found in all atomic nuclei. The proton was previously believed to be an elementary particle, but current theory and experimental evidence indicate the proton is composed of quarks.

Pyrite — Iron pyrite, an iron and sulfur mineral with the composition FeS_2. When removed from the ground and exposed to the atmosphere, the sulfur oxidizes to sulfate. Percolating rainwater will extract the sulfate, resulting in an acid leachate that can contaminate water supplies.

Quadrupole	A system composed of two dipoles of equal but opposite directed moment. In accelerators, quadrupole magnets are used to focus beams of particles (in the same way a lens focuses light).
Quantum	A small division or "particle" of electromagnetic radiation. The quantum theory in physics is based on the concept that electromagnetic radiation can be divided into finite quantities (quantum).
Quarks	Subatomic particles that experience the strong force and make up hadrons (protons, neutrons). Current theory proposes there are six quarks (and six corresponding antiparticles), but that quarks appear to exist only in combinations of two or three.
Quaternary	The period in the age of the earth estimated to be from approximately 600,000 years ago to the present. The Period is characterized (and defined) by the presence of continental glaciers covering a large portion of North America and Europe. The Ice Age. The period is divided into two epochs, the Pleistocene and the Holocene.
Quench	To put out, extinguish; to cool quickly. In superconducting magnets, the process whereby the entire magnet is brought quickly from the superconducting state to the normal state; when any element of the superconducting coil undergoes such a transition.
RADRISK	A computer code.
RADTRAN III	An analytical computer code for calculating both the incident-free and accident impacts of transporting radioactive material.
RCRA	The Resource Conservation and Recovery Act. RCRA gives the Federal goverment power to regulate hazardous waste from the time it is generated to its ultimate disposal, in effect from "cradle to grave." In addition, RCRA regulates non-hazardous solid waste (e.g., garbage, ash from municipal incinerators) and certain underground storage tanks.

RDS	The SSC Reference Designs Study (of 1984).
RF	Radiofrequency.
RHTM	Radioactive, Hazardous and Toxic Material.
RMF	Radiation Measurements Facility.
ROD	Record of Decision.
ROI	Region of Influence. The region that would be influenced directly or indirectly by an action. (The ROI for each site alternative is defined in Chapter 5.)
RQD	Rock Quality Designation.
RTK	An AE/CM consortium currently working with the CDG and DOE on the preparation of the SSC EIS. The consortium consists of Kaiser Engineers Inc. (previously Raymond Kaiser Engineers), Tudor Engineering Co., and Keller and Gannon-Knight.
Rad	The unit of absorbed (radiation) dose is equal to 100 ergs/gram in any medium.
Radiation	Originally, the emission of fast atomic and subatomic particles or rays (photons) from the nucleus of radionuclides during radioactive decay. Now includes all energy radiated in the form of waves (photons) or particles.
Radioactive Decay	The spontaneous transformation of an unstable nuclide to another nuclide (stable or unstable) as a result of the emission of charged particles from the nucleus.
Radioactivity	The property shown by some isotopes of elements to undergo radioactive decay.
Radionuclide	An unstable isotope that will undergo radioactive decay; referring to the specific atoms of the isotope.
Radon	A naturally occurring radioactive, gaseous element formed by the disintegration of radium; part of the uranium decay series.
Raptor	A bird of prey (hawk, eagle, etc.).
Reconnaissance	A preliminary survey to gain information.

Relativistic Mass Increase	Einstein's Theory of Relativity predicted and experiments have demonstrated that as a body with mass approaches the speed of light, the mass of the body increases.
Relict Population	A species or biological community that once occupied a wider range but is presently restricted to a small portion of its previous range as a result of physical changes in environmental conditions.
Rem	A special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by a number of modifying factors that account for the type of radiation, the portion of the body, and other necessary factors.
Retardation	The process in which material dissolved in groundwater is temporarily removed from solution by interaction with the sediments. The time out of solution delays (retards) the movement of the material compared with the movement of the groundwater.
Riparian	Relating to, living, or located on the banks of a natural water course such as a river, in an environment that is at least periodically flooded.
SAR	Safety Analysis Report.
SCADA	Supervisory Control and Data Acquisition.
SHPO	State Historic Preservation Officer.
SIC	Standard Industrial Classification.
SLAC	Stanford Linear Accelerator Center. SLAC is located in Palo Alto, California, and is operated by Stanford University for the DOE. SLAC operates the world's largest linear accelerator (2 miles long), the Positron-Electron Project (PEP), and the SLAC Linear Collider (SLC). (see Linear Accelerator, PEP, SLC)
SLC	SLAC Linear Collider. The SLC is a "single pass" collider added to the end of the SLAC LINAC. Instead of a continuous ring, the SLC consists of two half rings. Positrons and electrons accelerated by the LINAC are separated upon entering the SLC and are

directed to either half ring. The particles are steered through the half rings until they collide at the far side, where the two half rings meet. Unlike synchrotrons and colliders, where particles orbit many times, the SLC is a single pass device. (see Collider, Linear Accelerator, SLAC, Synchrotron).

SLD	Stanford Linear (Collider) Detector.
SPS	Super Proton Synchrotron. The largest currently operating synchrotron at CERN. (see CERN, Synchrotron)
SRD	SSC Safety Review Document.
SSC	Superconducting Super Collider.
STF	Site Task Force.
Sandstone	A sedimentary rock formed from cemented quartz sand grains.
Saprolite	Thoroughly decomposed rock with a soft, clay-rich texture formed in place by chemical weathering of bedrock.
Saturated Zone	The subsurface zone in which all pore space or other openings are filled with water.
Savanna	A tract of level land supporting grass and other low vegetation. Sometimes applied to tracts of open prairie land.
Scenario	An account or synopsis of a projected course of action or events.
Schist	A medium- to coarse-grained metamorphic rock with subparallel orientation of the micaceous minerals that dominate its composition.
Sedimentary	Referring to rocks formed by the accumulation of sediments in water (aqueous deposits) or in air (eolian deposits).
Seismic	Pertaining to an earthquake or earth vibrations, including vibrations that are artificially induced.
Sere	The complete series of changes occurring in the cycle of plant formation.

Shale	A laminated, fine-grained, cemented sedimentary rock. Particles are predominantly of clay size. Includes both claystone and siltstone.
Siltstone	A cemented sedimentary rock consisting of predominantly silt sized particles. (see Shale)
Sinkhole	A dish-, funnel-, or well-shaped depression in the land surface developed by the solution of the underlying rock. Generally found in a region underlain by limestone bedrock, the sinkhole will communicate with subterranean passages also developed by solution of the rock. (see Karst)
Socioeconomic	Of, relating to, or involving a combination of social and economic factors.
Solicitation	The request for site proposals.
Solifluction	The process of slow flowage from higher to lower ground of a mass of loose material saturated with water. A common process in regions of perennial frost.
Spoils	Earthen material removed from an excavation and not used for aggregate, backfill, or other construction purposes.
Spore	See Fungal Spores.
Storativity	The amount of water released by an aquifer as a result of a decrease in pressure. Specifically defined as the volume of water that an aquifer releases from storage per unit surface area of aquifer per unit decline in the component of hydraulic head normal to that surface.
Strata	Plural of stratum.
Stratified Fee	A real estate transaction in which the purchaser receives the ownership of a volume of ground between two depths. The original owner retains the rights to the surface, down to the top of the volume of ground, and probably any mineral rights below the volume of ground.
Stratigraphy	The branch of geology that studies the formation, composition, sequence, and correlation of the stratified rocks as parts of the earth's crust.

Stratum	A section of a layered geologic formation that consists throughout of approximately the same kind of rock material; a single sedimentary bed or layer, regardless of thickness.
Subatomic Particle	A particle smaller than the size of an atom.
Substrate	Forming or relating to a substratum.
Substratum	A part, substance, or element that lies beneath and supports another. In biology, the medium upon which an organism grows.
Subterranean	Being or lying under the surface of the earth.
Superconducting	The ability of some materials to maintain perpetual electric currents without loss, owing to the complete absence of electrical resistance. The property was initially discovered at very low temperatures approaching absolute zero.
Swale	A slight, marshy depression in generally level land.
Swallet	A dish-, funnel-, or well-shaped depression that communicates with the underground drainage system in limestone regions. Synonymous with swallow hole, sinkhole, and sink. (see Sinkhole, Karst)
Swelling Clay	A type of clay mineral that easily incorporates water into its structure, resulting in a significant increase in volume. The process is easily reversible. The significance is that when a deposit of swelling clay loses water, large cracks can form in the material.
Symbiosis	Co-existence of two or more organisms in a close association that is mutually beneficial.
Synchrocyclotron	A cyclotron that compensates for the relativistic mass increase of particles as they reach high energy by adjusting the radiofrequency to account for the slower revolutions of the heavier particles. (see Cyclotron, relativistic mass increase)
Synchrotron	An accelerator constructed in the shape of a circle or oval. The path of the particles is controlled by magnetic fields while kinetic energy is imparted to the particles by radiowaves with variable frequencies. The

charged particles "orbit" inside the accelerator until used. Additional kinetic energy can be continually imparted to the particles, obtaining higher energies than available with a linear accelerator, cyclotron or synchrocyclotron.

TBM	Tunnel Boring Machine.
TDS	Total Dissolved Solids. The quantity of material dissolved in a water sample.
TENR	Technologically Enhanced Natural Radiation. A term used by the DOE to refer to the increase in background radiation from natural radioactive materials as a result of man-made changes in the environment. Generally used to refer to spoils material excavated during mining operations, particularly uranium mill tailings. Removal of the material from the ground (with possible physical and/or chemical concentration) increases the exposure to radiation at the surface without changing the total quantity of radioactive material present.
TeV	Trillion Electron Volts.
TFR	Task Force of Radioactivation (for the SSC).
TIG	Tungsten Inert Gas.
TLD	Thermoluminescent Dosimetry or Dosimeter.
TLV	Threshold Limit Values.
TNRLC	Texas National Research Laboratory Commission.
TSD	Treatment, Storage, and Disposal of hazardous materials (as in a TSD facility). A term from RCRA.
TSP	Total Suspended Particulate. The amount of material suspended (not dissolved) in a water sample.
TVA	Tennessee Valley Authority (Knoxville, Tennessee).
Tau	An unstable lepton that has the same charge as an electron but a much greater mass. It decays at rest in seconds into an electron and a neutrino.

Technical Components	The major technical (scientific) systems and/or components that comprise the SSC collider and injection accelerators (as opposed to conventional facilities).
Tectonic	Of, pertaining to, or designating the rock structures and external forms resulting from the deformation of the earth's crust.
Terrestrial	Consisting of or pertaining to the land.
Tesla	The unit of magnetic field strength in the mks system; equal to 10,000 gauss (T).
Tevatron	The 1-TeV synchrotron at Fermilab (Batavia, Illinois).
Thermic	Of, relating to, utilizing, producing, or caused by heat.
Threatened Species	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
Till	Nonsorted, unstratified sediments carried or deposited by a glacier.
Topography	The configuration of a surface including its relief and the position of its natural and man-made features.
Torr	A unit of pressure equal to 1/760 of atmospheric pressure.
Transformer	An electrical device used to change the voltage and current in one electric circuit to a different voltage and current in another circuit.
Transmissivity	A measure of the ease with which water will flow through the entire saturated thickness of an aquifer. Specifically defined as the product of the hydraulic conductivity of the aquifer material, and the thickness of the aquifer.
Tuff	A rock formed from fine (generally smaller than 0.4 centimeters in diameter) volcanic material.
UA1	Underground Area 1 (at CERN).
UA2	Underground Area 2 (at CERN).

UBC	Uniform Building Code.
UL	Underwriters Laboratory.
UNAMAP	User's Network for Applied Modeling of Air Pollution.
URA	Universities Research Association.
USC	United States Code.
USSC	United States Soil Conservation Service.
USFWS	United States Fish and Wildlife Service.
USGS	United States Geological Survey.
Unconfined Aquifer	An aquifer in which the water table forms the upper boundary.
Unique Farmland	Land other than prime farmland that is used for the production of specific high value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods.
Unsaturated Zone	The subsurface zone, usually starting at the land surface, where the pore spaces and other openings contain both water and air.
VMT	Vehicle Miles Travelled.
VRM	Visual Resource Management.
Vadose	Similar in definition to the "unsaturated zone". The vadose zone, however, may also contain discontinuous saturated bodies of perched water.
Viewshed	The area between major ridgelines, coinciding with watershed boundaries.
WBS	Work Breakdown Structure.
WL	Working Level. The specific activity of radon or individual radon decay product isotopes can be measured in picocuries per liter (pCi/l). However, the specific activity of short-lived radon decay products collectively is also measured in units called working levels (WL).

One working level is defined as the quantity of short-lived decay products that have the potential to release 130 billion electron volts of alpha particle energy per liter of air.

WSA	Wilderness Study Area. An area being considered for inclusion as a Wilderness under the National Wilderness System. (see Wilderness)
Water Table	The upper surface of the saturated zone.
Watershed	A region or area where all water drains ultimate to a particular body of water or watercourse.
Weak Force	An extremely short-range force that affects all quarks and leptons. The weak force is responsible for most radioactive decay processes and for the decay of many short-lived particles.
Wetland	Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly aquatic plants; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non soil and is saturated with water or covered by shallow water at some time during the growing season each year.
Wilderness	A tract of land, usually in excess of 5,000 acres, that has been designated by Congress as part of the National Wilderness System under the Wilderness Act.
Wild and Scenic River	A portion of a river that has been designated by Congress as part of the National Wild and Scenic River Act.
Xeric	Requiring only a small amount of moisture.
Xeroriparian	Relating to, living, or located on the banks of a dry wash (in a desert environment). The dry wash receives sufficient additional moisture to support a different plant community than the surrounding desert.

X-Rays

Electromagnetic radiation whose wave lengths are shorter than those of visible light, and hence of higher energy, but less than that of Gamma-rays.

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