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Briefing Report to the Honorable Dennis DeConcini, U.S. Senate

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FEDERAL RESEARCH

Final Site Selection Process for DOE's Super Collider

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GAO

United States
General Accounting Office
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Resources, Community, and
Economic Development Division

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June 16, 1989

The Honorable Dennis DeConcini
United States Senate

Dear Senator DeConcini:

This report responds to your November 10, 1988, request on behalf of yourself and Senators Dixon, Levin, Riegle, Simon, and Wirth, concerning the Department of Energy's (DOE) site selection process for the superconducting super collider, a $4.4 billion (in fiscal year 1988 dollars) high-energy physics facility. In January 1989 the Secretary of Energy selected Texas as the site for the super collider from among seven best qualified states. As agreed with your office, we are providing information on whether the DOE site task force (1) verified data that states submitted and considered the changes made to the draft environmental impact statement in its ratings of the sites against the DOE technical criteria, (2) gave evidence to support its technical evaluation of each site, and (3) considered environmental and geological concerns raised by two Texas residents.

In summary, we found the following:

- The task force relied on information provided by the states and verified data primarily through its site visits to the seven best qualified sites and the environmental impact statement process. Although the task force assessed public comments on the draft environmental impact statement and determined that none sufficiently justified changing any of its ratings for the technical evaluation criteria and subcriteria, we noted that the task force probably would have had to conduct additional field studies to determine the impact of a potentially significant environmental issue at the Tennessee site.
- Our limited analysis provided us no reason to question the decision to site the super collider in Texas. In evaluating and rating the sites, the task force used DOE's technical and cost criteria and provided evidence to support its ratings. However, the task force did not provide sufficient documentation for us to (1) resolve an apparent inconsistency between its rating of Illinois as outstanding for the geology and tunneling criterion and its estimate that Illinois would have the second highest underground construction costs and (2) determine the appropriateness of its use of a weakest-link theory to evaluate the electrical power subcriterion.

- DOE and its contractors assessed the three concerns identified by Texas residents as part of the site evaluation and environmental impact statement processes and determined that these concerns were not serious problems. DOE officials noted that each of these concerns will be analyzed in more detail as part of the preparation for construction at the Texas site.

The Site Evaluation Process

The DOE task force evaluated and rated each of the seven best qualified sites on the basis of information that the states provided. The task force verified this data through 4-day visits to each site, discussions and correspondence with officials from federal, state, and local governments, public utilities, and other organizations; and information obtained from the environmental impact statement process.

While officials representing the seven sites generally were satisfied with DOE's overall process for gathering and verifying data, officials of four states expressed concern about the timing of the site evaluations in relation to the environmental impact statement process. DOE task force members acknowledged that the final environmental impact statement changed the assessment of potential impacts in some significant areas for several states. However, according to task force members, although additional environmental data were collected after the task force initially evaluated and rated the technical criteria for the sites, the task force subsequently examined these data and the revised assessments of the potential environmental impact for each site and concluded that they did not justify changing any criteria or subcriteria ratings.

Task force members and contractor personnel stated that the most significant new information they received through the comments process was about the network of underground caves that are located in the northern part of the Tennessee site. This information raised questions about the super collider's environmental impact because little is known about the location of the caves or whether they are sensitive habitat for any threatened or endangered species. While the task force decided not to change any of its ratings for Tennessee on the basis of this information, some task force members and contractor personnel expressed concern that the caves could pose greater environmental and construction problems than expected at the Tennessee site.

The Task Force's Evaluation of the Sites

Our limited analysis provided us no reason to question the decision to site the super collider in Texas. The task force evaluated and rated the proposed sites in accordance with DOE's technical and cost criteria and provided evidence to support its ratings. In addition, the chairman of the National Academy of Sciences and National Academy of Engineering committee that identified the best qualified sites stated that Texas was a very good site and he found no glaring inconsistencies between the task force's and his committee's evaluations of the sites.

The task force did not provide sufficient documentation for us to resolve the following:

- The task force rated Illinois outstanding overall for the geology and tunneling criterion even though its life-cycle cost estimates for the seven sites showed that Illinois was the second most costly site for underground construction and substantially more costly than three other sites that had lower ratings. Geologists associated with the site selection process stated that the geology and tunneling criterion reflected practical concerns about construction costs, schedule delays, and risks associated with uncertainties. The chairman of the task force's geology and tunneling subcommittee stated that Illinois' higher costs reflected costs associated mainly with deeper tunnel shafts that would pass through water-bearing rock rather than with tunnel construction. He also noted that the cost estimate did not consider contingency factors for each site, which for Illinois would be minimal because of its excellent geological database.
- To evaluate the electrical power subcriterion, the task force used a weakest-link theory, which maintained that the quality of the sites' power service was only as good as the weakest link in the electrical power factors that the task force considered. This resulted in a rating of good for all of the sites. Alternatively, as it did with the other technical criteria and subcriteria, the task force could have weighted the electrical power factors and differentiated between sites on the basis of its ratings for the more important factors.

Concerns of Residents Near the Texas Site

Two residents living near the Texas site identified concerns about the hazards posed by fire ants, the reliability of Texas' geological data, and the potential hazard to nearby residents from increased levels of radiation exposure. DOE and contractor officials told us that they had considered these issues and had not identified any significant problems. They noted, however, that DOE will examine these issues further both in the supplemental environmental impact statement and as DOE does more

corehole drilling to better characterize the geology of the Texas site. In addition, according to representatives of four power utilities that service fire ant-infested areas in the southern United States, fire ants have not caused any major power outages in their systems and they consider fire ants a nuisance rather than a serious hazard to their companies' workers and electrical power supply.

Scope and Methodology

As agreed with your office, we did not conduct an independent technical evaluation of the seven best qualified sites against DOE's technical and cost criteria, nor did we verify the accuracy and completeness of data the task force and its contractors evaluated. To provide information on the task force's site evaluation process, we interviewed senior state officials responsible for each of the seven best qualified proposals to identify potential problems with the process and DOE's site evaluations. We then reviewed the task force's supporting documentation and interviewed the site task force members, DOE technical advisers, and contractor personnel to (1) ascertain how the task force gathered and verified information and evaluated the sites, (2) identify the bases for the task force's technical evaluations, and (3) discuss the specific problems that state officials expressed about the timing of the site evaluations in relation to the environmental impact statement process.

We provided the DOE task force an opportunity to comment on a draft of this briefing report, and made appropriate changes. However, as requested by your office, we did not obtain official agency comments on this report. Section 1 of this report provides an introduction to the site selection process and additional details on our objectives, scope, and methodology. Section 2 discusses the task force's process for evaluating the proposed sites. Section 3 highlights the bases for the task force's evaluations and ratings of each site against six technical criteria and the estimated cost to construct and operate the super collider at each site. Appendix I lists a chronology of events leading to the selection of Texas as the super collider site, and appendix II lists major contributors to this report.

We are sending copies of this briefing report to Senators Dixon, Levin, Riegle, Simon, and Wirth, the Secretary of Energy, and other interested parties. Copies will also be made available to others upon request. If you have any further questions, please contact me at (202) 275-1441.

Sincerely yours,

Keith O. Fultz
Director, Energy Issues

Contents

Abbreviations

BLM	Bureau of Land Management
DOE	Department of Energy
EIS	environmental impact statement
NAE	National Academy of Engineering
NAS	National Academy of Sciences
RTK	joint venture of Raymond Kaiser Engineers, Inc.; Tudor Engineering Company; and Keller & Gannon Knight
SSC	superconducting super collider
TVA	Tennessee Valley Authority

Introduction

The Department of Energy's (DOE) proposed superconducting super collider (SSC) will be the largest high-energy physics accelerator in the world. The SSC, designed to provide insight into the fundamental components of matter and the physical laws of the universe, is estimated by DOE to cost $4.4 billion (in fiscal year 1988 dollars). President Reagan submitted the proposal to construct the SSC to the Congress in January 1987. The Congress has appropriated funds for SSC research and development costs, including $100 million in fiscal year 1989, but has not appropriated funds for SSC construction.

The Site Selection Process

In April 1987 DOE issued an invitation for site proposals, which described the SSC facility, the site selection criteria, and DOE's process and time frames for evaluating the site proposals. The invitation identified five minimum qualification criteria that proposals were required to meet. It also listed six technical evaluation criteria, in the order of their importance, against which the proposals would be evaluated. In addition, the invitation stated that cost considerations were important and would be used in conjunction with the technical criteria in selecting the final site, although primary emphasis would be placed on the technical criteria.

DOE received 43 site proposals by its September 2, 1987, deadline. DOE's SSC site task force reviewed these proposals and determined that 36 met the invitation's minimum qualification criteria. DOE then transmitted the 36 proposals to a site evaluation committee established by the National Academy of Sciences (NAS) and National Academy of Engineering (NAE) to identify the best qualified sites.

On the basis of its evaluation of the site proposals against the invitation's technical and cost criteria, the NAS/NAE committee determined in November 1987 that eight were the best qualified.[1] New York State subsequently withdrew its Rochester proposal from further consideration on January 15, 1988. The Secretary of Energy announced his acceptance of the seven remaining sites as best qualified on January 19, 1988. These sites were Arizona (Maricopa), Colorado (Denver), Illinois (Fermilab), Michigan (Stockbridge), North Carolina (Raleigh-Durham), Tennessee (Nashville), and Texas (Dallas-Fort Worth).

[1]Our report, Federal Research: Determination of the Best Qualified Sites for DOE's Super Collider (GAO/RCED-89-18, Jan. 30, 1989), assesses the selection of the best qualified sites.

The process of evaluating the seven best qualified sites for the final SSC site selection consisted of (1) the DOE site task force's evaluation of the seven best qualified sites against the technical and cost criteria, (2) issuance of the draft and final environmental impact statements (EIS) for the SSC, and (3) presentations to the Secretary of Energy by state officials representing each site. (See app. I for a chronology of events leading to the selection of the SSC site.)

The DOE site task force comprised 10 members who were chosen for their experience in high-energy physics, accelerator design, construction and operation management of DOE scientific facilities, procurement, real estate acquisition, civil engineering, and environment. To evaluate the sites, the task force formed a subcommittee for each criterion, which consisted of task force members and other DOE personnel who provided technical expertise.

The task force also was assisted by several contractors. RTK (a joint venture of Raymond Kaiser Engineers, Inc.; Tudor Engineering Company; and Keller & Gannon Knight) developed life-cycle cost estimates for each site and prepared the draft EIS and final EIS. RTK was assisted by Earth Technologies, Inc., in geotechnical analysis and by members of the SSC Central Design Group, which had developed the conceptual design for the SSC. In addition, Exeter Associates, Inc., assessed electrical power costs and C.H. Geurnsey & Company assessed electrical power services for each site. In September 1988 DOE contracted with Argonne National Laboratory, a DOE contractor-operated laboratory located in Argonne, Illinois, to conduct field verification studies at each site to assess (1) whether suitable habitat existed for endangered or threatened species and (2) the quantity and quality of wetlands that potentially would be affected.

While the DOE task force members gathered and assessed data to evaluate the seven sites, RTK developed the draft EIS for the SSC, which assessed environmental impacts for each site. DOE held scoping hearings at each site in February 1988, and an RTK team visited each site during February and March 1988. RTK completed a preliminary EIS in June 1988. DOE issued the draft EIS in August 1988, and the Environmental Protection Agency announced the draft EIS' availability on September 2, 1988, which started a 45-day comment period that closed on October 17, 1988. DOE held public hearings on the draft EIS at each site between September 26 and October 6.

Task force members stated that they evaluated the sites against the technical criteria and subcriteria on the basis of (1) information provided in the original site proposal and supplemental information that the states submitted in March 1988, (2) the draft EIS, (3) 4-day visits to each of the sites and the states' written responses to any follow-up questions, (4) verification of states' information by contacting officials in federal and state agencies and other organizations, and (5) Exeter's utility report and RTK's life-cycle cost estimates for construction and 25-year operations for each site. Each subcommittee rated the sites against a criterion and component subcriteria and drafted its report during August and early September 1988. The task force and its DOE technical advisers met in Frederick, Maryland, from September 18 to 23, 1988, and developed consensus ratings on the technical criteria and subcriteria for each site.

In early October 1988, senior state officials made oral presentations of their site proposals to the Secretary of Energy and other high-ranking DOE officials.

The task force met on October 31, 1988, to assess public comments on the draft EIS and issued a summary review of the comments on November 3, 1988. The summary review stated that on the basis of members' review of over 3,000 of the 7,179 comments and RTK's summary of all of the comments, the task force (1) believed that all major issues raised by the public and identified in Argonne's additional field studies had been appropriately considered and (2) found that none of this information would justify a change in its technical evaluation ratings or life-cycle cost estimates for the sites. The task force completed its site evaluation report, SSC Site Evaluations: A Report by the SSC Site Task Force, on November 4, 1988.

On November 8, 1988, the task force presented its evaluation of each site, but did not recommend a preferred site, to the Secretary of Energy and the Energy System Acquisition Advisory Board. On November 10, 1988, the Secretary announced that he had selected Texas as the preferred site for the SSC on the basis of the task force's site evaluations, the draft EIS, comments received on the draft EIS, and his meetings with the site proposers.

The notice of availability for the final EIS was published on December 16, 1988, after the task force formally responded to public comments on the draft EIS. No substantive comments were received on the final EIS during the 30-day comment period. On January 17, 1989, the task force

reviewed the final EIS and public comments on the final EIS and determined that new information about the potential environmental impacts at each site did not warrant changing any of its ratings for the technical criteria and subcriteria. The Secretary of Energy issued the record of decision that selected Texas as the site for the SSC on January 18, 1989.

Objectives, Scope, and Methodology

Senator Dennis DeConcini, on behalf of himself and Senators Dixon, Levin, Riegle, Simon, and Wirth, asked us to review the process for selecting the preferred site for the SSC to (1) ensure that the technical evaluation criteria were objective and appropriate and (2) determine whether the process was competitive and based on sound technical data. After initial discussions, Senator DeConcini's office also asked us to investigate how a Texas lobbyist obtained a copy of a DOE contractor's report on cost savings associated with Illinois' proposal to use the Fermi National Accelerator Laboratory's tevatron both as an accelerator and as the injector complex for the SSC. Subsequently, we also were asked to consider in our review letters from two Texas residents concerning the impact of fire ants in Texas on the SSC project, the reliability of the geological data Texas submitted in its SSC site proposal, and the potential effects of radiation on residents living near the site.

As agreed with Senator DeConcini's office, we are providing information on whether the DOE task force (1) verified data that states submitted and considered the changes made to the draft EIS in rating the sites against the DOE technical criteria, (2) gave evidence to support its technical evaluation of each site, and (3) considered environmental and geological concerns raised by Texas residents. Senator DeConcini's office agreed that an October 1988 report by the DOE Office of Inspector General sufficiently examined how the Texas lobbyist obtained the DOE contractor's report.

We did not conduct an independent technical evaluation of the seven best qualified sites against the technical and cost criteria. We also did not verify the accuracy and completeness of the data that the task force or its contractors evaluated. Rather, we assessed whether the general evaluation process and the bases for the task force's overall technical criteria ratings—and, therefore, the distinctions among sites—were consistent with the criteria established in DOE's invitation for site proposals.

We contacted senior state officials responsible for each of the seven proposals to identify potential problems and concerns with the site selection process and the task force's evaluation of the sites. We then reviewed

the invitation for site proposals, the subcommittees' technical evaluation reports, the task force's final report, the draft and final EIS, DOE correspondence, and contractors' reports. We interviewed the 10 site task force members, and we interviewed or talked with 11 DOE technical advisers and 10 personnel from RTK, Earth Technologies, the SSC Central Design Group, C.H. Guernsey and Company, and Argonne National Laboratory to (1) ascertain the process the task force followed to gather and verify information and evaluate the sites, (2) identify the bases for the task force's technical evaluations and ratings, including the sites' strengths and weaknesses, and (3) discuss the specific problems raised by the states.

Finally, to address the concerns mentioned in two Texas residents' letters, we interviewed task force members and RTK personnel to determine what they had done to assess the potential effects of fire ants and radiation exposure at the Texas site and the reliability of the geological data that Texas had submitted in its SSC proposal. We also spoke with technical personnel at four power utilities in fire ant-infested areas in the southern United States about their experiences with fire ants and the nature and extent of their problems.

We conducted our review between January 1989 and March 1989 in accordance with generally accepted government auditing standards.

The DOE Task Force's Process for Evaluating the Proposed Sites

Senior officials for the seven best qualified sites stated that they generally were satisfied with the DOE task force's process for gathering and verifying data. However, officials of four states expressed concern that the timing of the task force's technical evaluation in relation to the EIS process may have affected their sites' ratings. The task force rated the sites before the 45-day public comment period on the draft EIS was closed and before public hearings were held at each site. The state officials noted that, in response to public comments, the final EIS corrected factual errors and reduced the stated impact for some environmental factors for their sites. However, despite these changes, the DOE task force did not revise its ratings of the sites for any of the technical criteria or subcriteria in its subsequent reviews of comments on the draft EIS on October 31, 1988, and the final EIS on January 17, 1989.

DOE task force members and RTK officials acknowledged that the final EIS assessment changed for several states, particularly for the potential impacts on threatened and endangered species, wetlands, air quality, and prime farmland. Several task force members and RTK officials stated that the most important new information from the comments on the draft EIS indicated the presence of a more extensive network of caves in the northern section of the Tennessee site. However, little information was available on where the cave systems were located, how extensive they were, and whether they were sensitive habitat for any threatened or endangered species.

Task force members stated that (1) the task force had access at its September 1988 meeting to data for some environmental factors that were more reliable than the draft EIS data and (2) while new information for other factors may have been sufficient to change the task force's characterization of a potential impact or its assessment of an environmental factor, this information was not sufficient to justify revising the task force's rating for any criteria or subcriteria.

Two residents living near the Texas site noted that DOE's draft EIS had not considered the potential hazard of fire ants that infest the Texas site. In addition, one of the residents questioned the reliability of Texas' geological data and expressed concern about the potential hazard to nearby residents from increased levels of radiation exposure. DOE and RTK officials stated that they considered these issues and had not identified any significant problems. They added that DOE and Universities Research Association, its management contractor for the SSC, will examine these issues further in the supplemental EIS and as DOE drills more coreholes to characterize the geology of the Texas site more completely.

In addition, according to representatives of four power utilities that service fire ant-infested areas in the southern United States, fire ants have not caused any major power outages in their systems and are a nuisance rather than a serious hazard to their companies' workers and electric power supply.

Efforts to Gather and Verify Information

The DOE task force evaluated the seven best qualified sites on the basis of the states' information and its own efforts to confirm the accuracy of this information. In comparison with the NAS/NAE site evaluation committee, which relied on the data provided in the original site proposals to identify the best qualified sites, the task force (1) obtained additional data from the best qualified states, (2) used environmental data in the preliminary EIS and draft EIS, (3) made site visits, and (4) confirmed information through discussions and written responses from federal, state, and other officials.

According to task force members and RTK officials, the seven best qualified sites in March 1988 provided substantial additional information that was identified in appendix D of DOE's invitation for site proposals for the EIS process and related to the electric power generating and transmission grid systems and electric power rates. In addition, the task force requested individual states to provide information to address specific concerns. For example, DOE asked for additional geological data from Michigan because the NAS/NAE committee had identified a risk that the tunnel could encounter a buried valley and from Tennessee because of the task force's concern about the adequacy of the database. Michigan subsequently submitted a simpler geological profile based on additional corehole drilling data, and Tennessee further confirmed its geological profile with additional corehole drilling data.

The task force made 4-day visits to each of the seven sites between April and July 1988. About 1 week before each visit, the task force forwarded to the state a list of questions that it wanted to address. After an introductory meeting and a general tour of the site, the task force broke into teams to assess individual criteria and subcriteria. For example, the geology and tunneling subcommittee surveyed the general topography of the site, met with the states' geological experts, and examined the sites' drilling cores and data logs. Similarly, the regional resources subcommittee members (1) assessed the quality of roads and commuting distances and times to residential areas and airports and (2) met with state and local officials to discuss factors associated with each

of the subcriteria, such as the location, availability, and quality of housing and other community resources. The task force then asked the states to respond to follow-up questions on any unresolved issues within 4 weeks.

While the task force was gathering and analyzing data to evaluate the seven sites against the technical criteria, RTK developed the draft EIS for the SSC, which assessed the potential environmental impact at each of the sites. An RTK team visited each site in February and March 1988 to survey the sites and meet with technical counterparts for the states. RTK completed the preliminary EIS in June 1988 and submitted the draft EIS to DOE in August 1988. Task force members and RTK personnel stated that they interacted frequently so the task force members were familiar with the draft EIS data.

To improve the reliability of the data for estimating life-cycle costs for each site, RTK and other contractors assessed information in the original site proposals and the March 1988 submissions by the best qualified states. RTK also reviewed the geological data gathered during its site visits for the EIS process and obtained more detailed state and local tax information. In addition, Exeter contacted the power utilities for each site to verify power rate information.

Site Evaluations and the EIS Process

The DOE invitation for site proposals stated that DOE expected to identify the preferred site by July 1988. However, in February 1988 DOE announced that the preferred-site decision would be deferred until late-November 1988 so that the Secretary of Energy could consider the draft EIS and public comments on it in making his decision. However, while the task force assessed draft EIS data in evaluating and rating the sites between September 18 and 23, 1988, it could not consider public comments on the draft EIS because the written comment period, which began on September 2, 1988, extended to October 17, 1988, and public hearings at each site were held subsequent to the task force meeting.

Senior officials of four of the seven sites noted that the task force rated the sites before the 45-day public comment period on the draft EIS was closed and before DOE held public hearings at each site. Officials for three of the sites stated that the final EIS reduced the potential impact identified in the draft EIS for some environmental factors at their sites, citing as examples the potential impact on threatened and endangered species, the acreage of affected wetlands and prime farmland, and air quality.

RTK officials noted that they used an April 15, 1988, cutoff date for information considered in the draft EIS. Consequently, the draft EIS was based on information that the seven states submitted in March 1988 and RTK's site visits in February and March 1988; it did not include data that the states submitted after April 15 or information that the DOE site task force gathered during its site visits or in response to its specific questions.

Task force members, while concurring that the final EIS provided more accurate data for the four factors than the draft EIS, stated that they (1) had data on affected wetlands that were more accurate than the draft EIS data for evaluating and rating the sites in September 1988, (2) reviewed over 3,000 public comments on the draft EIS, which they considered representative of the 7,179 comments received, and (3) determined in a meeting on October 31, 1988, that the new data did not warrant any changes in the site ratings for the technical criteria or subcriteria. The task force then completed its site evaluation report.

Threatened and Endangered Species

To resolve uncertainties about the potential impact on threatened and endangered species and wetlands at each site, DOE and RTK officials decided on September 8, 1988, that DOE should contract with Argonne National Laboratory to conduct a field verification survey at each site to assess the (1) existence of suitable habitats on-site or downstream for any federally threatened or endangered species and (2) quantity and quality of affected wetlands.

Argonne personnel completed their work by mid-October 1988, relying on information obtained from state and federal agencies' surveys and gathered through site visits in late September. The DOE task force's summary review of comments on the draft EIS stated that the Argonne studies (1) found an extremely low probability of locating Tumamoca globeberry at any of the Arizona SSC surface facility locations, (2) indicated that Colorado's SSC surface facility locations would not coincide with suitable habitat for the black-footed ferret, although further studies would be necessary if the Colorado site were selected, (3) found potential summer habitat for the Indiana bat at both the Illinois and Michigan sites, (4) found dwarf wedge mussels, a federal- and state-listed endangered species, and other sensitive mussel species in the Tar River and the Flat River downstream from the North Carolina SSC site, (5) indicated that the Tennessee purple cone flower and suitable foraging areas for the Indiana bat did not exist at the Tennessee SSC site, and

(6) found no suitable habitat for the black-capped vireo at any of the Texas SSC surface facility locations.

Table 2.1 shows the number of threatened and endangered species and species that are candidates for federal listing that the final EIS identified in the vicinity of each site. These numbers, which reflected information provided by Argonne's field verification studies, included both resident and migratory animals species.

Table 2.1: Number of Threatened and Endangered Species

State	Federally listed species		State-protected species
	Threatened and endangered	Candidate	
Arizona	1	5	5
Colorado	9	10	3
Illinois	5	6	87
Michigan	1	4	27
North Carolina	1	6	21
Tennessee	4	11	22
Texas	6	0	11

Note: Threatened and endangered species include both resident and migratory species.

Source: Final EIS for the SSC.

The numbers of threatened and endangered species that may be found at each of the sites did not change substantially between the draft EIS and the final EIS. The most significant changes were for Illinois, where the number of state-protected species was reduced from 94 to 87, and Michigan, where the number of federal candidate species was increased from 1 to 4.

In addition, the Nashville chapter of the National Speleological Society and the state of Tennessee gave DOE reports that discussed the potential impact of SSC construction and operations on an existing network of caves in the northern section of Tennessee's SSC site. These caves, which are karst features formed by water flowing through limestone, mainly are found within 50 feet of the surface. Consequently, they might be affected by the SSC's tunnel shafts, though not by the tunnel itself, which would be located more than 200 feet underground.

The Speleological Society identified 58 caves in the area of the SSC site, of which at least 42 are located within 1 mile of the site boundary. A consultant for the state of Tennessee traced the flow of surface and underground streams from upstream locations through the tunnel ring

location. The consultant reported that all known and mapped passages of the Snail Shell Cave, which is the sixth-longest cave in Tennessee, are upstream of the proposed SSC campus and injector site and most likely would not be affected. However, the consultant stated that the campus and injector sites are drained by cave streams, and the consultant's map indicated that underground water channels would be located near an SSC service area.

In its September 1988 report, the environment subcommittee rated the impact on threatened and endangered species moderate for Colorado, Illinois, Michigan, and Texas and high for Arizona, North Carolina, and Tennessee. The task force did not change this assessment or its ratings for any site on the basis of the draft EIS comments and the Argonne field verification study. Task force members stated that the additional information about the network of caves in Tennessee generated the most discussion because of the potential impact on a sensitive environment and increased risks associated with sinking the tunnel shafts.

Wetlands

Table 2.2 shows the acres of potentially affected wetlands that were identified in the draft EIS, the report of the DOE task force's environment subcommittee, the task force's review of public comments on the draft EIS, and the final EIS. According to an RTK official, RTK and the subcommittee became aware that the draft EIS mistakenly listed the 2,800 acres for Michigan soon after the draft EIS was printed. The official stated that the 2,800 acres represented the total wetlands acreage that are above the SSC tunnel rather than the more limited acreage on which DOE would construct surface facilities.

Table 2.2: Impact on Wetlands for Each Site

Acres of wetlands

State	Draft EIS in August 1988	Task force evaluation in September 1988	Task force review in October 1988	Final EIS in December 1988
Arizona	0	0	0	0
Colorado	20	5	5	4
Illinois	850	450	655	199
Michigan	2,800[a]	120	560	190
North Carolina	258	258	153	41
Tennessee	<10	<10	104	38
Texas	<10	<42[b]	41	3

[a]Represents total wetlands acreage above the SSC tunnel rather than for the land to which DOE would take fee simple title.

[b]Total included 32 acres associated with Chambers Creek that could be avoided by relocating an SSC buried beam zone access area.

The change in the wetlands acreage for each site between the draft and final EIS reflected (1) the Argonne study group's analysis of the affected wetlands for each site and (2) a new definition of affected wetlands that limited the impact to wetlands in the fee simple areas that would be within and adjacent to the surface facilities, instead of all wetlands to which the government would have fee simple title. In addition, DOE assumed for the final EIS that only two of the six buried beam zone access areas (so-called "J" facilities) would be constructed.

As table 2.2 indicates, the DOE task force did not rely on the draft EIS wetlands acreage for its evaluation of the Illinois and Michigan sites. However, the acreage that the task force used for its September 1988 evaluation and its October 1988 reassessment varied from the acreage in the final EIS for several sites. The task force reviewed revisions in the quantity and quality of the wetlands for each site at its October 31, 1988, meeting before its report was made final and at its January 17, 1989, meeting before the Secretary of Energy issued the record of decision. The task force changed its assessment for (1) Illinois from a moderate impact to a moderate-to-low impact because of the reduced acreage and the relatively low functional value of most of the wetlands, (2) North Carolina from a high to a moderate impact because of the reduced acreage, although some of these wetlands were of high value, (3) Tennessee from a moderate to a small impact because of the reduced acreage, and (4) Texas from a high to a minimal impact because of the reduced acreage. The task force did not change its assessment of the

impact on Michigan's wetlands despite the reduced acreage because of their high quality.

Air Quality

According to RTK officials, the sites uniformly benefited from more accurate air quality data in the final EIS, particularly for carbon monoxide emissions. The final EIS noted that (1) three sites appeared to exceed carbon monoxide standards because the background data were for a nearby large metropolitan area that was not representative of the SSC site and (2) Arizona appeared to exceed the total suspended particulates standards, which reflected the amount of dust caused by SSC construction, because only 1978 data were available to estimate background levels. The final EIS indicated that dust emissions could be mitigated at a relatively low cost. In the January 17, 1989, reassessment of its ratings, the task force modified the impact on Arizona's air quality from high to moderate.

Prime Farmland

Table 2.3 shows the draft EIS and the final EIS estimates of the acreage of prime and important farmland that would be converted for SSC use and the percentage of the area's inventory of prime and important farmland that this represented. According to RTK officials, because they obtained better data than were available for the draft EIS for estimating the county's total acreage of prime and important farmland, the percentage of prime and important farmland for SSC use was reduced in Michigan, for example, from 1 percent to .0006 percent.

Table 2.3: Impact on Prime and Important Farmland

	Draft EIS estimate		Final EIS estimate	
State	Converted farmland[a] (acres)	Percent of region's inventory[b]	Converted farmland[a] (acres)	Percent of county's inventory[b]
Arizona	36	0.001	0	0
Colorado	464	0.2	819	.0005
Illinois	163	0.01	197	.0003
Michigan	259	1.0	341	.0006
North Carolina	593	0.001	955	.0010
Tennessee	395	0.1	606	.0014
Texas	341	0.02	588	.0015

Note: Prime and important farmland is defined as land of statewide importance in producing food, feed, forage, fiber, and oil seed crops.

[a]Prime and important farmland that would be converted for SSC use.

[b]Ratio of prime and important farmlands converted for SSC use to affected region's or county's inventory.

In response to the changes made in the final EIS, the task force revised its evaluation of the impact on prime and important farmland in three states. For Michigan, the impact was reduced from high to minor. For Colorado, the impact was reduced from moderate to low-moderate. For Tennessee, the impact was increased from low to moderate because of the increase in the number of affected acres from 395 to 606. According to the chairman of the task force's environment subcommittee, the prime and important farmland subfactor was not important for distinguishing between sites and, consequently, changes in the subfactor did not affect the task force's overall evaluation of the environment criterion and subcriteria.

Concerns of Residents Near the Texas SSC Site

Two residents living near the Texas SSC site identified three concerns that they believed were not sufficiently addressed by the task force or in the draft EIS. Both residents pointed out that although the Texas site is infested with fire ants, the draft EIS did not mention their potential hazard to workers and the SSC's electricity supply. In addition, one of the residents questioned the reliability of the geological data that Texas submitted for the site, stating that the actual geology is more complex than Texas had indicated, and expressed concern about increased levels of radiation exposure to residents living near the SSC as a result of the SSC's operations.

Fire Ants at the Texas Site

The task force did not consider the impact of fire ants in its evaluation of the Texas site in September 1988 but did consider their impact during its October 31, 1988, and January 17, 1989, review meetings. The task force did not change its environment ratings for Texas in response to the fire ants' potential hazard because, while the fire ants cannot be eradicated, task force members and RTK officials believed that effective control methods could be developed to prevent adverse effects on workers and construction and operation of the SSC. An official in DOE's Office of National Environmental Policy Act Compliance also noted that the supplemental EIS will address appropriate measures to control fire ants.

To better assess the hazard of fire ants to the SSC's electric power supplies and workers, we talked with representatives of (1) Alabama Power Company, (2) Houston Lighting and Power Company, (3) Mississippi Power Company, and (4) the Tennessee Valley Authority (TVA). All four utilities supply power to areas in the southern United States that are

infested with fire ants. According to the representatives, fire ants are more of a nuisance than a serious problem and the ants have not caused any major outages to their power systems. A Houston Lighting and Power representative told us that the company's 1986 survey found that fire ants caused 28 outages that affected between one and four homes in each case, typically knocking out a transformer in a residential neighborhood. A TVA official stated that TVA has had no fire ants in its structures, substations, or equipment, and TVA takes no special actions to control fire ants or to prevent their gaining access to TVA's electrical equipment.

The Reliability of the Texas Geological Data

The task force rated Texas outstanding for the construction risk subcriterion, stating that the proposed site is underlain by a simple layered sequence of chalk and marl that has been confirmed by 39 project-specific borings. The chairman of the task force's geology and tunneling subcommittee stated that the subcommittee reviewed the site's drilling core logs, inspected the core, and discussed the geology with the Texas team's two geologists, who are recognized in the field. Subcommittee members also contacted construction contractors who have tunneled through Austin Chalk and Taylor Marl for storm water tunnel projects in Austin, Texas. The subcommittee chairman noted that DOE will drill more coreholes around the proposed tunnel ring location to better characterize the geology in preparation for construction.

Potential for Increased Radiation Exposure

Both the draft and the final EIS considered the potential impact of increased radiation exposure because of the construction and operation of the SSC. The SSC will not produce or use fissionable materials associated with nuclear power reactors. However, its two proton beams will generate some radionuclides. The task force's environment subcommittee found that radiation had a low impact at all the sites and did not provide a basis for differentiating between the sites.

Appendix 12 of the draft EIS considered a worst-case scenario of an SSC proton beam loss accident that could generate radionuclides, particularly sodium-22 and tritium, that could migrate through the soil and contaminate the local drinking water. The draft EIS analysis showed an annual dose equivalent of about .5 millirem for residents living near the North Carolina site and lower doses at the other sites. In contrast, the Environmental Protection Agency's National Primary Drinking Water

Regulations for Radionuclides (40 C.F.R. part 141) specify that the combination of all man-made radionuclides in a drinking water supply cannot result in a dose that exceeds 4 millirem per year. The draft EIS did not include Arizona and Texas in this analysis because migration of radionuclides into groundwater was not considered probable—Arizona has a dry surface and its local aquifer is below tunnel depth; Texas has some small perched aquifers in streambeds that cross above the tunnel at several spots, but its major aquifer is below tunnel depth.The final EIS stated that normal SSC operations would increase the radiation exposure of the maximally exposed individual at any of seven sites by less than 1/1000th of the dose equivalent from natural background radiation to which all individuals are subject.

The DOE Task Force's Evaluation of Each Site

The DOE site task force evaluated and rated the seven best qualified sites against six technical evaluation criteria—geology and tunneling, regional resources, environment, setting, regional conditions, and utilities—and related subcriteria that DOE's invitation for site proposals had specified. Our limited analysis provided no reason to question the decision to site the SSC in Texas. However, we noted that (1) while the task force rated the Illinois site outstanding for the geology and tunneling criterion, the life-cycle cost estimate showed that Illinois was the second most costly site for underground construction, and (2) the task force's use of a weakest-link theory to evaluate the electrical power subcriterion resulted in a rating of good for all of the sites.

Task force members stated that they reached consensus in rating each of the criteria and subcriteria, using a scale of outstanding, good, satisfactory, poor, and unsatisfactory. The task force was able to differentiate between the sites for the geology and tunneling, regional resources, and setting criteria and subcriteria, with scores ranging from outstanding to poor. The task force rated the sites from outstanding to satisfactory for the regional conditions criterion and subcriteria. However, it found less of a basis to distinguish between sites for the environment criterion and subcriteria, rating the sites either outstanding or good, and the utilities criterion and subcriteria, rating all of the sites either good or satisfactory.

This section presents the task force's evaluation of the seven sites against the criteria, subcriteria, and component factors that were derived from the task force's final report, the subcommittee reports, and discussions with task force members. It also presents the estimated cost of constructing and operating the SSC at each site over the SSC's 33-year life.

Geology and Tunneling

For the geology and tunneling criterion, the task force rated Illinois, Tennessee, and Texas outstanding; Colorado and North Carolina good; and Arizona and Michigan satisfactory. The geology and tunneling subcommittee broke the four subcriteria into factors. For example, the subcommittee in evaluating the geologic suitability subcriterion assessed whether (1) the tunnel rock was generally uniform in composition and structure, (2) the tunnel rock had low permeability (resistance to the flow of water), (3) the tunnel and shafts would need support and lining, and (4) the site's topography permitted easy access to surface facility locations for efficient construction. The subcommittee rated Arizona satisfactory for geologic suitability mainly because its tunnel would pass

through three distinctly different rock types with the potential for a substantial amount of mixed-face tunneling (tunneling simultaneously through two or more rock types of significantly different strength and/or hardness). The subcommittee rated Michigan satisfactory mainly because (1) its tunnel was proposed for geological formations of sandstone, shale, and limestone that, while not structurally complex, were very heterogeneous and poorly predictable either laterally or vertically, (2) some of the sandstone was moderately permeable, and (3) the whole tunnel would require a concrete liner for both water control and structural support.

The task force considered other subcriteria less important than geologic suitability for the overall rating in geology and tunneling. Both Illinois and Tennessee were rated poor in operational efficiency because of the depth of the experimental halls and tunnel shafts, but they were rated outstanding for their overall suitability.

Geology and Tunneling Subcriteria and Factors

Geologic Suitability

- uniformity of tunnel material
- permeability of tunnel material
- need for support and lining
- topography for efficient construction

Operational Stability

- seismic zone
- strength of the rock under the experimental halls

Operational Efficiency

- depth of experimental halls
- depth of tunnel

Construction Risk

- predictability of the geology

Task Force Evaluation

Arizona: Satisfactory

Geologic Suitability

- Tunnel will pass through three major rock types (granites, layered volcanic, and fanglomerate (a weakly cemented sedimentary rock)) that have different engineering properties; tunnel will pass through about 16 separate contacts between different rock types; mixed-face tunneling is likely in the volcanic and at the granite-fanglomerate contacts.
- Tunnel located substantially above the regional water table.
- Precast segmented concrete liner needed to support 68 percent of the tunnel in fanglomerate.
- Six shafts located in rugged and mountainous terrain, requiring significant grading for access and construction.

Operational Stability

- Moderate earthquake potential.
- Three experimental halls located in fanglomerate would require drilled piles for support.

Operational Efficiency

- Average depth to the base of the experimental halls is 140 feet.
- Average tunnel shaft depth is 245 feet; however, seven shafts are at least 300 feet in depth.
- Up to 18 percent of the tunnel can use cut-and-cover excavation.

Construction Risk

- Site database included only eight coreholes, nine auger holes, two rotary holes, and short refraction seismic sections around the tunnel ring.

Colorado: Good

Geologic Suitability

- Tunnel located in a thick homogeneous sequence of claystone (Pierre Shale) that generally is uniform and predictable.
- Claystone is essentially impermeable.

- Tunnel will need immediate installation of a precast segmented concrete liner for the whole tunnel to prevent slaking (drying out and crumbling of the claystone).
- Good access to surface facility locations.

Operational Stability

- Low earthquake potential.
- Experimental halls may require drilled piles, spread footings or similar measures to minimize unacceptable movements due to the elastic character of the claystone.

Operational Efficiency

- Average depth to the base of the experimental halls is 105 feet.
- Average tunnel shaft depth is 125 feet.

Construction Risk

- Pierre Shale is highly uniform and laterally predictable; considerable regional experience in building tunnels in Pierre Shale.

Illinois: Outstanding

Geologic Suitability

- Tunnel located in a uniform sequence of dolomite that is homogeneous and highly predictable.
- Dolomite is essentially impermeable; overlying glacial sediments and weathered bedrock carry substantial water volumes.
- Tunnel can be left unlined with only occasional rock bolts for support; up to 22 percent of the total lengths of the shafts require systematic ground support and water control before excavation; tunnels connecting the injector complex with the SSC tunnel require structural and waterproof liners through the overlying glacial material.
- Good access to surface facility locations.

Operational Stability

- Low earthquake potential.
- Dolomite is a high-strength material that provides a stable foundation for the experimental halls.

Operational Efficiency

- Average depth to the base of the experimental halls is 475 feet.
- Average tunnel shaft depth is 430 feet.

Construction Risk

- Bedrock geology is simple and well understood; Illinois added data from 30 site-specific coreholes and three rotary holes to an extensive regional database.
- The state of Illinois proposed in its offer to excavate the SSC tunnel and access shafts as part of its site infrastructure improvement program.

Michigan: Satisfactory

Geologic Suitability

- Tunnel is located in low-strength sandstone, shale, and limestone that have different engineering properties and that occur in layers of varying thickness, vertical distribution, and lateral extent; minor coal seams also are found.
- Seventy-five percent of the tunnel is located in Saginaw Formation sandstone, which has low to moderate permeability (water can flow through the sandstones as well along fissures in the rock); all shafts will penetrate overlying unconsolidated materials that, along with the sandstone, are a major source of the region's groundwater.
- Precast concrete liner with gasket is required for the whole tunnel; systematic ground support and water control is required before excavation of all shafts and experimental halls.
- Good access to surface facility locations.

Operational Stability

- Low earthquake potential.
- Saginaw Formation sandstone should provide a sufficient foundation for the experimental halls.

Operational Efficiency

- Average depth to the base of the experimental halls is 195 feet.
- Average tunnel shaft depth is 140 feet.

Construction Risk

- Site database includes 28 coreholes, of which only 15 extend to tunnel depth; rock sequence is very heterogeneous and poorly predictable.

North Carolina: Good

Geologic Suitability

- Tunnel is located in a complex series of 7 rock formations that consist of metamorphosed volcanic and sedimentary rock into which granitic bodies have intruded; the formations have similar engineering properties, so they can be considered a single construction unit; 30 separate contacts between formations; fracture zones within granitic rocks and near contacts with adjacent rocks are common and poorly predictable.
- Less weathered bedrock tends to be impermeable except along joints or fractures; shafts will penetrate zone of weathered bedrock that is highly transmissive.
- Most of the tunnel can be left unlined; localized fracture zones in the tunnel will require structural support and treatment for water (typically rock bolts and shotcrete); a watertight lining is required for all shafts where they penetrate the weathered bedrock zone.
- Good access to surface facility locations.

Operational Stability

- Low to moderate earthquake potential.
- High strength of the unweathered bedrock provides a stable foundation for the experimental halls.

Operational Efficiency

- Average depth to the base of the experimental halls is 215 feet.
- Average tunnel shaft depth is 170 feet.

Construction Risk

- Site database consists of 23 coreholes around the tunnel ring, 4 soil borings in the campus area, 18 regional water wells, and 30 seismic profiles.
- Site is in a complex geologic setting; the rocks along the tunnel alignment have a long history of structural deformation; poor predictability of fracture zones.

Tennessee: Outstanding

Geologic Suitability

- Tunnel is located in a thick, uniform sequence of high-strength limestone that is predictable both vertically and laterally; karst features, such as caves, disappearing streams, and sinkholes, are common in the shallow subsurface.

- Limestone is essentially impermeable at tunnel depth.
- Tunnel and most of the shafts can be left unlined with only occasional rock bolts for support.
- Good access to surface facility locations.

Operational Stability

- Low earthquake potential.
- High-strength limestone provides a stable foundation for the experimental halls.

Operational Efficiency

- Average depth to the base of the experimental halls is 385 feet.
- Average tunnel shaft depth is 405 feet.

Construction Risk

- Large regional database from deep core drilling for lead and zinc exploration; site database includes 11 coreholes and 8 percussion holes.
- Potential during shaft sinking and surface building construction to encounter caves and other karst features near the surface, some of which may be water-bearing and/or need to be cleaned and filled with grout or cement.

Texas: Outstanding

Geologic Suitability

- Tunnel located in a simple layered sequence of Austin Chalk (74 percent) and Taylor Marl (26 percent) with uniform and well-characterized material properties; chalk and marl are soft, low-strength rock; inactive faults of limited displacement cross the tunnel ring in several places.
- The chalk and marl are essentially impermeable.
- Marl will require a precast segmented concrete liner for structural support and to prevent slaking; chalk will be coated with shotcrete for dust control; small volume water inflow along discrete fractures can be controlled by grouting or a waterproof liner.
- Good access to surface facility locations.

Operational Stability

- Very low earthquake potential.

- Chalk provides a stable base for three experimental hall foundations; the other three experimental halls will bottom on Eagle Ford Shale or marl and may require drilled piles or spread footings to redistribute the heavy foundation loads.

Operational Efficiency

- Average depth to the base of the experimental halls is 220 feet.
- Average tunnel shaft depth is 152 feet; at two points the collider tunnel is less than the required minimum depth of 35 feet underground.

Construction Risk

- Highly predictable geology; extensive regional experience with tunneling in Austin Chalk and Taylor Marl; site database includes 39 borings.

Regional Resources

For the regional resources criterion, the task force rated Illinois, Michigan, and Texas outstanding; North Carolina good; and Arizona, Colorado, and Tennessee satisfactory. The regional resources subcommittee evaluated the criterion on the basis of the four subcriteria and their component factors. For the community resources subcriterion, the subcommittee considered the proximity, price, and diversity of housing; the quality of primary and secondary schools; and spousal employment opportunities. Adequate housing was within relatively close proximity (less than 45 minutes) to the proposed sites in Illinois, Michigan, North Carolina, Tennessee, and Texas. However, despite the closeness of Tennessee's housing, the task force rated it satisfactory for community resources because of concerns about the quality of its schools and other resources. The task force rated Arizona good for the subcriterion mainly because adequate housing was 50 to 60 minutes from the site, and rated Colorado satisfactory mainly because its community resources were more than 75 minutes away. Key factors for accessibility were airport proximity, the quality and frequency of air service, and the quality of roads to the site. Ratings for institutional support, which ranged from outstanding to poor, generally reflected (1) the extent of support or opposition by community groups, including state and local governments, businesses, unions, environmental organizations, and citizens' organizations, (2) a state's ability to effectively respond to public concerns about the SSC project, and (3) state and local administrative support for obtaining permits and complying with laws, regulations, and codes.

Regional Resources Subcriteria and Factors

Community Resources

- housing: proximity, price, diversity
- education: primary and secondary schools
- spousal employment opportunities

Accessibility

- air: frequency of air service and commuting time
- roads and highways: proximity and quality
- rail, water, and public transportation

Industrial Base

- operations: availability of high technology labor, materials, and services
- construction: availability of construction labor, materials, and equipment

Institutional Support

- extent of local support or opposition
- type of institutional program (coordinated mechanisms to provide information and limit opposition)
- state and local administrative support

Task Force Evaluation

Arizona: Satisfactory

Community Resources

- Adequate residential housing within 50 to 60 minutes.
- Excellent public schools.
- Excellent employment opportunities for spouses.

Accessibility

- Good air accessibility based on air service and about a 60-minute commute to Sky Harbor International Airport.
- Limited road access between Phoenix and the site through a single route, which currently includes about 7 miles of jeep trails and 31 miles of

paved, two-lane road, until a new freeway is completed in the mid-1990s.

Industrial Base

- Limited high technology labor force and industrial base.
- Limited construction labor force, materials, and equipment.

Institutional Support

- State and local government and citizen support.
- Potential for organized opposition to withdrawing the Wilderness Study Area designation.
- Very limited institutional program; limited state and local coordination.

Colorado: Satisfactory

Community Resources

- Abundant residential communities beyond 75 minutes.
- Good public schools.
- Access to major employment centers may require a longer-than-average commute for family members.

Accessibility

- Good air accessibility based on air service and about an 80-minute commute to Stapleton International Airport, about a 70-minute commute to the proposed new airport.
- Limited road access; roads and highways need improvements.

Industrial Base

- Excellent but distant high technology labor force and industrial base.
- Good but distant construction labor force, materials, and equipment.

Institutional Support

- Excellent state and local government and citizen support.
- Only limited individual opposition.
- Well-organized institutional program coordinated with state agencies and local governments.

Illinois: Outstanding

Community Resources

- Abundant residential communities within 20 to 30 minutes.
- Excellent public schools.
- Excellent employment opportunities for spouses.

Accessibility

- Excellent air accessibility based on air service and about a 45-minute commute to O'Hare International Airport.
- Extensive access from many roads that are now open.

Industrial Base

- Excellent high technology labor force and industrial base; two DOE national laboratories near site.
- Excellent construction labor force, materials, and equipment.

Institutional Support

- State and local governments are very supportive; strong, organized opposition by affected homeowners and others led by CATCH-Illinois; some erosion of local government support has started.
- State has implemented an institutional program and prepared an impressive variety of public information materials; state has been ineffective in responding to issues raised by CATCH-Illinois.

Michigan: Outstanding

Community Resources

- Abundant residential housing within 30 to 45 minutes.
- Excellent public schools.
- Very good employment opportunities for spouses.

Accessibility

- Good air accessibility based on air service and about a 60-minute commute to Detroit Metropolitan Wayne County Airport.
- Access by 15 to 19 miles of two-lane roads that require major improvements.

Industrial Base

- Excellent high technology labor force and good industrial base.
- Good construction labor force, materials, and equipment.

Institutional Support

- Excellent state and local government and citizen support.
- Active and coordinated institutional program.
- State interaction with environmental groups.

North Carolina: Good

Community Resources

- Very good residential housing within 45 minutes.
- Average public schools.
- Outstanding employment opportunities for spouses.

Accessibility

- Good air accessibility based on air service and a 40-minute commute to Raleigh-Durham Airport.
- Limited road access; long-term road construction and repairs.

Industrial Base

- Limited high technology labor force and industrial base.
- Limited construction labor force, materials, and equipment.

Institutional Support

- State and local government support; local institutional support may be eroding.
- Strong organized local resident opposition, including affected homeowners and two church congregations.
- Reactive institutional program and limited information dissemination; state developed the site proposal with limited involvement from the local governments or communities.

Tennessee: Satisfactory

Community Resources

- Good residential housing within 35-45 minutes.
- Average to below-average public schools.
- Good employment opportunities for spouses.

Accessibility

- Good air accessibility based on air service and a 35- to 40-minute commute to Nashville Metropolitan Airport.
- Excellent roads in place.

Industrial Base

- Limited high technology labor force and industrial base.
- Limited construction labor force, materials, and equipment.

Institutional Support

- Very supportive state and local governments.
- Some individual opposition and minimal organized opposition, including the local Sierra Club president.
- Limited institutional program and coordination among state and local agencies.

Texas: Outstanding

Community Resources

- Excellent residential housing within 30 to 40 minutes.
- Average public schools.
- Good employment opportunities for spouses.

Accessibility

- Excellent air accessibility based on air service and about a 45-minute commute to Dallas-Fort Worth International Airport.
- Excellent roads in place.

Industrial Base

- Excellent high technology labor force and good industrial base.
- Excellent construction labor force and good materials and equipment.

Institutional Support

- State and local government and citizen support.
- Very limited individual and no organized opposition.
- Well-organized institutional program and public information dissemination.

Environment

Texas and Colorado were rated outstanding because their sites were located in rural farmland with a low to moderate potential for SSC impact on water, endangered species and sensitive habitat, and other environmental concerns. The other five sites were rated good. For the environment criterion, environmental impact was the most important subcriterion. The subcommittee chairman stated that the other two subcriteria—regulatory compliance and ability to mitigate—did not affect the overall criterion ratings because (1) all proposed SSC sites would comply with existing environmental regulations and (2) the ability to mitigate any adverse effects from the SSC was about the same across sites. Further, the chairman said that none of the sites had environmental impact problems that would have precluded placing the SSC there.

Environment Subcriteria and Factors

Environmental Impact

- water

  quantity: impact of the SSC on local and regional water supply

  quality: potential impact of the SSC construction and operations on ground and surface water quality

  floodplains

- ecology

  federal or state threatened or endangered species/sensitive habitats at the site or downstream

  wetlands

- air quality

  ozone

  carbon monoxide

  fugitive dust

- other concerns

land resources: prime farmland, oil and gas wells, mineral resources, water wells

noise

socioeconomics

cultural: archeological and historical resources

scenic/visual

health and safety

Regulatory Compliance

- permits and regulatory standards for each site

Ability to Mitigate

- avoidance
- reduction of impact

Task Force Evaluation

Arizona: Good

Water

- Quantity: potential local water overdraft.
- Quality: little or no potential for ground or surface water contamination.

Ecology

- No wetlands.
- Endangered species/sensitive habitat: Wilderness Study Areas in the North Maricopa mountains; desert tortoise is a candidate category 2 for federal endangered species; potential big horn sheep habitat loss; potentially long recovery rate of Sonoran desert where cut-and-cover tunnel excavation is used.

Air Quality

- Projected elevated levels of fugitive dust and carbon monoxide.

Scenic/Visual Concerns

- Butterfield Stage Route and a proposed historic trail cross the site.

Colorado: Outstanding

Water

- Quantity and quality: minimal impact on surface or ground water; Colorado proposes to purchase water rights for the South Platte River.

Ecology

- 5 acres of wetlands.
- Land development pattern is generally unirrigated farmland.

Socioeconomic Impact

- Potential boomtown effect.

Illinois: Good

Water

- SSC water use would aggravate existing regional overdraft.

Ecology

- 450 acres of wetlands could be affected but the amount that would likely be affected would be smaller and mainly of low value.

Air Quality

- Site is in an ozone nonattainment zone.

Socioeconomic Impact

- Relocations and concerns about property values have generated a great deal of public controversy over the SSC.

Noise

- Location of SSC service areas in residential neighborhoods would expose 454 people to 70 to 75 decibels and 1,246 people to 60 to 70 decibels of background noise during construction.

Scenic/Visual Concerns

- Visual impacts, increased traffic, and general community disturbance.

Cultural

- Forty-seven Indian archeological sites have been identified within the proposed SSC site area.

Michigan: Good

Water

- Existing local overdraft.
- Tunnel located in sandstone formation that is one of the major developed aquifers in the region; shafts and tunnel may be constructed through gypsum, resulting in potential contamination of the aquifer.

Ecology

- 120 acres of generally high-quality wetlands may be directly affected; potential for encroachment on floodplains because of the amount of surface water in the area.

Air Quality

- Site is in an ozone nonattainment zone.

North Carolina: Good

Water

- Fractured bedrock conditions increase the potential for groundwater contamination.

Ecology

- 258 acres of wetlands, including high-value bottomland hardwood wetlands.
- Endangered species/sensitive habitat: significant aquatic and upland habitats inside and adjacent to the tunnel ring; seven animal species

found in the vicinity of the site are state-listed as threatened, endangered, or of special concern.

Noise

- Construction in residential neighborhoods will expose 136 people to 70 to 75 decibels and 705 people to 60 to 70 decibels of background noise during construction.

Tennessee: Good

Water

- Potential surface and groundwater contamination because the caves, sinkholes, and other karst features would allow contaminants to migrate quickly and because of the location of some spoil disposal areas.

Ecology

- Less than 10 acres of wetlands potentially affected.
- Endangered species/sensitive habitat: Snail Shell Cave System is located upstream from the tunnel ring and thus would not be affected, but injector area B contains karst limestone surface rocks; potential impact to sensitive habitats such as cedar glades and downstream cave systems.

Air Quality

- Site is in an ozone nonattainment zone.

Cultural

- Nine properties listed on the National Register of Historic Properties.

Texas: Outstanding

Ecology

- Riparian wetland at Chambers Creek could be avoided so that only about 10 acres of wetlands would be affected.

Land Resources

- Agricultural land covers 32,000 acres of the 38,000-acre study area.

Health and Safety

- The DOE site task force did not consider the impact of fire ants during its September 1988 meeting in Frederick.

Setting

For the setting criterion, the task force rated Tennessee and Texas outstanding; Arizona and Colorado good; Michigan and North Carolina satisfactory; and Illinois poor. According to the chairman of the setting subcommittee, the real estate rating was a function of the complexity of the land acquisition program and the state's ability to meet DOE's land acquisition schedule, which was measured by (1) the extent of the state's planning effort, (2) the number of staff, and (3) their experience with federal acquisition requirements.

Setting Subcriteria and Factors

Real Estate

- parcels, land owners, and relocations
- real estate acquisition team
- state management of real estate acquisition

Flexibility

- large-scale flexibility to shift tunnel location
- local flexibility to adjust individual facilities

Natural and Man-Made Features

- natural features that could affect SSC construction or operations
- man-made features that could affect SSC construction or operations

Task Force Evaluation

Arizona: Good

Real Estate

- Area includes 224 parcels, 131 owners, 6 relocations; 62 percent of the proposed site (9,748 acres) is federal land under the jurisdiction of the Bureau of Land Management (BLM) in the Department of the Interior. A portion of the BLM land has been designated as Wilderness Study Area and, while BLM has recommended against Wilderness designation, the Congress must make the final determination of its status.

- Private contractors would acquire the real estate; the Arizona Department of Transportation would manage the acquisition program.
- Arizona had not sufficiently organized its acquisition team, developed its plan, or coordinated its acquisition effort among state agencies or with BLM.

Colorado: Good

Real Estate

- 157 parcels, 67 owners, 23 relocations.
- Private contractors would acquire the real estate; the Colorado Department of Local Affairs, which would manage the acquisition, has no real estate acquisition experience.
- Colorado had not sufficiently organized its acquisition team or developed its plan.

Flexibility

- Colorado proposed to acquire 52,520 acres to provide flexibility and future expansion potential.

Illinois: Poor

Real Estate

- 3,305 parcels, 2,750 owners, 219 relocations; strong landowner opposition.
- A private contractor would acquire the real estate; the Illinois Department of Energy and Natural Resources, which would manage the acquisition, has no real estate acquisition experience.

Flexibility

- Use of the Fermi Laboratory's tevatron as the injector complex for the SSC limits the flexibility to shift the tunnel ring.

Natural and Man-Made Features

- SSC construction activities could be restricted at night because of traffic, noise, and unsightliness affecting nearby residential communities.
- SSC operations could be restricted at night because of noise from SSC service areas located near residences.

Michigan: Satisfactory

Real Estate

- 801 parcels, 687 owners, and 221 relocations.
- A private contractor would use about 90 staff members to acquire the real estate, which DOE considered adequate for the size of the acquisition; contractor has limited experience with federal acquisition requirements.
- State's acquisition schedule well conceived and complete; management team of two former Michigan Department of Transportation senior managers (1) has good federal real estate acquisition experience but (2) is insufficient in number because the contractor has limited federal acquisition experience.

Flexibility

- Nearby communities and wetlands restrict the flexibility to shift the tunnel ring.

Natural and Man-Made Features

- Wetlands may affect construction activities.

North Carolina: Satisfactory

Real Estate

- 826 parcels, 780 owners, about 180 relocations; organized landowner opposition.
- North Carolina State Property Office would use six staff members, which DOE considered inadequate for the size of the acquisition program; poorly developed acquisition plan and no relocation plan.

Tennessee: Outstanding

Real Estate

- 898 parcels, 807 owners, 128 relocations.
- The Tennessee Department of Transportation would acquire the real estate using 60 staff members, which DOE considered adequate for the size of the acquisition, and is experienced in federal acquisition requirements; well-conceived acquisition plans and schedules.

Flexibility

Utilities Subcriteria and Factors

Electric Generation and Transmission Grid Systems

- flexibility for future expansion
- transmission system adequacy
- system reliability
- system stability
- transmission service to the SSC
- SSC service reliability
- construction power

Water

- reliability
- quality
- quantity

Fuel Availability, and Waste and Sewage Disposal

Task Force Evaluation of the Power Subcriterion

Arizona: Rated good in all factors.

Colorado: Rated outstanding in transmission service to the SSC and SSC service reliability; rated good in the remaining factors.

Illinois: Rated outstanding in flexibility for future expansion and transmission system adequacy; rated good in the remaining factors.

Michigan: Rated outstanding in transmission service to the SSC and good in the remaining factors.

North Carolina: Rated outstanding in flexibility for future expansion and in transmission system adequacy; rated good in the remaining factors.

Tennessee: Rated outstanding in flexibility for future expansion and transmission system adequacy; rated good in the remaining factors.

Texas: Rated outstanding in flexibility for future expansion and transmission service to the SSC; rated good in the remaining factors.

Life-Cycle Costs

The RTK analysis showed that the life-cycle costs for the seven sites, which ranged from $10.4 billion to $11.57 billion, were all within 6 percent of the average cost for all sites. (See table 3.1.) For Illinois, this analysis included DOE's expected savings by using the tevatron at Fermi National Accelerator Laboratory as both (1) the injector complex for the SSC and (2) an accelerator facility when it is not needed for the SSC. DOE estimated that the tevatron would reduce construction and operating costs by $.5 billion to $1.03 billion, depending on whether the tevatron continued to operate as an accelerator facility for 5 to 15 years after the SSC began operation.

Table 3.1: Key Variable Components of the Life-Cycle Costs for Each Best Qualified Site

Billions of FY 1988 dollars

State	Labor during operations	Underground construction	Power	Total costs[a]
Arizona	$.40	$2.21	$1.50	$11.57
Colorado	.42	2.26	1.15	11.19
Illinois[b]	.50	2.32	1.23	10.40–10.94
Michigan	.51	2.29	1.30	11.49
North Carolina	.35	1.97	1.16	10.74
Tennessee	.34	1.98	1.22	10.75
Texas	.36	2.19	.97	10.82
Average cost	.41	2.17	1.22	11.03

[a]Includes fixed construction and operating costs of $5.68 billion.

[b]The component costs for the Illinois site are as estimated in the life-cycle cost model. However, the total cost for this site reflects a cost credit associated with the dual use of Fermi tevatron as an injector complex for the SSC and as an accelerator for a period ranging from 5 to 15 years.

Source: Gross Life-Cycle Cost Analyses of Best Qualified List Sites (Nov. 1988).

RTK used a life-cycle cost model to estimate the cost of constructing and operating the SSC for both the selection of the best qualified sites and the preferred site. Our report, Federal Research: Determination of the Best Qualified Sites for DOE's Super Collider, discussed four concerns about the life-cycle cost analysis for the NAS/NAE committee's identification of the best qualified sites. RTK officials told us that for revising its life-cycle cost estimates for the preferred site selection:

- The best qualified states provided more detailed information on the sites' geological characteristics and electric power rates. RTK personnel obtained additional data on state and local taxes, and Exeter personnel independently verified power rate information by contacting electric power utilities.

- Additional land adjacent to the site is readily available and relatively simple to acquire.

Natural and Man-Made Features

- Karst features, such as caves and sinkholes, could impact construction by requiring special foundation treatment.

Texas: Outstanding

Real Estate

- 614 parcels, 420 owners, 175 relocations.
- The Texas Department of Transportation, which would acquire the real estate, is experienced in federal acquisition requirements and has a pool of about 125 qualified personnel at its local district office; well-conceived acquisition plan and schedules and a thorough relocation plan.

Regional Conditions

For the regional conditions criterion, the task force rated Colorado, Michigan, and Tennessee outstanding; Illinois, North Carolina, and Texas good; and Arizona satisfactory. According to the chairman of the regional conditions subcommittee, the subcommittee principally was concerned that vibrations from outside sources, such as railroads, highways, and rock quarries, might affect the focusing of the proton streams during SSC operations. The chairman added that climate did not significantly differentiate between the sites, although North Carolina's rating for regional conditions was raised to good because a satisfactory for vibrations was balanced by an outstanding in climate.

Regional Conditions Subcriteria and Factors

Vibrations and Noise

- calculated vibration levels at the tunnel and the experimental halls as compared with SSC tolerances
- ability to increase the margin of safety for vibrations

Climate

- loss of SSC construction or operating time due to climate
- other unusual climatic factors

Task Force Evaluation

Colorado, Michigan, and Tennessee did not have any major vibration sources, and all vibration sources were at least an order of magnitude below the SSC vibration tolerance. In Illinois, rock quarries were relatively close to the tunnel ring, but calculated vibrations were well below SSC tolerance. In Texas, vibrations from a railroad line could easily be improved by increasing track maintenance and/or a better cushioning layer to increase the margin between calculated vibrations and SSC tolerance. In Arizona, calculations showed that vibrations from a mainline railroad were lower than SSC tolerances by a factor of only 2 to 4 and increasing the margin of safety might prove difficult. In North Carolina, data were not available about vibrations caused by blasting at an existing quarry, a quarry under construction, and a proposed quarry for which a permit was being sought.

Utilities

The task force rated all of the sites good for the utilities criterion and the electrical power subcriterion. For the electrical power subcriterion, the invitation for site proposals asked that the sites provide dual electrical power sources. The utilities subcommittee considered the grid system reliable and stable if it had a capacity of 12 times the rated peak site load of 200 megawatts.[1]

To evaluate the electrical power subcriterion, the utilities subcommittee used a "weakest-link" theory, which maintained that the quality of the sites' power service was only as good as the weakest link in the electrical power factors. In this way, the overall rating for the subcriterion was equal to the lowest rating for any component factor. While the subcommittee rated five of the seven sites outstanding for two factors, it rated all of the sites good for at least five factors.

The task force did not provide sufficient documentation for us to determine the appropriateness of its use of the weakest-link theory. Alternatively, as it did with other technical criteria and subcriteria, the task force could have weighted the electrical power factors and differentiated between states on the basis of its ratings for the more important factors.

[1]C.H. Guernsey and Co. assessed the acceptability, stability, and reliability of the electrical power systems. Exeter Associates, Inc., analyzed electric power rates for the SSC life-cycle cost analysis.

- RTK did not attenuate (or reduce) cost differentials between sites over time, which the NAS/NAE committee had requested for identifying the best qualified sites.
- Similar to the analysis for the NAS/NAE committee, RTK did not revise the structure of its life-cycle cost model for the preferred site selection to permit discounting by developing site-specific time streams of expenditures.
- RTK also did not reassess its previous determination of which SSC components would be purchased on the national market and thus be considered "fixed" costs, and which would be purchased on a regional or local market and thus be considered "variable" costs.

Table 3.2 shows the estimated underground construction costs for each of the best qualified sites. RTK estimated that construction at the Illinois site would cost $496 million, which was the second highest cost for this category. This primarily reflected higher costs associated with (1) sinking deep tunnel shafts through rock that carries substantial water, (2) underground excavation of the experimental halls, and (3) higher regional construction labor costs.

Table 3.2: Estimated Underground Construction Costs for Each Site

Millions of FY 1988 dollars

State	Tunnels[b]	Shafts	Halls	Total[c]
Arizona	$306.7	$30.6	$61.7	$399.1
Colorado	338.1	27.7	51.9	417.6
Illinois	294.0	104.3	98.0	496.3
Michigan	379.3	40.2	91.5	511.0
North Carolina	243.3	38.8	68.9	351.0
Tennessee	241.6	37.8	62.2	341.6
Texas	282.2	21.7	59.2	363.1

[a]Underground construction costs were based on (1) DOE's conceptual design for the SSC, (2) the site's geotechnical conditions, topography, and climatic conditions, and (3) the region's construction wage rates.

[b]RTK estimated an average tunnel advance rate, measured in linear feet per day, of 120 for Arizona, 107 for Colorado, 144 for Illinois, 117 for Michigan, 130 for North Carolina, 141 for Tennessee, and 136 for Texas.

[c]Totals do not include an estimated cost for contingencies at each site.

Source: Gross Life-Cycle Cost Analyses of Best Qualified List Sites (Nov. 1988).

DOE and NAS/NAE geologists have told us that the geology and tunneling criterion reflects practical concerns about construction costs, schedule delays, and risks associated with uncertainties. Although the Illinois site

had higher construction cost, the task force rated Illinois as outstanding for geology and tunneling.

Geology and tunneling subcommittee members stated that they based their ratings on the technical merit of the sites' geology although they reviewed the RTK estimates as part of their evaluation. The subcommittee chairman noted that (1) Illinois' higher costs mainly reflected costs associated with deeper tunnel shafts that would pass through water-bearing rock rather than with tunnel construction and (2) RTK's estimated costs did not include contingency factors for each site that addressed risk, which would be minimal for Illinois because of its excellent geological database. Subcommittee members believed that RTK may have over-estimated the depth that the shafts would have to be lined for water control, so that the $104 million estimated for shaft construction could be reduced by an estimated $15 million to $25 million.

Chronology of Events Leading to the Selection of the SSC Site

Date	Event
Jan. 1987	President Reagan requested congressional approval to construct the SSC.
Apr. 1, 1987	DOE issued the invitation for site proposals for the SSC.
Sept. 1987	DOE received 43 site proposals by its deadline and transmitted 36 proposals that met its qualifying criteria to the NAS/NAE site evaluation committee.
Dec. 24, 1987	NAS/NAE site evaluation committee submitted its final report, Siting the Superconducting Super Collider, to DOE.
Jan. 19, 1988	The Secretary of Energy announced that DOE accepted the NAS/NAE site evaluation committee's recommended list of best qualified sites without modification.
Feb. 1988	DOE site task force held EIS scoping meetings in the seven best qualified states.
Apr.-July 1988	DOE site task force conducted site visits to each of the best qualified sites.
Sept. 2, 1988	Notice of availability for the draft EIS issued with a 45-day public comment period.
Sept. 7, 1988	RTK presented life-cycle cost information for each site to the DOE task force.
Sept. 12-16, 1988	Germantown meeting for task force subcommittees to finalize technical content of their presentations for Frederick meeting.
Sept. 18-23, 1988	Frederick, Maryland, meeting at which the task force reached consensus on the ratings of each site against the technical criteria.
Sept. 26-Oct. 6, 1988	DOE held public hearings on the draft EIS at the seven best qualified sites.
Oct. 1988	Representatives of the seven best qualified states made presentations to the Secretary of Energy.
Oct. 31, 1988	Task force met to review whether changes to the draft EIS in response to 7,179 public comments and Argonne's field survey report on wetlands and endangered species would affect any of its ratings of the sites against the technical criteria and subcriteria. No changes in the ratings of any site were made.
Nov. 3, 1988	Task force issued its summary review of the comments on the draft EIS for the SSC.
Nov. 7, 1988	SSC Site Evaluations: A Report by the SSC Site Task Force issued.
Nov. 8, 1988	Task force presented the site evaluations to the Secretary of Energy and the Energy System Acquisition Advisory Board.
Nov. 10, 1988	Secretary of Energy announced his selection of Texas as the preferred site for the SSC.
Dec. 16, 1988	Notice of availability for the final EIS issued with a 30-day public comment period.
Jan. 17, 1989	Task force met to review changes between the draft EIS and final EIS to determine whether its ratings for any site should be revised. No changes in the ratings were made.
Jan. 18, 1989	Secretary of Energy issued the record of decision selecting Texas as the site for the SSC.

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