DOE/EA-1090

ENVIRONMENTAL ASSESSMENT

DISBURSEMENT OF $65 MILLION TO THE STATE OF TEXAS FOR CONSTRUCTION OF A REGIONAL MEDICAL TECHNOLOGY CENTER AT THE FORMER SUPERCONDUCTING SUPER COLLIDER SITE, WAXAHACHIE, TEXAS

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U.S. DEPARTMENT OF ENERGY
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DISCLAIMER

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ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
BVBWSC	Buena Vista Bethel Water Supply Company
CEQ	Council on Environmental Quality
DOE	U.S. Department of Energy
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FSEIS	Final Supplemental Environmental Impact Statement
linac	linear accelerator
LLUMC	Loma Linda University Medical Center
MEI	maximally exposed individual(s)
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
RMTC	Regional Medical Technology Center
SSC	Superconducting Super Collider
TNRLC	Texas National Research Laboratory Commission
TRCR	Texas Radiation Control Regulations
TWC	Texas Water Commission
WISD	Waxahachie Independent School District

SUMMARY

As part of a settlement agreement between the U.S. Department of Energy (DOE) and the State of Texas, DOE proposes to transfer $65 million of federal funds to the Texas National Research Laboratory Commission (TNRLC) for construction of the Regional Medical Technology Center (RMTC) to be located in Ellis County, Texas. The RMTC would be a state-of-the-art medical facility for proton cancer therapy, operated by the State of Texas in conjunction with the University of Texas Southwestern Medical Center. The RMTC would use the linear accelerator (linac) assets of the recently terminated DOE Superconducting Super Collider project to accelerate protons to high energies for the treatment of cancer patients. The proposed RMTC would be constructed on roughly 4 ha (10 acres) immediately adjacent to the existing linac facility. The current design provides for treatment areas, examination rooms, support laboratories, diagnostic imaging equipment, and office space as well as the accelerators (linac and synchrotron) and beam steering and shaping components.

The sole alternative to the proposed RMTC is no action. No action on the part of DOE would mean that the provision of the settlement agreement committing DOE to transfer $65 million of federal funds to TNRLC would be rescinded. Consequently, construction of the RMTC would require an alternative source of funding. The State of Texas would either develop alternative funding sources or abandon the proposed RMTC.

The potential environmental consequences of the proposed action are expected to be minor.

- Construction of the facility would disturb approximately 4 ha (10 acres) of previously disturbed land. Fugitive dust generated during construction would not increase ambient particulate matter concentrations above the 50 $\mu g/m^3$ National Ambient Air Quality Standard.
- The RMTC would be built on land previously disturbed by SSC construction. No federally listed threatened and endangered species would be impacted.
- There are no wetlands on the proposed site. Nearby wetlands would be protected from sedimentation during construction by erosion controls, such as hay bales and other runoff barriers.
- The proposed site is above the 100-year floodplain of Boz Creek.
- Water resources could receive sediment runoff during periods of heavy precipitation. During operations, tritium would result from activation of near-surface groundwater; concentrations would be below the EPA drinking water quality standard (20 pCi/mL). Groundwater discharges to Boz Creek would introduce low levels of radioactivity.
- Beyond the obvious benefits associated with improving the health and well-being of cancer patients, the proposed RMTC would provide jobs, boosting the local economy, and have little stress on the local infrastructure.
- There are no known cultural or historic resources on the proposed site.
- Noise effects from construction and operation of the RMTC are expected to be negligible.
- A potential hazard to workers and the general public during operation of the facility would be the emission of radioactive materials. Modeling results indicate that the maximum annual dose equivalent (8.6×10^{-3} mrem/year) would be delivered to an individual located 100 m (330 ft) north of the RMTC heating, ventilating, and air conditioning stack. This dose equivalent is less than 0.1% of the 10-mrem/year EPA public exposure limit from atmospheric radionuclide releases. Thus, atmospheric radionuclide emissions from the proposed facility would be expected to have a negligible impact on public health. The annual expected dose to an

occupational worker would be below 500 mrem (10% of the 5000 mrem/year DOE exposure limit).

- In the absence of adverse impacts to any populations arising from construction and operation of the proposed RMTC, no disproportionate impacts are expected for minority and low-income populations.

1. INTRODUCTION

Public Law 103-126 mandated the termination of construction of the Superconducting Super Collider (SSC) in Ellis County, Texas. A provision of the law required the Secretary of Energy to consider possible alternative uses of SSC assets to maximize their value to the nation. One use being considered by the Department of Energy (DOE) and the State of Texas is a Regional Medical Technology Center (RMTC) that would house a proton therapy facility for on-site treatment of patients with certain types of cancer. The RMTC would make extensive use of the partially constructed linear accelerator (linac) and ancillary facilities of the SSC project.

This environmental assessment (EA) has been prepared by DOE, in compliance with the National Environmental Policy Act (NEPA) of 1969, to evaluate environmental issues associated with the construction and operation of the RMTC. This section discusses the proposed action, purpose and need for the project, scope of the EA, assumptions and approaches, and agencies and individuals contacted.

1.1 BACKGROUND

Each year, more than 1 million Americans are diagnosed with cancer, and by 1999 it is expected that more than 90,000 cases will be seen each year in Texas alone. Some cancer deaths can be prevented by directly destroying cancer cells. A common and often effective form of therapy is to treat the cancer with beams of radiation, such as x-rays, gamma rays, or neutrons. With these types of radiation treatment, however, the greatest radiation dose is near the surface of the patient's body, and the dose decreases with depth of penetration into the body. As a result, the healthy tissue in front of a deep-seated cancer tumor would receive a larger dose of radiation than the tumor itself, and the healthy tissue behind the tumor could receive an appreciable dose. This unavoidable damage to healthy tissues often causes serious side effects and generally reduces the usefulness of such therapy in spite of its effectiveness in destroying the cancer itself.

In contrast, the treatment of cancer using a beam of protons (the positively charged particle in a hydrogen atom) has a significant advantage. When a proton beam is accelerated to high energy and directed at a tumor, the protons gradually slow down, releasing a modest radiation dose to the area near the surface of the body as they slow. Then, when the protons are moving very slowly, the radiation dose increases rapidly until the protons come to a complete stop. The increased radiation dose is called the "Bragg peak," named for the discoverer of this effect. Because proton beams can be specifically tailored to each patient by beam-shaping devices, an effective dose of radiation is delivered primarily to the tumor, and healthy tissues can largely be spared (Fig. 1.1). This ability to deliver the radiation dosage primarily to the diseased area makes proton therapy an extremely precise form of cancer treatment. Such precision is especially desirable when a tumor is located near the brain or spinal cord.

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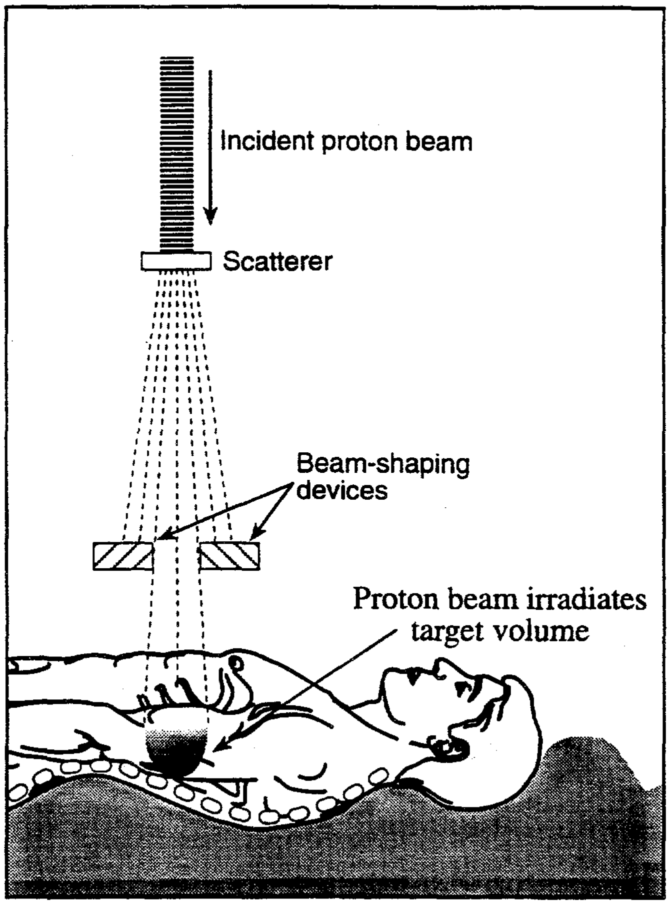

Fig. 1.1. Delivery of the proton beam to the tumor.

1.2 PROPOSED ACTION

As part of a settlement agreement between DOE and the State of Texas (November 3, 1994), the proposed action by DOE is to transfer $65 million of federal funds to the Texas National Research Laboratory Commission (TNRLC) for construction of the RMTC in Ellis County, Texas. It would be operated by the State of Texas in conjunction with the University of Texas Southwestern Medical Center. The RMTC would utilize the linac assets of the recently terminated SSC project to accelerate protons to high energies. Accelerated protons would be used for the treatment of cancer patients at the site. DOE's role in the proposed action is limited to providing the $65 million contribution.

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION AND PROJECT

A provision of Public Law 103-126 requires DOE to maximize the value to the nation of the former SSC assets. In addition, a settlement agreement was developed to resolve claims asserted by the State of Texas against the United States in connection with the termination of the SSC project. Included among the settlement agreement provisions are the following DOE actions: transfer SSC-related property (both real and personal) to the State of Texas, restore and remediate the former SSC site, provide an option for the State of Texas to purchase SSC-related computer equipment, pay $145 million to the State of Texas, and contribute $65 million to the State of Texas for the construction of the proposed RMTC at the site of the former SSC linac (the linac is to be part of the RMTC). The purpose of the proposed action is to satisfy the provision of the settlement agreement that provides the $65 million from DOE for the construction of the RMTC.

1.4 SCOPE OF THE ENVIRONMENTAL ASSESSMENT

This EA has been prepared in accordance with NEPA, as amended, the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1500-1508), and DOE's NEPA implementing procedures (10 CFR 1021). Although not required for an EA, DOE also conducted an external scoping process, including public meetings. An announcement of the intention to prepare the EA and hold public scoping meetings was published in the *Waxahachie Daily Light* on December 18, 1994, and January 8 and 12, 1995. The announcement invited the public to participate in the NEPA process and make suggestions on the proposed scope of the EA. Copies of the announcement were placed in public libraries in the towns of Waxahachie and Ennis, Texas. DOE held scoping meetings in Waxahachie on January 13 and 14, 1995. The public was invited to provide oral comments at the scoping meetings and to submit additional comments in writing to DOE by January 31, 1995. DOE received one written and two oral comments.

Potentially affected resources that were identified for analysis in the announcement included water resources, ecological resources, air resources, geology, noise, health and safety, socioeconomics, cultural resources, visual effects, and cumulative impacts. No additional potentially affected resources were identified during the public scoping process and the EA analyses.

DOE and the State of Texas are considering alternative uses for other assets of the SSC, including (1) the Applied Superconductivity and Cryogenics Technology Center, (2) the Regional Center for High-Performance Computing, and (3) Blackland Prairie Restoration. As appropriate, the environmental impacts of alternative uses would be evaluated independently of this EA according to the requirements of NEPA.

1.5 ASSUMPTIONS AND APPROACHES

The assumptions and approaches for this EA are:

1. Providing funding for the RMTC is independent of any other actions related to the closure and reclamation of the SSC.
2. The environmental impacts of the construction and operation of the SSC are described in the Final Supplemental EIS (FSEIS) for the SSC (DOE 1990). CEQ NEPA implementing regulations (40 CFR 1508.28) provide for the coverage of general matters in broader EISs with subsequent

narrower statements or environmental analyses incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Therefore the FSEIS is available as a reference document for this EA.

3. Consistent with item 2, this EA analyzes in detail only those environmental issues that have the potential to differ substantially from comparable issues analyzed in the FSEIS. When there is a substantial similarity, a brief summary is presented, followed by a reference to the appropriate section of the FSEIS.
4. It is beyond the scope of this document to attempt to determine the efficacy or appropriateness of radiation doses to the cancer patients who would be treated at the proposed RMTC.

1.6 AGENCIES AND INDIVIDUALS CONTACTED

The following people were contacted during preparation of this EA:

D. Madden	U. S. Army Corps of Engineers	Fort Worth, Texas
S. Sievers	Buena Vista Bethel Water Supply Company	Maypearl, Texas
R. Sokoll	City Manager	Waxahachie, Texas
D. Wilhelm	U.S. Fish and Wildlife Service	Arlington, Texas

2. PROPOSED PROJECT AND ALTERNATIVES

2.1 PROPOSED PROJECT

The RMTC would be a state-of-the-art proton cancer therapy facility, and would be operated by the State of Texas in conjunction with the University of Texas Southwestern Medical Center. The RMTC would utilize the partially completed linac assets of the recently terminated SSC project to accelerate protons to high energies for the treatment of cancer patients at the site. The facility would be located in the immediate vicinity of the existing linear accelerator.

2.1.1 Project Location

The proposed location of the RMTC in Ellis County, Texas (Fig. 2.1) is about 40 km (25 miles) south of Dallas and about 10 km (6 miles) southwest of Waxahachie. The site is south of Old Maypearl Road and west of Arrowhead Road (Fig. 2.2). Some flexibility exists in the exact positioning of the RMTC relative to the linac and the exact amount and distribution of land required. Current facility designs limit the site boundary to the land [approximately 4 ha (10 acres)] immediately surrounding the linac.

2.1.2 Project Description

The linac that would have functioned as the low energy portion of the proton beam injector for the SSC had been partially completed before the SSC project was terminated. As shown in Fig. 2.3, the RMTC would use existing linac assets in a proton therapy complex. A new proton synchrotron would be added to achieve the beam energy required for proton therapy.

The completed portion of the SSC linac along with a segment that has almost been completed, would be used to inject the linac beam into the new synchrotron, a type of circular accelerator designed to provide a high-energy proton beam. The high-energy beam from the synchrotron would then be transported through a system of magnets, instruments, and beam-shaping devices to be focused appropriately for the cancer patient. The energy of the proton beam provided by this system could be as high as 350 MeV.

The existing SSC Linear Accelerator Building would house the injector for the proton therapy synchrotron (Fig. 2.3). The injection beam would be transported from the injector to the synchrotron via a new underground tunnel, and the synchrotron itself would be located in a new multi-story building that would also house the patient treatment areas (Figs. 2.3 and 2.4). Clinical areas in this new building would be used for diagnostic imaging, treatment planning, patient support, administration, and staff support.

Liquid radioactive wastes would consist primarily of activated magnet cooling water. Activity in the cooling water would be monitored and released to the sanitary sewer system at levels well below the Texas Radiation Control Regulations (TRCR) specified in TRCR Part 21, Appendix B, page 66. Cooling water released would be replaced by clean tap water. The most abundant radionuclide at the time of release would be tritium (^3H). At LLUMC, a similar proton therapy facility has tritium levels in cooling water that are about 30% of the drinking water standard for tritium (20 pCi/mL).

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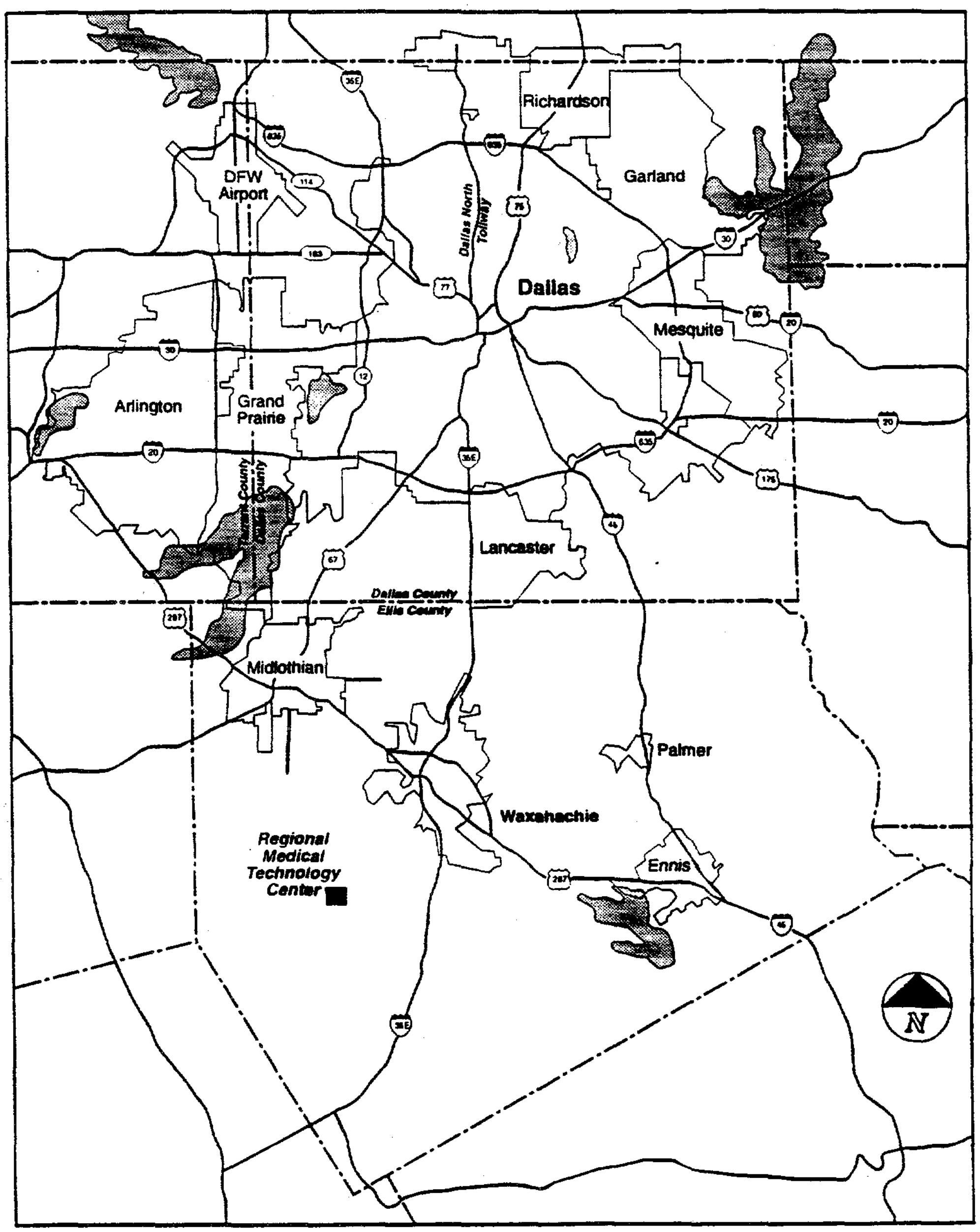

Fig. 2.1 Proposed location of the Regional Medical Technology Center in Ellis County, Texas.

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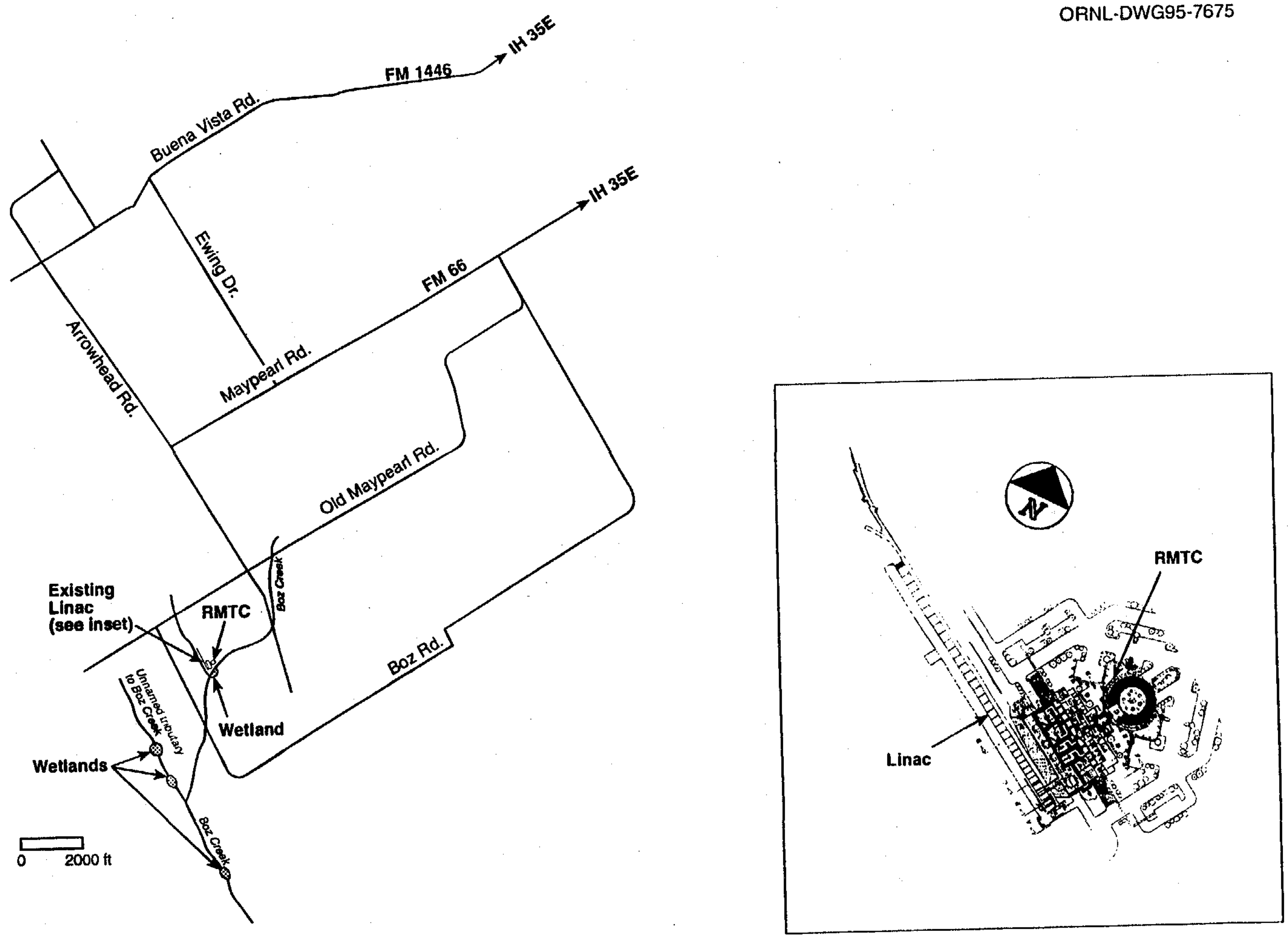

Fig. 2.2. Site of the proposed Regional Medical Technology Center. RMTC = Regional Medical Technology Center, FM = farm-to-market road, IH = interstate highway.

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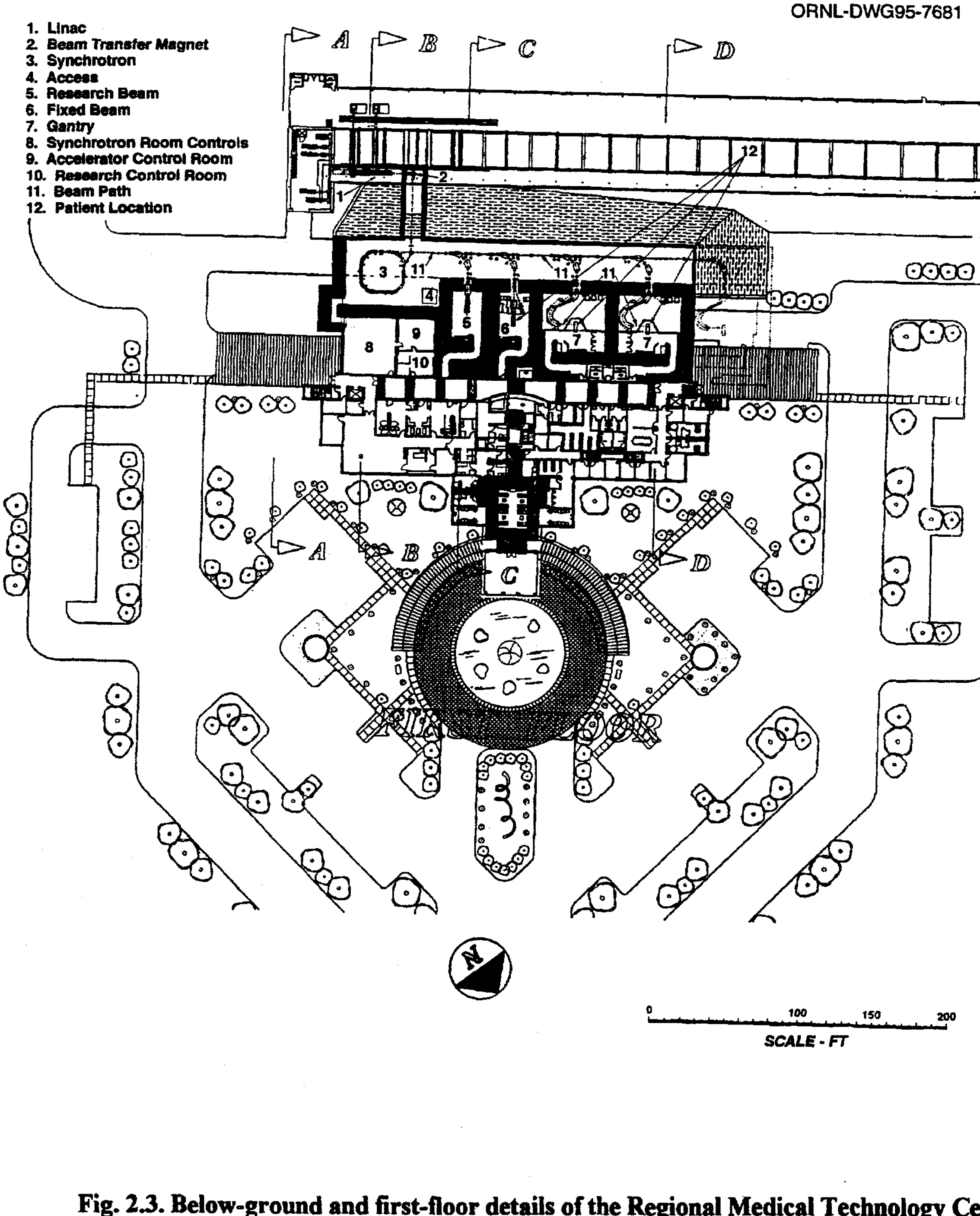

Fig. 2.3. Below-ground and first-floor details of the Regional Medical Technology Center. linac = linear accelerator. Cross-sectional views (A-A, B-B, C-C, and D-D) are shown in Fig. 2.4.

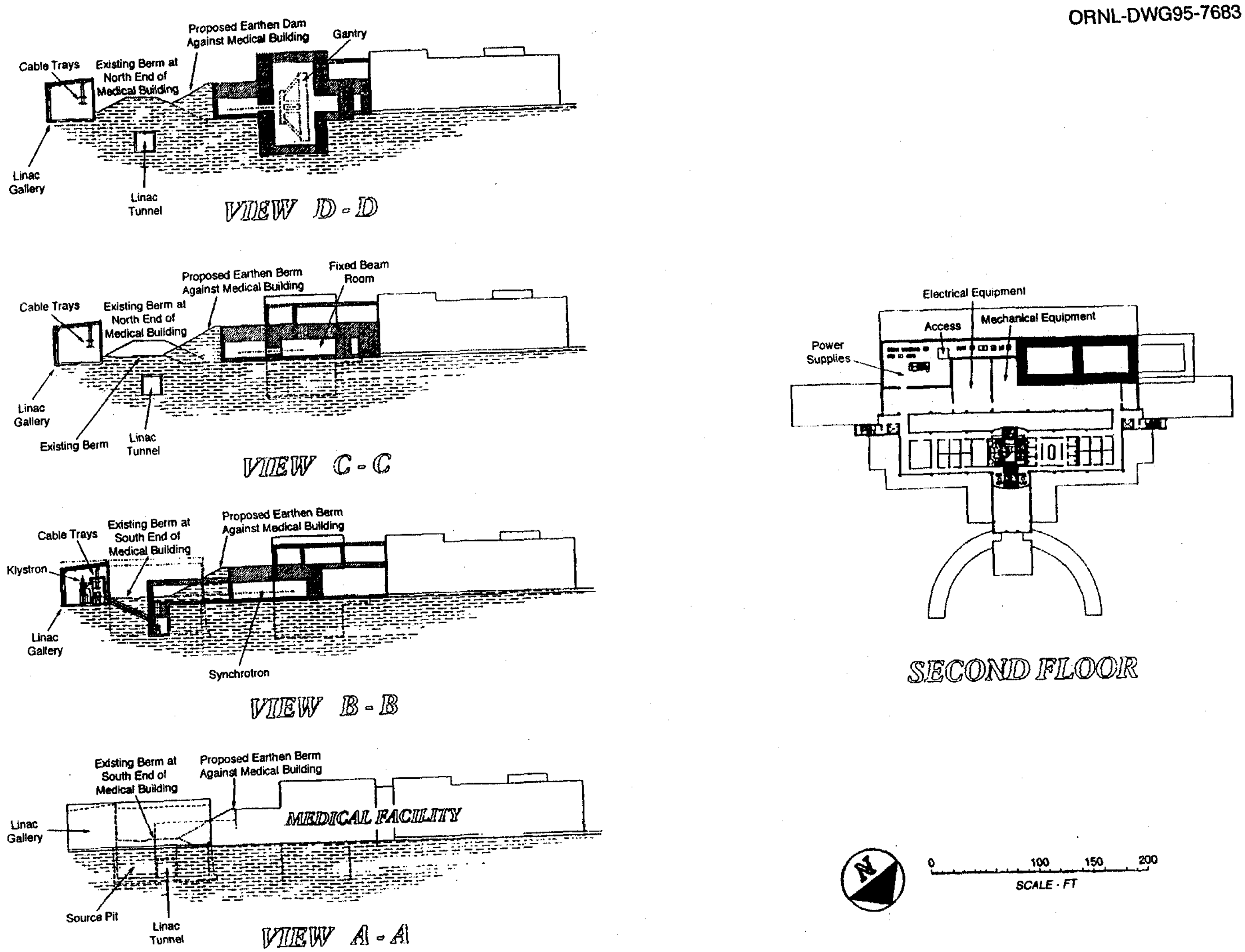

Fig. 2.4. Second-floor and cutaway details of the Regional Medical Technology Center. linac = linear accelerator.

Solid radioactive materials at the RMTC would consist primarily of activated beam line components which are reusable after storage to allow for radioactive decay of the induced short-lived radionuclides (see Sect. A.4.2). These activated beam line components would be replaced from inventory and stored on site until they could be reused. These materials are thus not strictly considered to be wastes. These and other activated materials produced during operation of the RMTC as a medical facility would be handled by the on-site radiation control officer under TRCR control (see Sect. 4.2.4.3). Total amounts of solid wastes are expected to be less than 100 kg/year (220 lb/year).

The RMTC would be located immediately north of a confluence where Boz Creek splits into eastern and western legs (see Fig. 2.2). The longer eastern leg extends northward for 3 km (2 miles). A portion of the shorter 1.6-km (1-mile) western leg was relocated during construction of the linac. The new channel was excavated approximately 50 m (150 ft) west of the linac.

Vehicular access to the RMTC would be provided by a driveway to Arrowhead Road, which would in turn provide access to Interstate Highway 35 via farm-to-market roads 66 or 1446. An existing hard-packed roadway extends around the site. The principal structure of the existing linac is the RF (Radio Frequency) Gallery Building, an 8-m (27-ft) wide, 6-m (20-ft) high, and 260-m (850-ft) long structure equipped with an operational chilled-water cooling system, gas heating units, and a functioning fire protection system. The RMTC would be a three-floor structure: one partial sub-surface floor, one floor at the surface level, and one above-surface level floor. The floor-to-floor heights would be approximately 5 m (15 feet) (TNRLC 1995). Proposed landscaping and layout for the subsurface and first floor of the facility are shown in Fig. 2.3. The layout of the second floor and cutaway views of the proposed facility are shown in Fig. 2.4. Berms shown in the cutaway views would provide additional radiation shielding for people outside the facility.

The proton beam originates in the linac (see Fig. 2.3), passes through a beam transfer magnet into the 11.5-m (35-ft) underground tunnel, accelerates to the required energy in the synchrotron, and moves down the beam path to the irradiation rooms. Gantries in two irradiation rooms enable the beam direction to be changed without moving the patient.

Utilities are readily available to this relatively flat site. Electrical power would be supplied by TU Electric from a Waxahachie substation. Transformers at the existing linac walk-in substation on the west side of the building would be replaced or rewound to accept a 25-kV primary voltage with 480/277-V output. The substation would be relocated adjacent to the main electrical loads.

Storm water drainage from the RMTC would be controlled by grading and sloping the land surface and installing a system of culverts, drains, ditches, and gutters. If necessary, a storm water detention basin would be installed. Sump pumps would remove excess surficial groundwater collected by French drains installed underground around the RMTC (similar to the existing French drains at the linac). The RMTC sump pumps would discharge into and augment the flow of Boz Creek. Sanitary/industrial or conventional sewage from the facility consisting primarily of human waste would be accommodated by piping (and pumping, if necessary) the wastewater effluent to a treatment plant located at the SSC West Campus (DOE 1990), or alternatively, by using a standard septic tank/drain field system.

Water supply during construction and operation would be obtained either from the Buena Vista Bethel Water Supply Company (BVBWSC) northeast of Maypearl (groundwater supply) or from the cities of Waxahachie and Ennis (surface water supplies). A water line is available at the linac that could be connected to any one of these water supplies.

2.2 NO ACTION ALTERNATIVE

No action on the part of DOE would mean that the provision of the settlement agreement to transfer $65 million of federal funds to TNRLC would be rescinded. The no action alternative could result in abandonment of the proposed RMTC or development of other funding sources by the State of Texas. The no action alternative is considered here in accordance with CEQ and DOE NEPA regulations even though there is a congressional mandate for DOE to execute a settlement agreement with the State of Texas.

2.3 ALTERNATIVES DISMISSED FROM CONSIDERATION

Alternative locations were not considered because the proposed RMTC would make use of the partially completed linac and ancillary facilities of the recently terminated SSC project. Consequently, it must be located near those facilities. Alternative siting at more remote locations would be an issue only if the RMTC were to be built without using the SSC facilities.

3. AFFECTED ENVIRONMENT

A brief description of those resources identified in the scoping process as potentially affected by the proposed RMTC are presented in this section. Those resources and related issues include land use, air quality, water resources, ecological resources, health and safety for both the public and workers, geologic issues, noise, socioeconomic resources, cultural resources, and visual effects. A detailed description of the affected environment in the vicinity of the proposed RMTC appears in the FSEIS (DOE 1990).

3.1 LAND USE

Ellis County is situated in the Blackland Prairie Ecological Province, a crescent-shaped zone that stretches from the Red River Bottomland through Dennison, Dallas, Waco, Temple, and Austin to the Rio Grande plain in the San Antonio area. The region's name is derived from the black soil that was very productive prior to the introduction of cotton. The Blackland region is host to 38% of the state's population on about 7.8% of its land (Baylor University 1990).

All the land to be utilized for the RMTC was formerly part of the SSC project. The land was previously used primarily for grazing livestock. The land had been disturbed by many years of intensive agricultural use. None of the original Blackland Prairie can be found at the site of the proposed RMTC (DOE 1988).

3.2 ATMOSPHERIC RESOURCES

The climate of northeast Texas is humid and subtropical with hot summers and mild winters. The relatively nearby Gulf of Mexico provides a moderating, humid effect. Local meteorology in the vicinity of the SSC site (and by inclusion the RMTC site) is described in the Final Environmental Impact Statement (FEIS) (DOE 1988).

Meteorological data representative of the area have been collected from the National Weather Service station at the Dallas-Fort Worth airport. These data have been used in air dispersion modeling of radioactivity produced when the RMTC proton beam travels through air to reach the patient (Appendix B). Comparable but somewhat older data are identified in the FSEIS (Sect. 3.5) for use in the modeling of SSC construction air quality impacts and exposure associated with routine releases of air activation products (radioactive species that would be produced when the proton beam would pass through air) during SSC operation.

As presented in the FSEIS (Sect. 3.6), Ellis County has excellent air quality and is designated as attainment or unclassifiable for all criteria pollutants designated by the U.S. Environmental Protection Agency (EPA) (criteria pollutants are those for which National Ambient Air Quality Standards (NAAQS) have been established to protect public health and welfare).

Emission inventories of existing air pollutant sources within and near Ellis County are presented in the FSEIS (Sect. 3.6.2). The FSEIS identifies only four sites having emission rates exceeding 450 kg/h (1000 lb/h) of any criteria pollutant. The four sites are north or north-northwest of the SSC site.

During site preparation and construction of the SSC facilities, ambient air monitors were operated on site because of concern over fugitive dust emissions. These ambient air monitors measured concentrations of particulate matter small enough to move easily into the lower respiratory tract (particulate matter less than 10 microns in diameter, designated PM_{10}). At no time during heavy construction activity (1992-1993) did levels exceed the 24-h or annual average NAAQS for PM_{10} (SSC 1992 and SSC 1993). The highest 24-h average PM_{10} concentration measured in 1992-1993 was just under 84 $\mu g/m^3$ (56% of the 150 $\mu g/m^3$ 24-h standard). Annual average concentrations for 1992 and 1993 were about 29 $\mu g/m^3$ and 34 $\mu g/m^3$, respectively (58% and 68% of the 50 $\mu g/m^3$ annual standard, respectively). Maximum concentrations were recorded at monitors north of the construction site in the direction that prevailing winds would transport fugitive dust.

Since the termination of the SSC project, disturbed areas were stabilized and revegetated, and fugitive dust emissions have been effectively curtailed. The highest 24-h average PM_{10} concentration measured between April 1994 and January 1995 was about 44 $\mu g/m^3$ (29% of the 150 $\mu g/m^3$ 24-h standard).The average concentrations for this period was about 18 $\mu g/m^3$ (36% of the 50 $\mu g/m^3$ annual standard). These values are well below the NAAQS indicating that air quality is good with respect to PM_{10}.

3.3 WATER RESOURCES AND GEOLOGY

Water resources and associated geologic issues are presented for both the surrounding region and the site of the proposed RMTC.

3.3.1 Surface Water

The details of the surface water environment are described in Sects. 3.3.1.1 (Hydrology), 3.3.1.2 (Water quality and use), 3.3.1.3 (Floodplains), and 3.3.1.4 (Wetlands).

3.3.1.1 Hydrology

The proposed RMTC would be located near the headwaters of a small, unnamed, ungaged, north-to-south flowing tributary to Chambers Creek that is referred to anecdotally as Boz Creek (see Fig. 2.2) (USGS 1978; DOE 1990). The confluence of Boz and Chambers creeks occurs approximately 5 km (3 miles) south of the RMTC. Chambers Creek is a major tributary of the Trinity River that originates northwest of Dallas and empties into the Gulf of Mexico near Galveston.

Flow in the Trinity River watershed, including Chambers Creek, is controlled by a series of retarding basins which provide for flood control, water supply, and aquatic recreation. Chambers Creek flows into Richland-Chambers Reservoir 64 km (40 miles) downstream and southeast of the RMTC site. Lake Waxahachie (on South Prong Creek) and Bardwell Lake (on Waxahachie Creek) are located upstream from the mouth of Chambers Creek and the RMTC. A small privately owned dam is located on Boz Creek 0.8 km (0.5 mile) above the Chambers Creek confluence. Storage behind the small dam is used to water livestock.

The flow of Boz Creek tends to be intermittent (usually nonzero) near the proposed RMTC site. During the summer and periods of prolonged drought, the flow near the RMTC site reduces to a small trickle, and on rare occasions is zero. Further downstream, the flow is more ephemeral (occasionally zero). The flow of Boz Creek is strongly coupled to the discharge of groundwater from the unconfined, surficial aquifer in the weathered Austin Chalk (see Sect. 3.3.2.2). The gaining reach near the RMTC site is sustained by groundwater discharge while the losing reach further downstream recharges the groundwater. The Boz Creek channel is incised from 1.5 to 4.5 m (5 to 15 ft), and the creek width varies from 3 to 6 m (10 to 20 ft). Water depths near the RMTC after moderate sustained rainfall range from 0.3 to 0.6 m (1 to 2 ft). The course of Boz Creek is well vegetated along both banks. The linac sump pumps presently discharge into and augment the flow of Boz Creek. The RMTC sump pumps would also discharge into and augment the flow of Boz Creek.

3.3.1.2 Water quality and use

Water quality in the Chambers Creek watershed is excellent (TWC 1992). The Texas Water Commission (TWC) (recently reorganized and designated the Texas Natural Resources Conservation Commission) has designated Chambers Creek as acceptable for recreation, high-quality aquatic habitat, and public water supply. Total dissolved solids, chloride and sulfate concentrations, and pH comply with national primary (40 CFR 141) and secondary (40 CFR 143) drinking water standards and TWC water quality criteria.

The Trinity River watershed (fed in part by Chambers Creek) has elevated fecal coliform levels as a result of runoff from livestock production areas and seepage from septic systems. Upstream urbanization associated with the Dallas-Fort Worth metropolitan area continues to deteriorate surface water quality (dissolved oxygen, suspended solids, phosphates, fecal coliform, algal blooms, and aquatic life) (TWC 1992). Water treatment is required prior to human consumption. Particularly stressed portions of the Trinity River watershed are located downstream from the RMTC site.

Approximately 90% of water withdrawals (including public water supply) for Dallas and Fort Worth are obtained from reservoirs in the Trinity River watershed (Barber, Lurry, and Lynn 1990). Dependence on surface water supplies has increased because groundwater reserves have been overpumped. Surface water supplies also are replacing groundwater for municipal use in Ellis County (DOE 1990).

3.3.1.3 Floodplains

In 1987, flood insurance studies were performed by the Federal Emergency Management Agency for unincorporated areas in Ellis County which have experienced or could be threatened by flooding from Chambers Creek. Delineation of the 100-year floodplain did not include Boz Creek. Baker and Mill branches—two tributaries of Chambers Creek—have drainage basin characteristics (e.g., soils and topography) and hydrology similar to Boz Creek. The 100-year floodplain widths (bank-to-bank) quoted for Baker and Mill Branches were 61 and 76 m (200 and 250 ft) respectively (DOE 1990). Boz Creek would be expected to have a similar 100-year floodplain width. The distance of the RMTC from the bank of the relocated portion of Boz Creek exceeds 50 m (150 ft); it is beyond the 100-year floodplain.

3.3.1.4 Wetlands

The nearest wetlands identified on U.S. Fish and Wildlife Service national wetland inventory maps are two small, less than 0.5 ha (1 acre), palustrine wetlands located about 800 m (2600 ft) south-southwest of the proposed site. These wetlands were formed by dams on a tributary to Boz Creek. Riparian wetland lies along Boz Creek itself approximately 1.5 km (0.9 mile) south of the RMTC site. Reportedly, there also is possibly a small, man-enhanced (via groundwater and stormwater discharge) wetland associated with Boz Creek roughly 100 m (330 ft) to the south and west of the existing linac. The proposed project would not physically encroach into the man-enhanced wetland area.

3.3.2 Groundwater and Geology

3.3.2.1 Geology, soils, and structure

The proposed RMTC site is underlain by massive sedimentary beds of Cretaceous (63–138 million years old) chalk, marl, and shale (DOE 1990). The topmost Austin chalk extends downward for 131–152 m (430–500 ft) (Nance, Laubach, and Dutton 1994). Thicker beds of chalk alternate with thinner beds of marl. The deeper Eagle Ford shale (South Bosque formation) varies in thickness from 91 to 130 m (300 to 425 ft) (Dutton et al. 1994). Fine-grained Woodbine sands underlie the Eagle Ford shale.

Weathering and unloading have altered the exposed surficial Austin chalk. The depth of the weathered zone averages 3.6 m (12 ft). Depths occasionally extend to 11 m (35 ft). The effects of weathering increase porosity and permeability, which in turn promote recharge, storage, and movement of shallow groundwater.

Regional topography near the proposed RMTC site consists of low floodplains, broad flat upland terraces, and rolling hills. Some stream locations in Austin chalk outcrops are controlled by fractures and faults. Holocene (as much as 10,000 years old) alluvium has been deposited along major stream channels and on their floodplains.

The Austin chalk breaks down into a fine-grained, poorly drained, black, waxy soil (Gordon 1911). The soil layer is thin because of the relative hardness and insolubility of the chalk There is no evidence of the past use of agricultural drain tiles on or near the proposed site.

The proposed RMTC site is located at the northern end of the Balcones Fault Zone, which is one of the several normal fault zones that rim the Gulf coastal basin. The Balcones Fault Zone extends southwestward from Dallas to beyond San Antonio. Major faults tend to be located west-to-northwest of the RMTC site, have displacements ranging from 6 to 30 m (20 to 100 ft), and probably flatten and die out within the Eagle Ford shale (Nance, Laubach, and Dutton 1994).

Faults and joints within the partially completed SSC tunnel (and in the Austin chalk) are arranged in clusters approximately 300 m (1000 ft) apart (Nance, Laubach, and Dutton 1994). The presence of fault and joints has been neither confirmed nor denied beneath the RMTC site. The transmission of groundwater through fault and joints is quite rapid relative to the slow seepage that occurs in massive bedrock.

3.3.2.2 Aquifers

The RMTC site is situated above a near-surface unconfined aquifer in the weathered Austin chalk and a deeper regional confined aquifer system (DOE 1990). In order of increasing depth, the deeper regional groundwater system consists of the Woodbine, Paluxy, and Twin Mountains aquifers. The Paluxy and Twin Mountains aquifers also are referred to as the Trinity group aquifers. Approximately 223–282 m (730–925 ft) of Austin chalk and Eagle Ford shale confine the deeper aquifers. The Woodbine, Paluxy, and Twin Mountains aquifers are separated by sedimentary strata which inhibit the vertical interchange of groundwater. The RMTC site is not located near shallow aquifers that reside in alluvial and terrace deposits adjacent to major surface drainageways.

The local extent of the shallow aquifer is defined by the Austin chalk. The highly variable flow direction in the surficial Austin chalk approximately parallels local topography and is strongly influenced by the direction and intensity of fracturing and weathering (DOE 1990). The presence of dry zones provides for an ephemeral, discontinuous flow of groundwater. Low areas receive upgradient groundwater, tend to be wet and muddy, and serve as discharge points into local creeks. Groundwater discharge from the area of the beam dump would be to Boz Creek. Recharge is provided directly by precipitation. The water table responds rapidly to rainfall and declines significantly during dry periods. Except possibly during periods of extreme drought, the elevation of the proton beam would be below the elevation of the shallow water table in the weathered Austin chalk.

The natural direction of groundwater flow in the Woodbine, Paluxy, and Twin Mountains aquifers (which all are confined aquifers) is downward to the east and southeast. Heavy pumping from the Woodbine and Twin Mountains aquifers has caused degradation of groundwater quality and flow (DOE 1990). The Paluxy aquifer has experienced minimal development because of its thinness relative to the Woodbine and Twin Mountains aquifers.

Outcrop areas for the Woodbine, Paluxy, and Twin Mountains aquifers are located west of the RMTC site. Recharge is provided by precipitation and stream crossings on these outcrops. Groundwater also flows downward through the confining layer (the Austin chalk and Eagle Ford shale beneath the RMTC site) and recharges the deeper regional aquifer system (Rapp 1988, cited in DOE 1990). Leakage through the confining layer is small relative to the recharge that occurs on the outcrops. Additional leakage, both natural and induced by pumping, occurs between the Woodbine, Paluxy, and Twin Mountains aquifers.

3.3.2.3 Groundwater quality and use

Groundwater in the shallow Austin chalk aquifer is low in total dissolved solids but very hard (DOE 1990). The highly variable flow of groundwater causes large water quality variations. Seepage from agricultural and anthropogenic activities has degraded water quality. Water treatment is required prior to human consumption. There are 75 registered wells completed in shallow aquifers in Ellis County (DOE 1990). Yields from the weathered Austin chalk aquifer approach 4 L/min (1 gal/min), while wells completed in alluvial or terrace deposits sometimes produce as much as 280 L/min (75 gal/min). The shallow aquifers provide groundwater to single family dwellings and small farms.

Groundwater quality in the confined aquifer system rapidly deteriorates to the east and southeast. Rapid total dissolved solids and temperature increases occur in direct proportion to the extreme depth to groundwater. Heavy pumping from the Twin Mountains aquifer has caused poorer-quality groundwater to migrate westward (i.e., flow reversal) beneath Ellis County.

The confined aquifer system is a major municipal water supply for Ellis County and the Dallas-Fort Worth metropolitan area. Larger communities in Ellis County are converting to surface water supplies such as Lake Waxahachie and Bardwell Lake (DOE 1990). Smaller municipalities such as Midlothian, Maypearl, and Rockett continue to pump the deeper aquifers for drinking water.

The BVBWSC pumps groundwater from the Twin Mountains aquifer (DOE 1990). A large cone of depression has formed beneath this pumping center. The area surrounding the BVBWSC is a critical groundwater management area as designated by the TWC and the Texas Water Development Board. Groundwater use in Ellis County is projected to remain relatively constant through the year 2020 because municipalities are converting to surface water sources.

3.4 HEALTH AND SAFETY

Licensed sources of man-made radiation are reported for the former SSC site area in the FEIS (DOE 1988). Although the actual number and location of licensed sites may have changed, the information presented is representative of the man-made radiation sources in the Dallas-Fort Worth region. No other sources of radioactivity, such as nuclear power plants, occur near the former SSC site. By inference, the distribution of sources of man-made radiation presented in the FSEIS is also representative for the proposed RMTC site. The total background radiation for Ellis County was given in the FSEIS as 100 mrem/year.

As reported in the FSEIS (DOE 1990), red fire ants and common household pests such as cockroaches occur in large numbers. The fire ants can cause extreme reactions in allergic individuals.

3.5 SOCIOECONOMIC RESOURCES

The socioeconomic environment defined for the SSC is also the affected environment for the proposed RMTC. Because SSC funding had been lower than projected in the FSEIS (DOE 1990), the direct workforce was approximately 19% smaller than predicted.

Termination of the SSC project is planned to continue through the 1996 fiscal year. Approximately 40% of the SSC workforce was terminated within the first 9 months, with another 40% lost the following year.

3.5.1. Demographics

The socioeconomic region of interest is the seven-county area (Ellis, Dallas, Hill, Johnson, Kaufman, Navarro, and Tarrant) and the metropolitan statistical areas of Dallas and Dallas-Fort Worth (see Table 3.1). Rockwall County was part of the original region of interest for the FSEIS (DOE 1990) and is included in this analysis for consistency. Because of the limited size of the proposed RMTC, all direct and infrastructure impacts described pertain to Ellis County and the city of Waxahachie.

The estimated 1993 population for Ellis County was 87,500, with 18,500 located in Waxahachie. This represents an estimated growth since 1990 of 2.7% for Ellis County and of 1.8% for Waxahachie. A number of minority groups live in Ellis County. In 1990, 10% of the population was Black, 0.4% was Native Americans, and 0.3% was Asian or Pacific Islanders; 13.2% of the total population classified themselves as Hispanic in the 1990 census. Waxahachie had 16.9% Black population, 0.4% Native American, and 0.02% Asian or Pacific Islanders. Among the total population, 14.7% classified themselves as having Hispanic origin (U.S. Bureau of the Census 1990).

Extensive demographic and marketing analyses were conducted for the SSC and are reported in the FSEIS (DOE 1990) and supplementary reports (TNRLC 1994a). Analysis of the regional labor market estimated that it would exceed 2.25 million by 1995 (Table 3.1). The largest demand for workers for the former SSC (roughly 3,900 in the peak construction year) would account for less than 0.5% of total regional employment (Orsak, McGlohen, and Jenkens 1992).

In the wake of the SSC project termination and prior to beginning the proposed RMTC, a number of personnel are currently employed on the SSC site. These individuals currently include a small construction and maintenance force, vendors, contractors, and security personnel.

Table 3.1. Employment in the region of interest

County	Total Employment		
	1990	1995	2000
Dallas	1,281,143	1,475,274	1,676,053
Ellis	22,291	25,670	29,165
Hill	5,627	6,482	7,361
Johnson	20,560	23,679	26,898
Kaufman	10,820	12,462	14,162
McClennan	80,300	92,471	105,054
Navarro	13,206	15,202	17,273
Rockwall	5,409	6,233	7,081
Tarrant	515,140	593,199	673,933
Total region of interest	1,954,496	2,250,672	2,556,980

Source: Orsak, McGlohen, and Jenkens 1992.

3.5.2 Public Services, Utilities, and Infrastructure

The proposed RMTC would require the following utilities: electricity, water, gas, sewage treatment, and stormwater removal. There are no rail lines serving the site.

Waxahachie is served by a municipal police force consisting of 49 officers and 6 reserve officers and a fire department with 34 paid personnel. Waxahachie is serviced locally by the Midlothian-Waxahachie Airport. The nearest airport with commercial air service is the Dallas-Fort Worth International Airport located 72 km (45 miles) to the north.

3.5.3 Cultural and Paleontological Resources

Previous research indicated that the SSC study area is "marginal," an archaeological term indicating that the study area is peripheral to the mainstream of sociocultural development witnessed throughout prehistoric and historic times in adjacent portions of Texas (Adovasio, Buyce, and Pedler 1992:88). Twelve significant historic sites eligible for the *National Register* were identified on the

SSC land. In addition, 19 archaeological sites consisting of artifact scatters and historic farmsteads were also identified.

3.5.4 Minority Groups in Ellis County, Texas

Executive Order 12898 of February 11, 1994, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directed all federal agencies to identify affected minority and/or low-income groups when determining the impacts of a proposed project using federal dollars. To examine whether specific minority groups would be impacted by the proposed project at the former SSC site in Ellis County, Texas, it was necessary to find where such groups existed in relation to the project site and their relationship to other groups within the county. As a conservative measure for health effects analysis, a 2-km (1.2-mile) radius was used around the proposed site in determining where minority groups were located. The minority group analysis used the most current census data, 1990, as directed by the DOE proposed guidelines on examining environmental justice impacts for NEPA documents. The Bureau of Census data provide the basis for identifying racial groups (U. S. Bureau of the Census 1993:4–5).

The data from the 1990 census indicate that minority groups of Hispanic origin lived in close proximity to the West Campus of the SSC when it was proposed. However, the acquisition of land for the SSC resulted in the relocation of about 500 people (including 2 subdivisions). Following the acquisition, the land was cleared. There are no populations, minority or otherwise, currently living within 1.2 km (0.7 mile) of the proposed RMTC site.

3.6 ECOLOGICAL RESOURCES

The FSEIS (Sect. 3.3) notes that substantially all the lands to be utilized for the former SSC project had been previously disturbed. There were no designated critical habitats for federally listed species. Of the species listed by the U.S. Fish and Wildlife Service, only one is a potential resident of Ellis County: the black-capped vireo. Breeding populations of the vireo have not been reported recently in Ellis County. None of the Category 2 species listed in the FSEIS were known to breed in the areas that would have been disturbed by the SSC surface facilities (including the linac). Two state-listed reptiles (timber rattlesnake and Texas horned lizard) have been confirmed in Ellis County, but their distribution was not given. There are no federal or state-listed plant species known to occur in the vicinity of the former SSC site. By inference, no protected plant species would occur in the vicinity of the proposed RMTC site.

4. ENVIRONMENTAL CONSEQUENCES

4.1 ENVIRONMENTAL CONSEQUENCES OF CONSTRUCTION

4.1.1 Land Use

The proposed RMTC would use the land and the SSC assets already in place. Although one portion of the proposed facility would be three stories tall, all measures would be taken in the design and landscaping of the proposed RMTC to ensure that it would not intrude on the visual attributes of the existing area. The facility would not be located in an industrial area but in an area likely to expand with other medical or high-technology development complementary to proton beam therapy. Centrally located on the 2,986-ha (7,376-acre) West Campus of the former SSC, the 4-ha (10-acre) site for the proposed RMTC facility would be largely devoted to grounds and parking lots.

The FSEIS (DOE 1990) concluded that the acreage involved with the former SSC would not cause perceptible reductions in major crops grown in Ellis County. Hence, the use by the RMTC of about 0.13% of the former SSC West Campus would have a negligible effect on crop production.

4.1.2 Atmospheric Resources

4.1.2.1 Air quality

The FSEIS (DOE 1990) presents an assessment of potential air quality impacts arising from construction of the SSC project [1,384 ha (3,418 acres) were expected to be disturbed]. It concluded that (1) the maximum annual PM_{10} concentration in the ambient air would be less than the 50 $\mu g/m^3$ standard, (2) emissions from construction-related vehicles and commuter vehicles would be minor, and (3) fugitive dust would be noticeable. For the SSC, mitigative measures (including wetting unpaved haul roads and wetting spoils piles) would have been applied to reduce fugitive dust generation to assure compliance with PM_{10} concentration limits. Construction impacts from the proposed RMTC would be only a very small fraction of those predicted for the SSC; the proposed RMTC would disturb less than 0.3% of the area expected to be disturbed by the SSC. The RMTC air quality impacts would be expected to be negligible if best management practices are employed.

4.1.2.2 Noise

Ambient noise levels would increase temporarily in the immediate vicinity of the site during the construction period. Construction of the proposed facility would require pneumatic tools, excavation equipment, trucks, and other miscellaneous equipment. Noise in the immediate vicinity of the construction activity would be well above the background value (40 dB) for a partially developed rural site, and also above the level recommended by EPA to protect against outdoor activity interference and annoyance (55 dB). For example, pneumatic power tools (e.g., jackhammers) can produce sound levels of 96 dB at distances of 16 m (52 ft) from the source (Canter 1977). This sound, propagating over a flat surface, could be readily audible outdoors (60 dB) at a distance of 1 km (0.6 mile) from the source during daylight hours (EPA 1974). A pile driver can generate impulse sounds of up to 105 dB at 16 m (52 ft) (Canter 1977). Such a sound could be heard at distances of 2 km (1.2 miles) or greater in partially developed rural area. Construction noise would only be generated during daytime hours and on a temporary basis. Use of particularly noisy equipment such as jackhammers or pile driver would occur on an even more temporary basis. Because the nearest resident is more than 1 km (0.6 mile) from the site, noise levels resulting from construction would be below the (70 dB) level of concern to protect against hearing loss to the nearest residents and, in most cases, would be below the level to protect against outdoor activity interference and annoyance (55 dB), with adequate margins of safety (EPA 1974).

In some cases, the noise could be audible to the nearest residents. Overall impacts of construction noise are expected to be very minor because the construction activities would occur during daylight hours, would not be continuous, and would cease after about 12 months.

4.1.3 Water Resources

4.1.3.1 Surface water

Excavation and earthwork during construction of the RMTC would alter the land surface. Construction would disturb soils and increase the potential for on-site runoff, erosion, seepage, and sedimentation. Standard engineering practices such as earthen and straw berms, liners, covers, plastic sheeting, and grading would control runoff, erosion, seepage, and sedimentation. Minimal, intermittent, uncontrolled runoff and associated sediments would flow overland into Boz Creek. Minimal adverse impacts would be expected because the flow in Boz Creek adjacent to the RMTC site is maintained by groundwater discharge from the shallow aquifer in the weathered Austin chalk, and would provide for continual dilution. During the summer the dilution provided by Boz Creek would be small because the flow reduces to a trickle. On rare occasions when the flow would be zero, no dilution would occur in Boz Creek. When available, the dilution would be augmented by the discharge of groundwater pumped from French drains surrounding the linac (see Sec. 4.1.3.2).

No adverse environmental impacts are expected from the disposal of sanitary waste during construction of the RMTC. Portable toilets would be provided for construction workers to augment existing linac facilities.

Accidental spills of construction materials would be rapidly cleaned up to minimize runoff and seepage. Impacts from accidental spills would be mitigated as well as minimized. At locations where the black waxy soil is undisturbed, accidental spills would tend to pond rather than seep into the ground, and would be accessible for cleanup for a longer time period.

4.1.3.2 Groundwater

Standard engineering practices for seepage control (see Sect. 4.1.3.1) would be implemented to minimize impacts to groundwater during construction. Potentially, some construction-related chemicals could seep into the shallow aquifer in the Austin chalk. These contaminants would migrate downgradient and discharge into Boz Creek with the natural baseflow or be captured by the French drains surrounding the linac from which pumping into Boz Creek would occur. The groundwater sink provided by the French drains partially protects the deeper confined aquifer system by collecting some of the construction-related seepage prior to downward migration. Additional groundwater protection would be provided by storing solvents in approved containers and refueling equipment in controlled areas. Impacts to the deeper aquifer are expected to be negligible. Abandoned wells, if encountered during construction, would be closed in a manner approved by EPA and the State of Texas.

4.1.3.3 Water Supply

Water supply during construction would be obtained from the BVBWSC northeast of Maypearl or from the cities of Waxahachie and Ennis. If the BVBWSC supplies groundwater from the Twin Mountains aquifer, no increase in potentiometric surface depression would occur because construction water requirements are intermittent. Large demands for short durations would be accommodated by storage tanks in the BVBWSC system designed to handle surges. The cities of Waxahachie and Ennis have reserve surface water capacity available from Lake Waxahachie and Bardwell Lake of approximately 3.26×10^6 m^3/year (2640 acre-ft/year) (combined total) that would be available through the year 2020 (DOE 1990). Consumption during construction represents 4% or less of the reserve surface water capacity of Waxahachie and Ennis.

Water use during construction would include rinsing of equipment and structures as well as preparation of mixtures such as concrete. Water would be available to extinguish accidental fires that could occur during construction. Based on experience with other projects similar in size and complexity to the RMTC, water consumption during construction would range from 0.1 to 0.4 ML/d (0.03 to 0.1 million gal/d) (Dames & Moore 1994, p. 4-12).

A water line is available at the linac that provides water for drinking, fire protection, and toilets. This water line would be tapped and used to provide water for construction activities. If required, drinking water for construction workers also would be provided using bottled water. Nonpotable water for construction also could be obtained from the discharge of groundwater pumped from French drains surrounding the linac when available.

4.1.3.4 Wetlands

There are no wetlands on the proposed site, but a potential wetland lies nearby along the small stream to the south of the site. DOE, through an interagency agreement (DE-AI02-90ER40600), has assigned the U.S. Army Corps of Engineers the task of evaluating and mitigating wetland impacts at the former SSC site. A riparian wetland also lies along Boz Creek about 1.5 km (0.9 mile) south of the proposed site. In any event, the proposed project would not encroach into this potential wetland. The principal effect of the proposed action on this possible wetland and the much more distant riparian wetland to the south would be a temporary increase in sediment loading from storm runoff during construction of the 4-ha site, and the possible introduction of accidentally spilled materials. These potential impacts could be minimized by standard engineering practices such as earthen and straw berms, liners, covers, plastic sheeting, and grading to control runoff, erosion, seepage, and sedimentation. The potential impacts of accidental spills could be further minimized by making spill clean up tools and materials always available and rapid implementation of a spill response and clean-up plan. The two wetlands on the unnamed tributary to Boz Creek would not be affected by project construction.

4.1.4 Health and Safety

Worker safety would be maximized during construction by adherence to good engineering practices, established safety procedures, and regulatory guidance.

There exists the potential for a non-zero health risk to construction workers arising from the pesticides used for the elimination of fire ants and other pests (DOE 1990). The risk would be minimized by adherence to the requirements of the Texas Department of Agriculture for application of baits and chemicals.

4.1.5 Socioeconomic Resources

The effects of construction of the RMTC on employment and demographics is presented in Sect. 4.1.5.1 and cultural resources in Sect. 4.1.5.2. It is expected that the small construction workforce would have negligible socioeconomic effects to the immediate community, county, and state.

4.1.5.1 Employment and demographics

The direct and indirect employment effects of the SSC were estimated in the FSEIS (DOE 1990) and in a follow-up study (DOE 1991). The finding that the SSC direct employment effects would exert pressure on only four occupations already in high demand in the region is likely to remain the same during construction of the proposed RMTC.These occupations are managers, secretaries, engineers, and technicians.

The construction workforce for the proposed RMTC would likely be similar to the original construction workforce for the SSC, but at a much lower scale. During construction of the RMTC, the estimated peak workforce would be 190, a number which could be accommodated easily within the regional labor market. The projected demand for 190 construction workers for the proposed RMTC would account for less than 0.01% of total regional employment (see Table 3.1). In Ellis County, with a projected 1995 labor force of 25,670, the 190 construction workers would account for only 0.7% of the total labor force. The labor requirements of the proposed RMTC would not constitute an adverse demand on the Ellis County and regional labor market.

4.1.5.2 Cultural resources

A programmatic agreement for the SSC project, detailed in the FSEIS (DOE 1990), was reached among the Advisory Council on Historic Preservation, DOE, the Texas Historical Commission, and TNRLC. The requirements of this agreement would ensure that inadvertent disturbance of undiscovered prehistoric or historic archaeological or cultural resources during construction of the RMTC would be mitigated.

4.1.5.3 Environmental Justice

In the absence of adverse impacts to any populations arising from construction of the proposed RMTC, no disproportionate adverse impacts are expected for minority and low-income populations.

4.1.6 Species of Special Concern

No breeding sites for the black-capped vireo have been identified near the proposed RMTC site. Hence, construction of the facility is not expected to affect the species. Because of the small size of the proposed site [4 ha (10 acres)], construction impacts on either the timber rattlesnake or the Texas horned lizard are expected to be negligible.

4.2 ENVIRONMENTAL CONSEQUENCES OF OPERATIONS

4.2.1 Land Use

The land proposed for use by the RMTC facility had been removed from agricultural use by the former SSC project. No change in use would be produced by operation of the RMTC on 4 ha (10 acres) of the former SSC West Campus site. Thus the operation of the RMTC would have a negligible impact of land use.

4.2.2 Atmospheric Resources

4.2.2.1 Air Quality

It was determined in the FSEIS (DOE 1990) that operation of the SSC would have a negligible impact on visibility. The projected CO_2 emissions from combustion of natural gas for heating and SSC-related traffic volumes were estimated to be negligible. Additionally, it was estimated that the SSC would contribute negligible quantities of methane and chlorofluorocarbons. By analogy, the substantially smaller RMTC would contribute only negligible quantities of CO_2 to global warming. Although the mix of gases utilized at the RMTC could differ from those estimated to be used at the former SSC, the difference in scale of the operations argues strongly in favor of the RMTC making negligible contributions to the atmospheric methane and chlorofluorocarbon inventory.

4.2.2.2 Noise

Operation of the proposed facility would introduce new equipment that would contribute a steady, broadband noise source that should blend in with the background nighttime sound level at distances of 500 m (1640 ft) or more under normal conditions. A large induced-draft fan, such as those used to cool power transformers, can generate up to 100 dB at 1 m (3 ft) (Canter 1977). This sound level would attenuate to about 45 dB at 500 m (1640 ft) if there are no barriers (e.g., walls) between the source and the receptor, and the sound propagates over a flat surface. These are worst-case assumptions; if silencers are used on any induced-draft fans, the noise would not be expected to be audible to an indoor resident during nighttime hours at distances of 500 m (1640 ft) or greater, even if the sound were propagating over a flat surface in a partially developed rural area. Because the nearest resident is more than 1 km (0.6 mile) away from the proposed facility, the noise would not be expected to be audible to any nearby residential population. Thus, noise effects from operation of the proposed facility on the nearest residents are expected to be negligible.

4.2.3 Water Resources

4.2.3.1 Surface water

Operation of the proton beam would have minimal impact on the water quality in Boz Creek. The tritium concentration in groundwater circulating beneath the beam dump and discharging into Boz Creek would be less than the primary drinking water standard.

Water lines within the RMTC would not be routed through the path of the proton beam or the beam dump area. Two factors would contribute to minimize activation of water: distance of water pipes from beam lines and beam dump and residence time of water in the pipes. If monitoring shows that water is being activated, water lines that could experience activation would be provided with shielding.

A small closed-loop cooling system would be used to cool magnets that control the direction of proton beam propagation. The closed-loop cooling system is located within the linac. Water in the closed-loop cooling system could be activated because of its close proximity to the beam and would be monitored on a regular basis. The radioactivity of any activated cooling water would be relatively low.

Experience with projects similar in size to the RMTC indicate that domestic wastewater would be discharged from the facility at approximately 114 m^3/d (30,100 gal/d) (Ensminger et al., 1991). Wastewater would consist of effluent from bathroom, shower, and laundry facilities as well as laboratory cleaning and monitoring devices. Hazardous, toxic, and medical (i.e., pathogenic) materials would not be discharged into the wastewater system. Wastewater would be piped from the RMTC site to a treatment plant located at the SSC West Campus (DOE 1990). The treatment plant was designed to accommodate wastewater from the SSC West Campus research facilities, linac, and booster rings. To accommodate the RMTC effluent, the treatment plant is expected to operate at 10–15% of capacity (a negligible impact) Effluent from the treatment plant would either be used for irrigation and industrial purposes if an appropriate permit could be secured, or evaporated to the atmosphere in a holding pond. Alternatively, wastewater would be accommodated using a standard septic tank/drain field system if the SSC West Campus treatment facility were not available. Sludge derived from either sanitary wastewater treatment option would be disposed of at an off-site facility licensed by the State of Texas.

Water resources would not be impacted by wastewater treatment that occurred at the SSC West Campus because undesirable constituents would not be released into the hydrosphere. If the septic tank/drain field option would be selected, increased levels of nitrates would occur in the surficial groundwater passing through the drain field. These nitrates would migrate down Boz Creek after the groundwater discharged into the creek. The presence of livestock along the lower portion of the Boz Creek already has increased the level of nitrates present.

Small volumes of activated water from the closed-loop cooling system for the magnets would be taken directly from the system and released into the wastewater system in a manner acceptable to both EPA and the State of Texas. Ordinary tap water then would be added to the cooling system. The maximum permitted release rate would be 5 Ci/year of tritium. Tritiated water would flow either to the SSC West Campus waste treatment plant or the septic system. The release rate would be too low to impact water resources.

If tritiated water from the closed-loop cooling system for the magnets could not be released into the wastewater system, as approved, suitably sized, holding tank(s) would be installed in a curbed area(s) for interim storage of activated cooling water. The tritiated water would be disposed of at a later date in a manner approved by both EPA and the State of Texas, and such that impacts to water resources would be minimized.

Boz Creek would receive runoff from parking lots and roofs during precipitation events. Anthropogenic contaminants would be mobilized and would flow downstream into the Trinity River watershed. This unavoidable impact would be expected to be negligible.

4.2.3.2 Groundwater

Operation of the RMTC would result in minimal impact to the shallow aquifer and the deeper confined aquifer system. Adequate shielding would be provided in the beam dump area to protect groundwater. At the 270-MeV–20-nA proton beam design point (Schailey 1995), groundwater radioactivity at a distance of 1 m (3 ft) from the bottom of the beam dump area (in the shallow aquifer) would comply with the primary drinking water standard for tritium (20 pCi/mL) (40 CFR 141). Schailey (1995) utilized the groundwater model developed by Baker et al. (1994) for use at the SSC project site to estimate groundwater radioactivities beneath and surrounding the RMTC facility. Routine operations would be 2–10 times lower in average beam intensity, typically lower in beam energy than the design point, and would result in less groundwater activation. Potential groundwater activation resulting from operation of the linac, proton beam transport through the new underground tunnel, and the synchrotron would be less than activation that could occur beneath the beam dump area.

French drains would be installed around the base of the RMTC. Groundwater collected by these drains would be pumped into Boz Creek. The French drains would decrease the residence time of a portion of the shallow groundwater beneath the facility and in turn decrease the time available for activation. The radioactivity induced in groundwater collected by the French drains and pumped into Boz Creek would comply with the primary drinking water standard for tritium. Impacts to Boz Creek would be minimized.

4.2.3.3 Floodplains

The linac borders the 100-year floodplain of Boz Creek. The RMTC would be built contiguous to the linac away from the relocated portion of the channel. This locale is below the 500-year floodplain and above the 100-year floodplain. Regional flooding would not threaten RMTC structural integrity.

4.2.3.4 Wetlands

During operations, very small amounts of tritiated water may be indirectly discharged to the potential wetland and the more distant riparian wetland. Because levels of tritium would be kept well below prescribed EPA and State of Texas limits, no adverse effects on the wetland or the biota supported by them would be expected. Triated water from the site would not reach the two wetlands on the unnamed tributary to Boz Creek.

4.2.3.5 Water Supply

Water consumption during operation would be more continuous relative to the intermittent supply required for construction (see Sect. 4.1.3.3). Water would be required for drinking, showers, laboratories, toilets, and fire protection. Surface water reserves are available from the cities of Waxahachie and Ennis. Water supply impacts would be minimal during operation if the water supply were obtained from Lake Waxahachie and Bardwell Lake.

If groundwater is supplied by the BVBWSC, the Twin Mountains aquifer would incur minimal depression of the potentiometric surface (personal communication, S. Sievers, Buena Vista Bethel Water Supply Company, to R. Johnson, Oak Ridge National Laboratory, May 3, 1995). The elevation of the potentiometric surface has risen approximately 3 m (10 ft) since the beginning of the SSC project. This has occurred because a strategic plan has been implemented by the TWC and the Texas Water Development Board to manage supply and demand in the Ellis County critical groundwater area, and because demand for BVBWSC groundwater has diminished due to private property purchases associated with the SSC project. Additionally, the BVBWSC had installed equipment to provide groundwater for fire protection to the SSC. The BVBWSC has sufficient reserve capacity to supply all water requirements of the RMTC without overpumping the Twin Mountains aquifer.

4.2.4 Health and Safety

Radiological protection involves the prevention of unnecessary radiation doses to patients, clinical personnel, operations personnel, visitors, and off-site individuals by all potential pathways. Shielding, access control, incorporation of safety into the design, and a radiological control program would be expected to ensure that doses are as low as reasonably achievable (ALARA) below accepted dose standards.

Doses to members of the public could result from direct radiation, releases of activation products to air or water or activation of materials in soil and water that could enter food chains. For occupational groups, the major concern is direct external radiation exposure from activated materials and external exposure from proton-induced neutrons. In areas where the primary proton beam or induced neutrons pass through air, exposure to air activation products may also be of concern.

The proposed RMTC is being designed to minimize exposure to both the general public and occupational workers. Experience and calculations for proton accelerators including the canceled SSC and the LLUMC proton therapy facility have been adopted to provide a design to ensure that occupational doses would be less than 500 mrem/year and that dose to any individual in the public would be less than 1 mrem/year.

These doses are well below the EPA, DOE and Texas occupational dose limit of 5,000 mrem/year and the EPA Clean Air Act Limit of 10 mrem/year for a member of the public.

4.2.4.1 Radiation doses to the public

Off-site doses to maximally exposed individuals (MEIs) and populations were computed. Doses to members of the public could result from direct radiation, releases of activation products to air or water or activation of materials in soil and water that could enter food chains.

Doses to individuals in the population around the proposed RMTC were estimated using components of the computer program CAP88-PC (see Appendices A and B) (Parks 1991). CAP88-PC is composed of dose assessment methods developed under auspices of DOE, NRC and EPA. CAP88-PC can be used to calculate doses and risks to the MEI and to populations due to inhalation, food chain, air immersion and ground radiation.

Atmospheric dispersion in the CAP88 system is estimated using the Gaussian plume model. The model is especially well suited to the flat terrain surrounding the RMTC site and is probably accurate to within a factor of 2 (Parks 1991). For the proposed RMTC location, a rural setting, D class atmospheric stability and a wind speed of 2 m/s is considered appropriate for conservative analysis (a conservative analysis produces an over-estimate of the radiation exposure).

The primary off-site exposure mode for the proposed RMTC is air immersion because atmospheric releases would consist primarily of short-lived radioisotopes which have higher dose conversion factors for immersion than for inhalation. Those short-lived radioisotopes decay before intake could occur through the food chain. Longer-lived radioisotopes such as tritium and carbon (^{14}C) may occur as contaminants in air, groundwater and surface water. However, because tritium and carbon-14 are produced by neutrons penetrating the shielding, shielding thickness for the RMTC design ensures that concentrations immediately adjacent to the RMTC do not exceed drinking water criteria. Tritium and carbon-14 generated by the RMTC have rates of production combined with dose conversion factors for immersion or inhalation that make them of much less concern than immersion doses from the short-lived beta/gamma emitters.

Doses due to releases from the proposed RMTC were estimated for reference distances of 100 m (330 ft) and 1 km (0.6 mile) (see Appendices A and B). The nearest residence is about 1.3 km

(0.8 mile) from the RMTC. The nearest town is Waxahachie; it is located about 5 km (3 miles) northeast of the RMTC site. About 40,000 people live within 16 km (10 miles) of the RMTC site.

The primary releases to the atmosphere result from proton activation products when the beam passes through air. The proton beam passes through about 2.5 m (8.2 ft) of air in the cancer patient treatment rooms. Radionuclides are formed primarily by spallation reactions of protons with ^{16}O and ^{14}N. The primary radioisotopes produced are given in Appendix A, Table A.1 along with their half lives, production cross sections, and amounts produced during a 1-min patient treatment time. For a patient-to-patient treatment cycle of about 15 min, all the airborne activation products would be removed from the room by normal room ventilation and released to the atmosphere between patients.

Doses are estimated to be less than 10 μrem/year even at the 100-m (330-ft) distance with both treatment rooms and research rooms operating. The maximum dose rate [1600-cm^2 (250-in.^{2}) beam area] assuming continuous operation would be about 16 times higher (160 μrem/year). However, only a few patients per year, if any, would be expected to be treated using the maximum beam area.

Dose rates 1 km (0.6 mile) from the release point are estimated to be less than 0.1 μrem/year for a 100-cm^2 (15-in.^{2}) beam area (a typical beam area) and less than 2 μrem/year for a 1600-cm^2 (250-in.^{2}) beam area (the maximum beam area). The nearest residence is located about 1.3 km (0.8 mile) from the release point. Dose to the total population within 16 km (10 miles) of the RMTC site (40,000) is estimated to be less than 4×10^{-3} person·rem compared to a background dose to the same population of about 1×10^{4} person·rem [300 mrem/year from NCRP (1987) times 40,000 population.]

4.2.4.2 Radiation doses to the occupational workers

Details on the methodologies used for determining potential doses to clinical personnel and other workers are given in Appendix A. The experience at LLUMC with respect to worker doses provides confirmation that the potential doses estimated for the RMTC design are reasonable estimates.

The primary occupational radiological concern for proton accelerators would be external radiation consisting of gamma radiation from beam line activation, proton-induced neutrons, air activation products and cooling water activation products. Therapy facilities present somewhat unique concerns because clinical personnel would have to have ready access to patient treatment rooms between treatments. Clinical personnel would be routinely exposed to activated patients, activated beam line components in the treatment area and air activation products. Entry must be through a maze arrangement because of the necessary external facility shielding during beam operation.

Personnel exposures to external gamma radiation and neutrons are typically controlled by shielding, labyrinths, and access control. Radiological control programs would appropriately emphasize these potential exposures and the RMTC design limits them. Clinical personnel would be necessarily exposed to air activation products, activated patients and activated nozzles. Protection against exposures to activated nozzles has been emphasized and nozzles would be replaced to prevent excessive exposures. Exposures of clinical personnel to air activation products and activated patients have been less emphasized.

Doses to clinical personnel from air activation products produced by proton penetration of air in the treatment rooms were estimated for maximum beam currents and for currents (about 0.33nA) required to produce a 200-rad dose to the tumor volume of patients in about 1 min (see Sect. A.3.1 and A.4.1 for further details). The 0.33-nA current (about 1 nA at entry to the nozzle area) is typical of patient irradiations at LLUMC (personal communication, J. Siebers, Loma Linda University Medical Center, to P. Walsh, private consultant, Kingston, Tennessee, April 28, 1995). Doses to clinical personnel from all significantly contributing air activation products at the full beam current (20 nA) and an irradiation time of 2 min would be about 230 μrem/h. (personal communication, M. Schulze, Texas National Research Laboratory Commission, to P. Walsh, private consultant, Kingston, Tennessee, January 1995). For the commonly used 0.33-nA beam and 1-min irradiation to produce a 200-rad dose to the tumor volume of patients, the total dose would be about 120 times lower or about 2 μrem/h. The Texas occupational dose limit (5 rem/year) corresponds to 2500 μrem/h for a 2000-h work year. Significant occupational doses from air ions are not expected.

Estimates of doses to clinical personnel from activated nozzle components for commonly used currents (1 nA) at entry to nozzles (Sects. A.2.1 and A.4.2) is estimated to be about 1 mrem/h at 1 m (3 ft). The first set of brass and lead absorbers in the nozzle will be about 3.2 m from patients; the second set about 2.2 m (7.2 ft) from patients; and the third set (nearest the patients) will be changed for each patient. The resulting dose rate at patient positions is about 5–10 times less than the dose rate at 1 m (3 ft). Therefore, the dose rate to clinical personnel attending to patients would be about 0.1–0.2 mrem/h or 200–400 mrem/year for 2000 h/year exposure times. Because the activity of nozzle components will increase over time, the nozzle components will be periodically replaced. Routine replacement of activated nozzle components is standard industry practice.

Clinical personnel will be also be exposed to activated patients. For clinical personnel exposure times of 15 min per irradiated patient, the annual (2000 h/year) dose is estimated to be about 180 mrem for common beam currents (Sect. A.4.3). If a few patients are irradiated using the maximum beam area, annual doses could exceed 200 mrem.

Total annual doses to clinical personnel primarily from activated nozzle components and patients are estimated from the above results to total about 400–600 mrem given continuous (2000 h/year) occupational exposure times. Doses to clinical personnel can be lowered by reducing patient contact times (e.g., by delaying entry and/or moving patients to holding areas away from clinical personnel who enter the treatment rooms).

All workers, including clinical personnel, will be exposed to the general radiation levels outside shielding and labyrinths. Detailed calculations using standard methods were made on shielding and labyrinth designs for the proposed RMTC. (personal communication, M. Schulze, Texas National Research Laboratory Commission, to P. Walsh, private consultant, Kingston, Tennessee, January 1995). All shield wall thicknesses were determined to be adequate to ensure that accident point losses of full beam power (20 nA) for up to 1 h would not result in doses exceeding 10 mrem. For a 1% operational loss of full beam power, resulting dose rates for full time occupancy outside shields would not exceed 0.25 mrem/h.

The present design for labyrinths is adequate to ensure that accidental point losses of full beam poer would not result in doses exceeding 10 mrem and 1% operational beam losses would not result in doses exceeding 0.25 mrem/h for radiation workers.

Commonly used beam powers to deliver 200 rads to tumors would be closer to 1 nA. Thus, accidental full beam loss for 1 h would produce doses of about 0.5 mrem and 1% operational losses would produce dose rates of less than 12.5 μrem/h.

Typical potentail annual doses for continuous occupancy by individuals at shield walls or labyrinth entrances are less than 250 mrem compared to the Texas limit of 5000 mrem. Since no requirement exists for personnel to occupy locations where such doses could occur, control of actual doses to levels well below these estimates could be routine.

The RMTC radiation control officer would use area monitoring, hand held monitoring, personnel monitoring, and access control to ensure that annual personnel doses outside shields and labyrinths are less than 100 mrem.

In summary, clinical personnel, who must enter treatment rooms to attend to patients and therefore would be exposed to activated beam line components (nozzles) and patients would receive the highest occupational doses at the RMTC. According to the estimates for RMTC and LLUMC experiences, annual doses can be controlled to below 500 mrem compared to the current occupational limit of 5000 mrem.

4.2.4.3 Radiological and Hazardous Wastes

During operation of the proposed RMTC both radiological and hazardous wastes would be generated. The liquid radiological wastes would consist of activated water from the magnet cooling system. This water is expected to contain tritium at levels well below EPA and Texas limits for release to the sanitary sewer system. The experience at LLUMC confirms this expectation. The closed systems at LLUMC currently contain tritium at concentrations less than 0.005 μCi/L (personal communication, M. D. Martz, Loma Linda University Medical Center, to J. Terry, Oak Ridge National Laboratory, n.d. [1995]). The drinking water quality criteria for tritium is 0.020 μCi/L; tritium generation and disposal is expected to create a negligible impact. During operation solid materials (principally beam line components) would become radioactive from contact with the proton beam. These solid radioactive materials would be replaced from inventory and stored on-site and monitored until the radioactivity has decayed to the point that the materials could be reused. The activated solids would not be treated as wastes; they would not be removed to a licensed low-level waste repository.

The impact from storing the radioactive solids is expected to be small. Occupational exposures would be minimized by storing the materials in the restricted area with the accelerators and beam lines. Workers are prevented from entering these areas until radiation levels have reached safe levels. Other wastes attendant to operation of the RMTC as a medical facility would be handled by the on-site radiation protection officer under Texas regulations. Special care would be taken to assure that generation of mixed wastes would be minimized. Mixed wastes would be stored on site until regulating agencies develop guidance and disposal sites are developed. Hazardous wastes would be disposed of at an appropriately licensed facility. Handling, packaging, and transportation of the radiological and hazardous wastes would be carried out according to Texas regulations. The total volume of wastes would be expected to be small compared with the quantity expected to be generated by the SSC (DOE 1990). It was projected that the wastes generated by the SSC would have a minor effect on the storage capacity of the utilized waste repositories.

4.2.5 Socioeconomic Resources

The proposed RMTC would utilize assets of the terminated SSC in a complementary and beneficial manner. The productive use of the assets for advanced cancer treatment offers the primary market area [80-km (50-mile) radius], the secondary market (the state of Texas) and the tertiary market (the neighboring states) a unique opportunity to advance cancer therapy and further the research capabilities of the University of Texas Southwestern Medical Center.

The TNRLC has estimated that employment would reach 65 during full scale operation of the RMTC. It is expected that the small operations work force would have minor to negligible socioeconomic effects on the local community, county, or state.

The original estimates for the former SSC project indicated that most fiscal benefits would be felt in Ellis County (DOE 1990). Because the proposed RMTC is much smaller than the former SSC project, it is unlikely that benefits would be felt beyond Ellis County. It is expected that benefits would occur directly in Waxahachie. It has been projected (TNRLC 1994b) that the proposed facility would treat approximately 1000 patients per year by 2002; the increase would be gradual and likely to occur without cumulative impacts.

4.2.6 Environmental Justice

In the absence of substantial adverse impacts to any populations arising from operation of the proposed RMTC, no disproportionate adverse impacts are expected for minority and low-income populations.

4.2.7 Species of Special Concern

No breeding sites for the black-capped vireo have been identified near the proposed RMTC site. Hence, operation of the facility is not expected to affect the species. Because of the small size of the proposed site [4 ha (10 acres)], impacts from operation of the facility to either the timber rattlesnake or the Texas horned lizard are expected to be negligible.

4.3 IMPACTS OF THE NO ACTION ALTERNATIVE

For the purposes of this analysis, the no action alternative would result in conditions at the linac site remaining as they are.

4.3.1 Land Use

Assuming that the RMTC would not be built, alternative uses for the 4-ha (10-acre) site surrounding the existing linac facility would be determined by the State of Texas. No land use impacts would result from the no action alternative.

4.3.2 Atmospheric Resources

In the absence of the RMTC, there would be no noise impacts or fugitive dusts arising from construction. There would be no radioactive materials emitted into the atmosphere during operation, and there would be no impacts to the atmospheric resources resulting from the no action alternative.

4.3.3 Water Resources

Under the no action alternative, the RMTC would not be built. Runoff, erosion, seepage, and sedimentation attributable to construction-related activities would not occur. No increased water consumption would occur during facility construction and subsequent operation, and no releases of wastewater would occur. Water resources would not be impacted.

4.3.4 Health and Safety

Without the RMTC, there would be no added radiation or chemicals exposure for either the general public or occupational workers. No construction-related exposure to chemicals, accidents, or naturally occurring radioactive materials would occur, and the health and safety of the general public and occupational workers would not be impacted.

4.3.5 Socioeconomic Resources

In the absence of the RMTC, there would be no use of local utility services. Socioeconomic resources would not be impacted.

4.4 ENVIRONMENTAL CONSEQUENCES OF UNEXPECTED EVENTS

4.4.1 Accidents During Construction

An unmitigated, accidental spill of a hazardous substance during construction could impact water resources (see Sect. 4.1.3.1) by seeping into the shallow aquifer and flowing overland into Boz Creek. The spill would be cleaned up immediately to minimize seepage and runoff and to mitigate potential impacts to off-site water resources. Groundwater throughput that is collected in the system of French drains surrounding the linac is pumped into Boz Creek. This system would partially protect the deeper confined aquifer by capturing some of the unmitigated portion of the spill, and diverting it into Boz Creek where impacts then would occur. Minimal impacts would be expected to water resources if the accidental spill were immediately cleaned up.

4.4.2 Unexpected Events During Operation

4.4.2.1 Maximum credible accidents

No operational accidents have been identified that would impact water resources. Laboratory areas would be curbed to contain accidental spills inside the RMTC. Areas surrounding the closed-loop system used to cool magnets would be curbed to contain leaks and spills. Activated cooling water would be stored in approved tanks in curbed areas if necessary. Telemetry would sense proton beam misalignment and energize alarms. Operators would realign the beam immediately or shut the system down until repairs could be made. Insufficient time would be available for the misaligned beam to activate substantially the shallow groundwater or water in nearby pipes.

4.4.2.2 Natural disasters—floods and extreme storms

The RMTC is located near the headwaters of Boz Creek where regional flooding that could jeopardize structural integrity and occupant safety is not anticipated (see Sect. 4.2.3.3). A locally intense, extreme storm could produce a large quantity of precipitation in a short time and cause flash flooding. In extreme cases, some rainwater would leak into the RMTC and cause nuisance flooding. Structural integrity and occupant safety would not be compromised. Waterproofing around the base of the building and installation of flexible seals around doors and windows would minimize nuisance flooding during an extreme storm.

4.5 CUMULATIVE IMPACTS

No major projects have been identified in the vicinity of the RMTC site or in Ellis County that would require large-scale, process-type water requirements (DOE 1990). New reservoirs are planned in Tarrant County to supply future increased demand for surface water to the Dallas-Fort Worth metropolitan area. Groundwater consumption in Ellis County has declined and is projected to remain relatively constant through the year 2020. Tritiated water entering Boz Creek from the RMTC would flow downstream into the Trinity River watershed. Impacts would be minimal because of additional dilution occurring in Chambers Creek and the Trinity River, and because the radioactivity of tritiated water released at the RMTC would not exceed the 20-pCi/mL primary drinking water standard.

No major sources of radioactive materials emissions have been identified near the RMTC (within Ellis County). No major construction projects have been identified in Ellis County that could substantially impact atmospheric resources.

No new major projects have been identified in Ellis County that would substantially alter employment patterns or demands on municipal infrastructure. The proposed action would result in beneficial impacts to socioeconomic resources in the form of additional goods and services. These beneficial impacts would contribute to the mitigation of potentially adverse socioeconomic impacts from the termination of the SSC project.

4.6 MONITORING AND BEST MANAGEMENT PRACTICES

During initial operation of the RMTC, water samples would be obtained from nearby wells in the shallow groundwater and downstream locations along Boz and Chambers creeks to confirm proper operation of shielding installed within the RMTC, linac, new underground tunnel, and synchrotron facility.

At the onset of facility operations, an ALARA program would be implemented to assure that the occupational workers receive the minimum annual radiation exposure consistent with safe, reliable operations and patient care.

Open construction areas, unpaved surfaces, and dirt piles would be sprinkled with water to reduce fugitive dust emissions by approximately 50% (Jutze, Axetell, and Parker 1974).

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6. GLOSSARY

Accelerator — An experimental physics device for imparting large amounts of 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 first accelerator of the RMTC is a linac. It supplies protons to the second accelerator, a synchrotron.

ALARA — As low as reasonably achievable: A DOE policy to minimize the exposure of workers to ionizing radiation as much as practical. This minimization is in addition to keeping exposures below mandatory guidelines.

Background radiation — Naturally occurring radiation primarily from cosmic rays and natural radioactivity.

Beam — A unidirectional or approximately unidirectional flow of electromagnetic radiation or particles.

Hydrology — The branch of earth sciences 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.

Infrastructure — The basic facilities, equipment, and installations supporting the function of a system or community.

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 a 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.

Linear accelerator — An accelerator designed to accelerate electrically charged atomic and subatomic particles in a straight lines.

Mitigation — Methods used to reduce the significance of or to eliminate an anticipated adverse environmental impact.

Natural radioactivity — Radioactivity exhibited by naturally occurring radionuclides. There are more than 50 naturally occurring radionuclides.

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.

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 progressive decrease in the number of radioactive atoms in a substance as a result of spontaneous nuclear disintegration or transformation.

Radioactivity — The property shown by some isotopes of elements to undergo radioactive decay.

Radionuclide — An unstable isotope that will undergo radioactive decay; refers to the specific atoms of the isotope.

rem — A special unit of dose equivalent. The dose equivalent in rem 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.

Synchrotron — A circular particle accelerator in which the high frequency accelerating voltage and the low frequency magnetic field are modulated to achieve greater energies for the charged particles to compensate for the variation in mass that the particles experience with increasing velocity (and energy).

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APPENDIX A

RADIOLOGICAL ASSESSMENT

A. RADIOLOGICAL ASSESSMENT

The proposed Regional Medical Technology Center (RMTC) would be designed to deliver a proton dose of several hundred rads to cancer patients in 1 or 2 min. Proton beams are also provided for radiographic and/or structural studies of patients or materials. The proton beam would produce neutrons, activate structural materials, air, soil and water producing an array of radioactive materials. Depending on proton energy, several neutrons would be produced for each proton absorbed producing a complex neutron spectrum ranging in energy from the incident proton energy to thermal. External dose from the neutrons as well as radiations from neutron activated materials are of radiological importance.

A.1 RADIOLOGICAL PROTECTION

Radiological protection concerns include prevention of unnecessary radiation doses to patients, clinical personnel, operations personnel, visitors, and off-site individuals by all potential pathways. Shielding, access control, incorporation of safety into the design, and a radiological control program would be expected to ensure that doses are as low as reasonably achievable below accepted dose standards.

The primary occupational radiological concern for proton accelerators is external radiation consisting of gamma radiation from beam line activation, proton-induced neutrons, air activation products and cooling water activation products. These concerns have been recognized since the first studies of the disintegration of elements by high velocity particles (Cockcroft and Walton 1932; Van de Graaff, Compton, and Van Atta 1933; Lawrence and Livingston 1932). Operational experience and calculation methods have now evolved to the point where adequate radiological protection can be based upon shielding design, access control, real time monitoring and replacement/control of activated materials. The beam currents used in proton therapy facilities (nA) are much lower than those used in accelerators for high energy physics research or radioisotope production (up to mA). Thus, proton therapy facilities have potential impacts that are relatively low compared to common experience.

Experience at Loma Linda University Medical Center (personal communication, M. D. Martz, Loma Linda University Medical Center, to J. W. Terry, Oak Ridge National Laboratory, December 1994) is that annual occupational doses have been less than 500 mrem/year primarily from beam line activation products and neutrons.

Therapy facilities might be considered to present somewhat unique concerns because clinical personnel must have ready access to patient treatment rooms between treatments. Clinical personnel would be routinely exposed to activated patients, activated beam line components in the treatment area and air activation products. Entry must be through a maze arrangement because of the necessary external facility shielding during beam operation. These unique concerns have been a focus of this analysis. In addition, air and patient activation products are considered (even though they have not been emphasized in other studies) because the proton beam would pass through about 2.5 m (8.2 ft) of air which results in the production of air activation products and proton beams are designed to be absorbed in patients.

A.2 METHODOLOGY

This analysis evaluates radiation doses to members of the public and to occupational personnel. Off-site doses to maximally exposed individuals (MEIs) and populations are considered. Doses to occupational personnel including clinical staff attending to patients, proton treatment facility (PTF) operators, scientists conducting radiographic, structural or special studies, health and safety, management and administrative personnel are considered. Results are summarized and discussed in the following sections.

Doses to members of the public could result from direct radiation, releases of activation products to air or water or activation of materials in soil and water that could enter food chains. For occupational groups, the major concern would be direct external radiation exposure from activated materials and external exposure from proton-induced neutrons. In areas where the primary proton beam or induced neutrons pass through air, exposure to air activation products may also be of concern.

The proposed RMTC is being predominantly designed in response to these concerns. Experience and calculations for proton accelerators including the canceled Superconducting Super Collider (SSC) and the LLUMC proton therapy facility have been adopted to provide a design to ensure that occupational doses would be less than 500 mrem/year and that dose to any individual in the public would be less than 1 mrem/year. These doses are well below the Environmental Protection Agency and Texas occupational and public annual dose limits of 5000 mrem and 100 mrem respectively and the Clean Air Act limit of 10 mrem.

Key documentation related to this analysis includes radiation calculations for the SSC linear accelerator (linac) (Waters and Bull 1994), radiological analysis of the linac cooling water system (Bull 1993); activation concentrations outside the SSC accelerator enclosures (Baker, Bull, and Stapleton 1994); the SSC Environmental Impact Statement; and a shielding and activation study for the Lawrence Berkeley, University of California Davis Medical Center Proton Treatment Facility by Gillespie Associates (Orthel, Knowles, and Hill 1993). The Gillespie Associates document provides a useful workbook using accepted methods for solving RMTC radiation shielding and activation problems. The LLUMC proton therapy facility, a good surrogate for the proposed RMTC, is discussed in the Gillespie Associates document. Visits were made to LLUMC and Los Alamos National Laboratory to discuss proton accelerators operational experience. Information regarding occupational and public doses was provided by staff members at these facilities. Dose calculations for the proposed RMTC based on maximum beam currents were obtained from the Texas National Research Laboratory Commission (TNRLC). Results are summarized in the following sections based on actual requirements for patient irradiation.

A.3 OFF-SITE DOSES ASSOCIATED WITH THE PROPOSED RMTC

Doses to individuals in the population around the proposed RMTC were estimated using components of CAP88-PC (personal computer version, Parks 1991). CAP88-PC is composed of dose assessment methods developed under auspices of the U.S. Department of Energy, the Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency; it has been certified for evaluating compliance with the National Emission Standards for Hazardous Air Pollutants. CAP88-PC can be used to calculate doses and risks to the MEI and to populations due to inhalation, food chain, air immersion and ground radiation.

The primary off-site exposure mode for the proposed RMTC would be air immersion because atmospheric releases would consist primarily of short-lived radioisotopes which have higher dose conversion factors for immersion than for inhalation. Those short-lived radioisotopes decay before intake could occur through the food chain. Longer-lived radioisotopes such as tritium and carbon-14 may occur as contaminants in air, groundwater, and surface water. Tritium may be produced by several reactions involving protons, neutrons, gamma photons, and deuterons. Tritium can be produced by neutron irradiation of ^{2}H, ^{3}He, ^{6}Li, ^{7}Li, ^{9}Be, ^{10}Be, ^{12}C and ^{14}N. However, shielding thicknesses for the RMTC insure that concentrations immediately adjacent to the RMTC do not exceed drinking water criteria. Tritium and carbon-14 produced in air as spallation and (n, p) reaction products due to proton and neutron interactions have rates of production combined with dose conversion factors for immersion or inhalation (Eckerman, Wolbarst, and Richardson 1988; Eckerman and Ryman 1993) that make them of much less concern than immersion doses from the short-lived beta/gamma emitters.

Reference doses were calculated at 100-m and 1-km distances from the RMTC release point. The nearest residence is located over 1.2 km (0.7 mile) from the release point. The nearest town is Waxahachie, about 10 km (6 miles) northeast of the RMTC site. About 40,000 people live within 16 km (10 miles) of the RMTC site.

A.3.1 Estimated Releases

Proton therapy facilities deliver about 200 rads to the tumor area of patients. A dose of 200 rads would be equivalent to 1.25×10^{10} MeV/g energy deposition. The number of protons of energy E required to deliver this energy would be $\frac{1.25 \times 10^{10}}{E}$ protons/g for complete absorption of the protons in tissue. The mass of tissue irradiated would be

$$\text{mass} = \text{beam area } (S) \times \text{penetration depth } (d) \times \text{tissue density } (\rho) = Sd\rho.$$

The penetration depth, d, for protons of energy E would be approximately

$$d = \frac{E}{\frac{dE}{dx}}$$

where $\frac{dE}{dx}$ is the average stopping power of tissue for protons over the energy range from 0 to E.

The number of protons required to deliver 200 rads to the total tissue mass would be

$$N_p = \frac{1.25 \times 10^{10} S}{\frac{dE}{dx}}$$

where $\frac{dE}{dx}$ is the average mass stopping power of tissue for protons.

All energy loss would not occur within the tumor. As a simplified example, if the tumor depth in the direction of the beam were about 10 cm and the tumor were located about 10 cm below the surface, then less than one-half the energy would be deposited in noncancerous tissue if the beam energy were sufficient to penetrate to the distal end of the tumor—because the energy loss rate in the tumor would be higher than in overlying noncancerous tissue. If the beam energy were selected to penetrate into the proximal end of the tumor, then most of the beam energy would be lost in overlying tissue. Special absorbers designed for each tumor to achieve a beam energy spread would be used and patients would be irradiated at various angles to ensure that the highest energy loss (i.e., the Bragg peaks for the different energies) would occur in the tumor mass. Exposure regimes would be designed for each patient. Thus the number of protons required to deliver 200 rads to the tumor mass would be less than the number of protons required to deliver 200 rads to the total tissue mass for monoenergetic beams in one direction.

Significantly higher stopping powers occur in the tumor mass compared to surrounding tissue. Using the average stopping power over the range of the protons is conservative since higher stopping powers would require a smaller number of protons to produce desired doses. An approximate value of the average stopping power for protons with initial energies of about 100 MeV is about 10 MeV·cm^2/g. Therefore, a conservative estimate for the number of protons required to produce about 200 rads to the tumor area is $N_p \approx 1.25 \times 10^9\ S$ protons/treatment. If treatment periods are 1 min, the required proton current is $N \approx 2.1 \times 10^7\ S$ protons/s.

For the maximum beam area of 1600 cm^2 (40 cm × 40 cm) [250 in.^{2} (16 × 16 in.^{2})], the number of protons required per treatment would be about 2×10^{12}. Such a beam area would rarely be used. A 100-cm^2 (15-in.^{2}) beam area should be sufficiently large to treat most tumors. Thus the number of protons required per typical treatment would be about 1.25×10^{11}.

About 70% of proton beams would be absorbed in preparing the beam for patient treatment. Thus 30% of the beam would be transferred to the patient, or about 1 nA would be required at entry to the nozzle area. The highest current used at the LLUMC facility is about 1.4 nA. Thus the above estimates for the RMTC seem reasonable.

The primary releases to the atmosphere result from proton activation products when the beam passes through air. The proton beam passes through about 2.5 m (8.2 ft) of air in the treatment rooms. The primary reactions which result in the formation of radionuclides are due to the spallation of ^{16}O and ^{14}N. The primary radioisotopes produced are given in Table A.1 along with their half-lives, production cross sections, and amounts produced during a 1-min patient treatment time. The methodology for proton activation of air, tissue, and beam line components is developed in Sect. 4. The proton current was assumed to be 0.33 nA spread over 100 cm^2 (10 × 10 cm field) and penetrating 2.5 m (8.2 ft) of air before interacting with a patient. The maximum beam current in air of 5.3 nA, corresponding to a 1600-cm^2 (250-in.^{2}) beam area would yield values about 16 times higher than those given in Table A.1 because the volume of air irradiated is about 16 times higher. The calculations are conservative because the volume of air irradiated is a pyramid or conical shape of base area 100 cm^2 (15 in.^{2}) or 1600 cm^2 (250 in.^{2}) rather than a box or cylindrical shape. However, more air may be irradiated because of scatter from absorbers. Thus, we use the conservative box-like volume.

If the patient-to-patient treatment cycle is about 15 min, all the airborne activation products would be removed from the room by normal room ventilation and released to the atmosphere between patients. The effective release time is the interpatient treatment time, about 15 min (900 s). Although the release rate would vary over the treatment time, the potential effects considered at the low dose rates involved are assumed to be linearly related to the total dose. The estimated release rates for the air activation products from one treatment room are given in Table A.2.

Table A.1. Spallation products from 0.33-nA proton beams penetrating 2.5 m of air at 50% relative humidity.[a]

Nuclide	Half-life	Production cross section (mb) From ^{16}O	From ^{14}N	Production rate[b] (nuclei/s)	Activity after 1 min. irradiation[c] (μCi)
^{3}H	12.3 years	30	30	8.6×10^{5}	3.5×10^{-6}
^{7}Be	53.3 d	5	10	3.0×10^{5}	7.0×10^{-5}
^{11}C	20.4 months	5	10	3.0×10^{5}	0.25
^{14}C	5730 years		1640[e]	3.7×10^{7}	2.3×10^{-7}
^{13}N	9.96 months	9	10	2.8×10^{5}	0.7
^{14}O	1.19 months	1	-	5.72×10^{3}	0.07
^{15}O	2.03 months	50[d]	-	2.86×10^{5}	2.2

[a]Mass of air irradiated ~ 100 cm² × 250 cm × 0.001293 g/cm³ ~ 32 g. Mass of ^{16}O nuclei ~ 7 g. Number

$$\text{of } ^{16}\text{O nuclei} \sim \frac{(7\ \text{g})\left(6.025 \times 10^{23}\ \dfrac{\text{nuclei}}{\text{g-mole}}\right)}{16\ \dfrac{\text{g}}{\text{g-mole}}} \sim 2.7 \times 10^{23}$$

$$\text{Number of } ^{14}\text{N nuclei} \sim \frac{(25\ \text{g})\left(6.025 \times 10^{23}\ \dfrac{\text{nuclei}}{\text{g-mole}}\right)}{14\ \dfrac{\text{g}}{\text{g-mole}}} \sim 1.1 \times 10^{24}$$

[b]Production rate $P = N\Phi\sigma$; N is number of ^{16}O or ^{14}N targets, Φ is proton flux, and σ is production cross section. The proton flux assumed here is $2.1 \times 10^{7}\ \frac{\text{p}}{\text{s}\cdot\text{cm}^2}$.

[c]See Eq. A.2.

[d]Spallation (40 mb) and γ, n (10 mb).

[e]From ^{14}N (n, p) ^{14}C assuming neutron flux = proton flux.

Table A.2. Release rates of air activation products from the proposed RMTC for a beam area of 100 cm² (0.33-nA current)

Nuclide	Release rate (μCi/s)
^{3}H	3.9×10^{-9}
^{7}Be	7.7×10^{-8}
^{11}C	2.7×10^{-4}
^{14}C	2.5×10^{-10}
^{13}N	7.3×10^{-4}
^{14}O	7.8×10^{-5}
^{15}O	2.4×10^{-3}

A.3.2 Exposure Pathways, Doses and Risk

CAP88-PC may be used to estimate radionuclide doses and risks for ingestion, inhalation, ground-level air immersion and ground surface to person irradiation. Releases from area and point sources can be accommodated. The proposed RMTC is considered a point source.
CAP88-PC contains options to evaluate dose and risk to the MEI and the collective population. CAP88-PC calculates the dose to the gonads, breast, red marrow, lungs, thyroid, and endosteum in addition to the 50-year effective dose equivalent. Total cancer risk is related to effective dose equivalent, which is the sum of the risk-weighted organ doses. The primary doses due to releases of air activation products from the RMTC result from total body immersion in air at the exposure point. Thus, total body effective dose equivalents are the focus of this analysis.

Atmospheric dispersion in the CAP88 system is estimated using the Gaussian plume model. The model is especially suited to the flat terrain surrounding the RMTC site and is probably accurate to within a factor of two for distances greater than 100 m. The CAP88-PC system uses the Briggs (1973) formulae to determine dispersion parameters as a function of atmospheric stability category. Details of the calculation are given in Appendix B.

Dose rates at 1 km from the release point are estimated to be less than 0.1 μrem/year for the 100-cm^2 (15-in.^{2}) beam area and less than 2 μrem/year for the 1600-cm^2 (250-in.^{2}) beam area. Dose to the total population within 10 miles of the RMTC site (40,000) is estimated to be less than 4×10^{-3} person-rem compared to a background dose to the same population of about 1×10^4 person-rem [300 mrem/year (from NCRPM 1987) times 40,000].

Proton energies and currents used in the research rooms may be higher but the volume of air irradiated would usually be lower. Reaction cross sections for the proton energies involved are not strongly energy dependent.

A.4 OCCUPATIONAL DOSE ASSOCIATED WITH THE PROPOSED RMTC

Occupational exposures from air activation products, activated patients, activated beam line components and proton induced neutrons are summarized in this section. Personal exposures to external gamma radiation and neutrons are controlled by shielding, labyrinths and access control. Radiological control programs have appropriately emphasized these potential exposures and the RMTC design limits them. Clinical personnel are necessarily exposed to air activation products, activated patients and activated nozzles. Protection against exposures to activated nozzles has been emphasized and nozzles are replaced to prevent excessive exposures. Exposures of clinical personnel to air activation products and activated patients have been less emphasized. Therefore, these exposures will be discussed in relatively more detail in the following sections.

A.4.1 Air Activation Products

During patient treatment, the rate of change in the number of air activation products, N_i, is

$$\frac{dN_i}{dt} = P_i - (\lambda_i + \lambda_a)N_i \qquad \text{A.1}$$

The activation products, N_i, are produced at an assumed constant rate of P_i where $P_i = N_T \Phi \sigma_i$, N_T is the number of target atoms in air, Φ is the proton flux in air, σ_i is the cross section for formation of air activation product i from the target atoms in units of cm^2. Simultaneous with the buildup of activation products, they are lost by two processes, (1) radioactive decay having a rate constant of λ_i s^{-1} and (2) air turnover having a rate constant of λ_a s^{-1}.

The number of atoms of isotope i at time t after irradiation begins is given by integration of Eq. A.1:

$$N_i = \frac{P_i\left[1 - e^{-(\lambda_i + \lambda_a)t}\right]}{\lambda_i + \lambda_a} \qquad \text{A.2}$$

After an irradiation time t_R, the isotopes continue to decay radiologically and are removed by air turnover. At time t_1 after irradiation, the number of atoms of isotope i would be

$$N_i(t_1) = \frac{P_i\left[1 - e^{-(\lambda_i + \lambda_a)t_R}\right]e^{-(\lambda_i + \lambda_a)t_1}}{\lambda_i + \lambda_a} \qquad \text{A.3}$$

The number of atoms of isotope i at time t_m after m irradiations separated by a time period T is the sum of all previous irradiations

$$N_i(t_m) = \frac{P_i\left(1 - e^{-(\lambda_i + \lambda_a)t_R}\right)e^{-(\lambda_i + \lambda_a)t_m}}{\lambda_i + \lambda_a} \times 1 + e^{-(\lambda_i + \lambda_a)T} + e^{-2(\lambda_i + \lambda_a)T} + \cdots + e^{-(m-1)(\lambda_i + \lambda_a)T} \qquad \text{A.4}$$

Since the summation $1 + e^{-(\lambda_i + \lambda_a)T} + \cdots + e^{-(m-1)(\lambda_i + \lambda_a)T}$ is equal to

$$\frac{1 - e^{-m(\lambda_i + \lambda_a)T}}{1 - e^{-(\lambda_i + \lambda_a)T}}$$

we have,

$$N_i(t_m) = \left\{\frac{\left[1 - e^{-(\lambda_i + \lambda_a)t_R}\right]e^{-(\lambda_i + \lambda_a)t_m}}{\lambda_i + \lambda_a}\right\} \times \left[\frac{1 - e^{-m(\lambda_i + \lambda_a)T}}{1 - e^{-(\lambda_i + \lambda_a)T}}\right] \qquad \text{A.5}$$

The total number of decays of isotope i in the room taking into account air turnover during the time between treatments of length T is given by integration of the activity from $t_m = 0$ to $t_m = T$. The result is,

$$N_i(T) = \lambda_i P_i \frac{\left[1 - e^{-(\lambda_i + \lambda_a)t_R}\right]\left[1 - e^{-m(\lambda_i + \lambda_a)T}\right]}{(\lambda_i + \lambda_a)^2} \qquad \text{A.6}$$

and the average decay rate or activity during time T is $A_i(T) = \frac{N_i(T)}{T}$.

The dose rate during the time between treatments is

$$D_i(T) \propto \frac{A_i(T) DCF_i}{V} \qquad \text{A.7}$$

where DCF_i is the dose conversion factor in mrem/h per μCi/cm^3 for immersion in air (Eckerman and Ryman 1993) or for inhalation (Eckerman, Wolbarst, and Richardson 1988) and V is taken as the volume of the treatment room (about 10^9 cm^3 for the proposed RMTC).

For isotopes with long half-lives relative to treatment times, air turnover times, time between treatments, and air turnover times greater than treatment times,

$$1 - e^{-(\lambda_i + \lambda_a)t_R} \sim \frac{t_R}{\tau_a}$$

In addition, after a few treatments,

$$1 - e^{-m(\lambda_i + \lambda_a)T} \sim 1$$

The resulting dose would be

$$D_i(T) \propto \frac{P_i \tau_a t_R DCF_i}{\tau_i V T} \qquad \text{A.8}$$

where $\tau_a = \frac{1}{\lambda_a}$ is the air turnover time, and $\tau_i = \frac{1}{\lambda_i} = 1.44\, T_{\frac{1}{2}}$ is the mean life of isotope i.

Eq. A.8 is applicable for ^{3}H, ^{7}Be, and ^{14}C at the proposed RMTC.

For the other isotopes, ^{11}C, ^{13}N, ^{14}O, and ^{15}O, half-lives are closer to the other times listed above and, after several irradiations,

$$D_i(T) \propto \tau_i \left[\frac{\tau_a}{(\tau_i + \tau_a)} \right]^2 P_i \left[1 - e^{-\left(\frac{1}{\tau_i} + \frac{1}{\tau_a}\right) t_R} \right] \left[\frac{DCF_i}{VT} \right] \qquad \text{A.9}$$

Using Eq. A.8, it can be shown that the dose rates from ^3H, ^7Be, and ^{14}C are very small and of no concern. Annual doses based on Eq. A.9 for the other isotopes are given in Table A.3 for air turnover time of 60, 10, and 5 min. Values for P_i and radiological half-lives are given in Table A.1. The total annual average dose assuming a 2000-h exposure time is estimated to be about 1.7 mrem for a normal room air turnover time of 60 min (one air change per hour). If the air turnover rate is increased to six air changes per hour (τ_a = 10 min.), the annual dose is reduced to about 0.8 mrem. Further increasing the air turnover rate to 15 air changes per hour (τ_a = 5 min), which is typical of hospital environments, reduces the annual dose to about 0.5 mrem. A 15-fold increase in air turnover rate is estimated to reduce dose to hospital staff by a factor of only about three. For the maximum beam area [1600 cm^2 (250 $in.^2$)], these doses are about 16 times higher for 2000 h/year exposure. However, only a few patients per year, if any, are expected to be treated using the maximum beam area.

Upper bound calculations were made by the TNRLC assuming full beam current (20 nA) and an irradiation time of 2 min. The total dose rate for all the significantly contributing isotopes was about 234 μrem/h for a typical operating scenario. For the 0.33-nA beam current, a 1-min irradiation time would be required to produce a 200-rad dose to a 100-cm^2 (15-$in.^2$) tumor. Under these conditions, the total dose would be about 120 times lower, or about 2.0 μrem/h. For a 2000-h/year occupational exposure, the total annual dose would be about 4.0 mrem. Air turnover was not considered.

Independent calculations by the preparers of this EA and the TNRLC are in good agreement. Significant occupational doses from air ions would not be expected.

A.4.2 Beam Line Activation Products

The activation of accelerator components containing primarily C, Al, Fe, and Cu would also produce radioisotopes that deliver doses primarily by external gamma irradiation. To the list of radionuclides considered above must be added ^{18}F, ^{22}Na, and ^{24}Na when Al is irradiated and numerous other radionuclides when Fe, Cu, or stainless steel is irradiated. Unlike the case for air activation products suspended in a volume of air, radiation is emitted from various geometrical shapes of solid sources. The overall methodology for activation and decay is similar to that given above for air activation products. The general problem has been treated by Barbier (1967) and by Sullivan (1992) and summarized by Gillespie Associates (Orthel, Knowles, and Hill 1993).

Table A.3. Doses to clinical personnel from airborne radioisotopes between patient treatments after multiple treatments for a 100-cm² beam area (0.33-nA current)

Isotope	Mean life (min)	Air turnover time (min)	Dose[a] (mrem)
^{11}C	29.40	60	0.45
		10	0.12
		5	0.075
^{13}N	14.34	60	0.67
		10	0.25
		5	0.16
^{14}O	1.71	60	0.02
		10	0.01
		5	0.1
^{15}O	3.00	60	0.53
		10	0.40
		5	0.31

[a]Integrated over a 2000-h work year.

Using radioisotope production data from Barbier (1967), Gillespie Associates estimated a dose to clinical personnel from activated Al during each entry, to be

$$DR^2 = 5.74 \times 10^{-7} \frac{\text{rem} \cdot \text{m}^2}{\text{nA} \cdot \frac{\text{g}}{\text{cm}^2}} \qquad \text{A.10}$$

From activated Cu or Fe, they estimated a dose to clinical personnel during each entry using Sullivan's (1992) methods to be

$$DR^2 = 2.83 \times 10^{-6} \frac{\text{rem} \cdot \text{m}^2}{\text{nA} \cdot \frac{\text{g}}{\text{cm}^2}} \qquad \text{A.11}$$

In Eqs. A.10 and A.11, Na refers to the amount of beam loss and g/cm² is the absorber thickness.

The basis of the equations is that Al, Fe, or Cu in the beam line components within the treatment area is bombarded by the proton beam. Beam absorbers and shapers within the nozzle absorb a significant fraction of the proton beam. Neither self-absorption nor nozzle shielding were taken into account in the derivation of Eqs. A.10 and A.11.

For a 12-h operational period and a continuous beam loss of 10 nA in a 20-g/cm^2 absorber thickness, Gillespie Associates estimated that the doses to clinical personnel at 1 m from nozzles are about 0.1 mrem per entry for Al absorbers and about 0.6 mrem per entry for Cu or Fe absorbers. At equilibrium (long irradiation times) the doses per entry for Al absorbers would be about four times higher. However, for the proposed facility, clinical personnel attending to patients should be 2.5–3 m from the most active components of nozzles so the resulting dose rate would be less than 0.1 mrem per entry. Under more typical beam losses ($\sim$1 nA), doses should be less than 0.05 mrem per entry (400 mrem/year for a 2000-h work year and 4 patients/h).

Calculations were made by the TNRLC for the proposed RMTC design using similar methodology. The calculations assume a 1-d and 1-week irradiation of Pb, Cu, Zn, and brass (Cu and Zn) materials in the nozzle to a proton flux of 6.3×10^9 p/s/cm^2 at a 100% duty factor. Beam energies of 500 MeV and 50 MeV were used to bracket the RMTC beam energies of 100–270 MeV and 350 MeV. A dose of 20 mrem/h at 1 m was estimated for a 20-nA beam current.

As discussed in Sect. A.3.1, a 1-nA beam current at entry to the nozzle would be necessary to give a 200-rad dose to a 100-cm^2 (15-in.^{2}) tumor. The dose for this more typical but probably conservative treatment situation would be about 1 mrem/h at 1 m. Because the first set of brass and Pb absorbers would be about 3.2 m from patients, the second set at about 2.2 m from patients, and the third set nearest patients would be changed for each patient, the dose rate at patient positions is about 5–10 times less than the dose at 1 m. Therefore, the dose rate to clinical personnel attending to patients would be about 0.1–0.2 mrem/h or 200–400 mrem/year for 2000-h/year exposure times. Therefore, independent calculations by the preparers of this EA and the TNRLC are in good agreement.

Because the activity of the nozzle components would tend to increase over time, the nozzle components would need to be replaced periodically, which is standard practice.

A.4.3 Patient Activation

The methodology for patient activation is similar to that for air activation. The density of tissue is higher and the beam is completely stopped in tissue so that the mass of irradiated tissue and the number of nuclei irradiated is much higher. The irradiated patient becomes a volume source of radiation. Again the primary radioisotopes of concern are spallation products of ^{16}O and ^{14}N at the proton energies involved (70–270 MeV). However, in the case of tissue, oxygen makes up about 70% of the tissue mass and nitrogen only about 3%. Other isotopes are formed [e.g., ^{38}K from ^{40}K (Sisterson, Koehler, and Eilbert 1978)] but their percentage abundances in tissue are generally low relative to ^{16}O. Patients would be removed after each irradiation so that each irradiation may be considered individually. For analysis, we assume a maximum beam area of 1600 cm^2 (2×10^{12} protons/treatment) and a more typical beam area of 100 cm^2 (1.25×10^{11} protons/treatment) of 270-MeV protons completely stopped in tissue with the average 67% content of ^{16}O and 3.5% content of ^{14}N by weight.

Because air turnover has no effect on radiation levels of the patient, the dose rate at time t after an irradiation time t_R is given by

$$D_i \propto P_i\left[1 - e^{\left(\frac{-t_R}{\tau_i}\right)}\right] e^{\left(\frac{-t}{\tau_i}\right)} DCF_i \qquad \text{A.12}$$

where DCF_i is the dose conversion factor for a volume source of external radiation from radioisotope i.

The average dose rate received by clinical personnel exposed to a treated patient from t_1 to t_2 is

$$D_i(t_1 - t_2) \propto \frac{P_i\left[1 - e^{\left(\frac{-t_R}{\tau_i}\right)}\right]\left[e^{\left(\frac{-t_1}{\tau_i}\right)} - e^{\left(\frac{-t_2}{\tau_i}\right)}\right] DCF_i \tau_i}{(t_1 - t_2)} \qquad \text{A.13}$$

Unit density tissue contains about 2.5×10^{22} ^{16}O atoms and about 1.5×10^{21} ^{14}N atoms per gram. The total mass of tissue irradiated is given by the beam area, *S*, times the depth of penetration of the beam for unit density tissue. A 270-MeV proton beam would penetrate about 30 cm (4.6 in.) in unit density tissue. Therefore, the mass is 30*S* g. The flux of protons is given by the number of protons per second divided by the area of the beam. The rate of production of isotope *i* is given by

$$\begin{aligned} P_i &= N \Phi \sigma_i \\ &= \left(2.5 \times 10^{22}\ {}^{16}\mathrm{O}\ \frac{\text{atoms}}{\text{g}}\right)(30 S\,\text{g})\left(2.1 \times 10^{7}\ \frac{\text{protons}}{\text{s} \cdot \text{cm}^2}\right)\left(10^{-27}\ \frac{\text{cm}^2}{\text{atom} \cdot \text{mb}}\right) \\ &= 6.4 \times 10^{4} S\ \frac{\text{nuclei}}{\text{s} \cdot \text{mb}}\ \text{for}\ {}^{16}\mathrm{O}\ \text{target atoms.} \end{aligned}$$

A similar calculation yields $3.8 \times 10^{3} S \frac{\text{nuclei}}{\text{s} \cdot \text{mb}}$ for ^{14}N target atoms.

Dose rates at 1 m from patients irradiated with 1600-cm^2 (250-$in.^2$) and 100-cm^2 (15-$in.^2$) beams are given in Table A.4 for 15-min time periods after irradiation. The specific gamma ray constants listed in Bull (1993) were used for the dose conversion factors.

For clinical personnel exposure times of 15 min per irradiated patient, the annual dose would be about 180 mrem for a 2000-h/year work period for the 100-cm^2 (15-$in.^2$) beam area. If a few patients per year WEre irradiated with the maximum beam area, annual doses could exceed 200 mrem.

Doses to clinical personnel could be lowered by reducing their contact with patients. This could be accomplished by delaying entry after treatments and/or by moving patients to a holding area away from clinical personnel who enter the treatment rooms.

Table A.4. Dose rates at 1 m from patients after a 1-min irradiation

Nuclide	Initial dose rate (mrem/h)		Average dose rate during 15-min post-irradiation period (mrem/h)	
	100-cm^2 (15-in.^{2}) beam area	1600-cm^2 (250-in.^{2}) beam area	100-cm^2 (15-in.^{2}) beam area	1600-cm^2 (250-in.^{2}) beam area
^{11}C	5×10^{-3}	0.07	4×10^{-3}	0.064
^{13}N	0.02	0.27	0.012	0.19
^{14}O	0.03	0.47	2.5×10^{-3}	0.04
^{15}O	0.35	5.8	0.075	1.2
Totals	0.4	6.6	0.09	1.5

A.4.4 Personnel Shielding and Labyrinth Analysis

Detailed calculations were made by the TNRLC on requirements for shielding and labyrinths for the proposed RMTC. All shield wall thicknesses are adequate to ensure that accidental point losses of full beam power for up to 1 h would not result in doses exceeding 10 mrem. For a 1% operational loss of full beam power, resulting doses for full-time occupancy outside shields would not exceed 0.25 mrem/h.

The current design for labyrinths is also adequate to ensure that accidental point losses of full beam power would not result in doses exceeding 10 mrem, and 1% operational beam losses would not result in doses exceeding 0.25 mrem/h for radiation workers. Because no requirement exists for personnel to occupy locations where such doses could occur, control of actual doses to levels well below these limits is readily achieved. Actual beam loss during typical operating conditions (200 rad to tumor area of patients) would be closer to 1 nA.

Area monitoring, hand-held monitoring, personnel monitoring, and access control would be used to ensure that actual annual doses outside shields and labyrinths are less than 100 mrem/year.

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APPENDIX B

IMPACTS OF ATMOSPHERIC RADIONUCLIDE EMISSIONS

B. IMPACTS OF ATMOSPHERIC RADIONUCLIDE EMISSIONS

Seven radionuclides may be emitted to the atmosphere from the proposed facility (Table A.2). Emission rates (Table B.1) are assumed to be continuous throughout the year. With these emission rates, the CAP88PC Model (Parks 1992) was run to determine annual effective dose equivalents downwind of the proposed Proton Therapy Facility. CAP88PC is a combination of two models: a flat terrain, Gaussian plume model for predicting downwind atmospheric concentrations, and a model for predicting annual effective dose equivalents and associated risks.

The stack configuration for the proposed RMTC has not been determined. Therefore, stack exit parameters providing upper-bound estimates of downwind concentrations were used. For example, a stack with height of 0 m was input into the model; actual stack heights (>0 m) would result in lower downwind atmospheric concentrations and subsequently, lower annual dose equivalents. Table B.2 shows the stack and site-specific parameters used in the analysis. Receptors (points at which annual dose equivalents were calculated) were located along concentric rings around the source with radii of 100, 200, 300, 400, 500, 750, and 1000 m. The location of the site boundary is not known at this time; however, the chosen receptors would probably bound the potential fenceline of the proposed facility.

Although on-site meteorological data have been collected for a 1-year period, Dallas-Fort Worth (DFW) International Airport meteorological data for 1984-92 were used in the modeling. DFW airport is located about 60 km (37 miles) north-northwest of the proposed facility. DFW meteorological data have been found generally representative of conditions at the Proton Therapy Facility and have been used for previous modeling studies at the site (M. Schulze, Proton Therapy Facility, Waxahachie, Tex., personal communication with D. A. Lombardi, Oak Ridge National Laboratory, Feb. 22, 1995). Since predicted annual dose equivalents resulting from potential emissions at the proposed facility are well below the regulatory limit, airport data are considered sufficient for this analysis; on-site data would have been used if a more refined analysis had been warranted. The airport data wind rose and joint frequency distribution of wind speed and direction are shown in Fig. B.1 and Table B.3 respectively.

The CAP88PC model does not compute equivalent doses for ^{14}O. To compute the annual dose equivalent for this radionuclide, a substitute was input into the model. The all-pathways dose conversion factor for ^{14}O is about two times greater than that for ^{15}O (P. Walsh, Independent Contractor, Kingston, Tenn., personal communication with D. A. Lombardi, Oak Ridge National Laboratory, Feb. 22, 1995). Therefore, two ^{15}O calculations were made, the first one being the ^{14}O surrogate with the appropriate emission rate. The ^{14}O annual dose equivalents were then obtained by multiplying model output by two. Table B.4 shows the dose equivalents calculated for each radionuclide and the total effective dose equivalent.

As shown in Table B.4, the maximum sum-total effective dose equivalent calculated for all radionulcides would be 4.7×10^{-3} mrem/year at a receptor 100 m north of the proposed stack. This result is less than 0.1% of the 10 mrem/year maximum regulatory public exposure limit from atmospheric radionuclide releases (40 CFR 61.93). Table B.5 shows the maximum sum-total effective dose equivalent calculated for all radionuclides at a receptor location 1000 meters north of the proposed stack would be 1.3×10^{-5} mrem/yr (less than 0.0005% of the regulatory limit public exposure). Based on these results, atmospheric radionuclide emissions from the proposed facility emissions would have a negligible impact on public health.

Table B.1. Proton Therapy Facility radionuclide emission rates

Radionuclide	Emission Rates	
	μCi/s	Ci/year
^{3}H	3.9×10^{-9}	1.2×10^{-7}
^{7}Be	7.7×10^{-8}	2.4×10^{-6}
^{11}C	2.7×10^{-4}	8.5×10^{-3}
^{14}C	2.5×10^{-10}	7.9×10^{-9}
^{13}N	7.3×10^{-4}	2.3×10^{-2}
^{14}O	7.8×10^{-5}	2.5×10^{-3}
^{15}O	2.4×10^{-3}	7.7×10^{-2}

Table B.2. Stack parameters and site information assumed for the RMTC CAP88PC runs

Parameter	Value
Stack height,[a] m	0
Stack diameter,[a] m	0
Plume rise,[a] m	0
Site temperature,[b] °C	19
Site precipitation,[b] cm/year	92
Site mixing height,[c] m	500

[a]Since no source data were available, these values were chosen to provide upper bound estimates of downwind effective dose equivalents.

[b]*Source*: Gale Research 1985, *Climates of the States*, Book Tower, Detroit Michigan.

[c]*Source*: Holzworth, G.C. 1972, *Mixing Heights, Wind Speeds, and Potential for Urban Pollution Throughout the Contiguous United States*, Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC.

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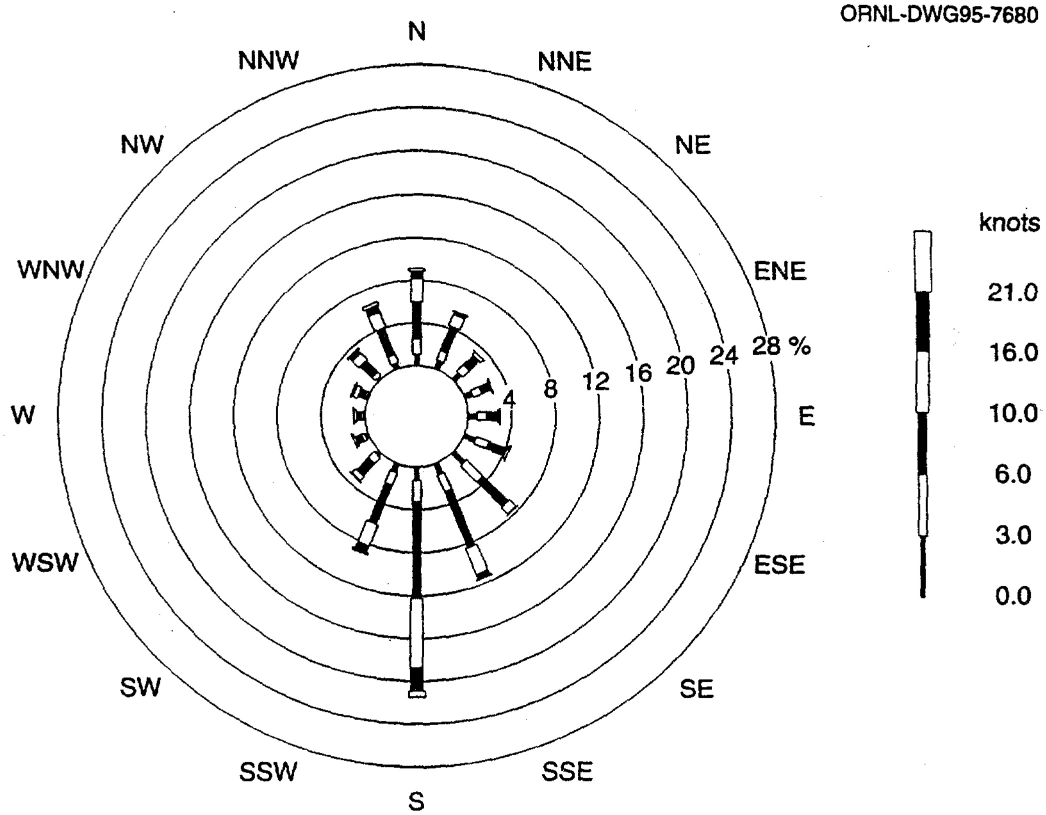

Fig. B.1. Wind rose for the Dallas-Fort Worth International Airport. The height of the anemometer was 10 m and the period of measurement was January 1984 to December 1992. A wind rose is a graph in which the frequency of wind blowing for each direction is plotted as a bar that extends from the center of the diagram. Wind speeds are denoted by bar widths; the frequency of wind direction is depicted according to the length of that section of the bar. Note that the wind rose displays directions from which the wind blows, emissions would travel downwind in the opposite direction.

Table B.3. Joint frequency distribution (percent) from wind data collected at the Dallas-Fort Worth International Airport between 1984 and 1992; anemometer height is 10 m.

Wind direction	Windspeed (knots)						Total
	1-3	4-6	7-10	11-16	17-21	> 21	
N	1.06448	1.45479	3.56853	2.14416	0.76794	0.24838	9.2
NNE	0.82497	0.99731	2.51419	1.16712	0.29020	0.07097	5.86
NE	0.86679	0.88580	1.30018	0.35736	0.03928	0.00380	3.45
ENE	0.78188	0.85665	0.90607	0.17741	0.01014	0.00634	2.74
E	0.85285	0.90354	1.09109	0.19769	0.01014	0.00507	3.06
ESE	1.06448	1.24442	1.81848	0.27246	0.01901	0.00253	4.42
SE	1.42437	2.01870	3.42153	0.81356	0.06590	0.01267	7.76
SSE	1.03786	1.68796	5.69368	2.57502	0.48155	0.09758	11.57
S	1.22035	2.05039	8.98469	6.51485	2.23794	0.57406	21.58
SSW	0.76541	1.29004	3.91956	2.14923	0.69444	0.21796	9.04
SW	0.42326	0.71599	1.52448	0.52464	0.12039	0.02788	3.34
WSW	0.29653	0.34722	0.63869	0.21163	0.04435	0.01394	1.55
W	0.17741	0.21416	0.46888	0.24584	0.05576	0.03802	1.20
WNW	0.16474	0.23444	0.64376	0.44226	0.15207	0.05322	1.69
NW	0.31554	0.46888	1.54222	0.90481	0.36623	0.17741	3.78
NNW	0.56138	0.94156	2.66373	1.58404	0.68684	0.30667	6.74
Total	11.84	16.31	40.70	20.28	6.04	1.86	97.03[a]

[a]Total winds do not include percent calms (winds less than 1 m/s). Percent calms are slightly under 3%.

Table B.4. Maximum effective dose equivalents calculated using the CAP88PC model for potential emissions from the proposed RMTC

Radionuclide	Maximum effective dose equivalent (mrem/year)[a]
^{3}H	1.9×10^{-9}
^{27}Be	7.8×10^{-7}
^{11}C	4.3×10^{-4}
^{14}C	2.4×10^{-9}
^{13}N	1.1×10^{-3}
^{14}O	1.9×10^{-4}
^{15}O	3.0×10^{-3}
Total	4.7×10^{-3}

[a]The location of the maximum annual dose equivalent was found to occur at a receptor located 100 m to the north of the proposed stack.

Table B.5. Maximum effective dose equivalents at 1000 m[a] using the CAP88PC model for potential emissions from the proposed RMTC

Radionuclide	Dose equivalent[b] (mrem/year)
^{3}H	6.1×10^{-11}
^{7}Be	1.2×10^{-8}
^{11}C	4.7×10^{-6}
^{14}C	1.8×10^{-10}
^{13}N	1.0×10^{-5}
^{14}O	7.5×10^{-7}
^{15}O	1.2×10^{-5}
Total	1.3×10^{-5}

[a]The location of the maximum annual effective dose equivalent was found to occur at a receptor located due north of the proposed site.
[b]This is the computed maximum effective dose equivalent at 1,000 m.

B.2 REFERENCE

Parks, B.S. 1992, *User's Guide for CAP88PC, Version 1.0*, Report No. 402-B-92-001, Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, Nevada.

DOE F 1325.8
(4/93)

United States Government **Department of Energy**

Oak Ridge Operations Office

memorandum

DATE: May 18, 1995

REPLY TO ATTN OF: SE-311:Phillips

SUBJECT: **ENVIRONMENTAL ASSESSMENT AND FINDING OF NO SIGNIFICANT IMPACT FOR THE DISBURSEMENT OF $65 MILLION TO THE STATE OF TEXAS FOR CONSTRUCTION OF A REGIONAL MEDICAL TECHNOLOGY CENTER AT THE FORMER SUPERCONDUCTING SUPER COLLIDER SITE, WAXAHACHIE, TEXAS**

TO: E. G. Cumesty, Assistant Manager for Energy Research and Development, ER-10

The subject environmental assessment (EA), dated May 1995, has been reviewed. Based upon the results of the analysis reported in the EA, and after consultation with the ORO National Environmental Policy Act Compliance Officer, and Office of Chief Counsel, I have determined that the EA is adequate for publication and is hereby approved. I have also determined that within the meaning of the National Environmental Policy Act of 1969, the proposed action is not a major Federal action significantly affecting the quality of the human environment, therefore, the preparation of an environmental impact statement is not required. The basis for this determination is explained in the attached Finding of No Significant Impact (FONSI).

Please note that your office is responsible for providing public notice of the availability of the EA and FONSI in accordance with 40 CFR 1021.322; and DOE 5440.1E, paragraph 6A (24). I am providing a copy of these documents for your files.

James C. Hall

James C. Hall
Acting Manager

Attachments

cc w/attachments:
C. Borgstrom, EH-4.2, HQ/FORS (5 paper copies, 1 electronic copy)
P. Phillips, SE-311, SE-311, ORO
C. Hickey, ER-8.2, HQ/GTN
W. Hasselkus, SSC
SSC Project Office
DOE Public Reading Room, ORO

FINDING OF NO SIGNIFICANT IMPACT

Disbursement of $65 Million by the U.S. Department of Energy to the State of Texas for Construction of a Regional Medical Technology Center at the Former Superconducting Super Collider Site, Waxahachie, Texas

AGENCY: U.S. DEPARTMENT OF ENERGY

ACTION: FINDING OF NO SIGNIFICANT IMPACT

SUMMARY: The U.S. Department of Energy (DOE) has completed an environmental assessment (DOE/EA-1090) of the proposed disbursement of $65 million to the State of Texas for construction of a Regional Medical Technology Center (RMTC) near Waxahachie, Texas. Based on the results of the analysis reported in the EA, DOE has determined that the proposed action is not a major Federal action that would significantly affect the quality of the human environment within the context of the National Environmental Policy Act of 1969 (NEPA). Therefore, preparation of an environmental impact statement (EIS) is not necessary, and DOE is issuing this Finding of No Significant Impact (FONSI). Additionally, pursuant to Executive Order 11988, *Floodplain Management* and 10 CFR 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements,* DOE reports in this EA that no riverine or palustrine wetlands that occur within riparian habitats would be adversely impacted by construction of the RMTC.

PUBLIC AVAILABILITY OF EA AND FONSI: The EA and FONSI may be reviewed at the following address and copies of the documents obtained from:

U.S. Department of Energy
Superconducting Super Collider Project Office
2275 Highway 77
Waxahachie, Texas 75165.
Phone: (214) 935-9000 ext. 2507

FURTHER INFORMATION ON THE NEPA PROCESS: For further information on the NEPA process, contact:

Carol M. Borgstrom, Director
Office of NEPA Policy and Assistance (EH-42)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Phone: (202) 586-4600 or (800) 472-2756.

BACKGROUND: In 1993, Public Law 103-126 mandated that DOE terminate construction of the Superconducting Super Collider (SSC), a proposed energy research facility near the town of Waxahachie in Ellis County, Texas. A provision of the law required the Secretary of Energy to consider possible alternative uses of SSC assets to maximize their value to the nation. As part of a settlement agreement with the State of Texas, DOE proposes to disburse $65 million of federal funds to the Texas National Research Laboratory Commission (TNRLC) for construction of a Regional Medical Technology Center (RMTC) in Ellis County, Texas. The RMTC is a proposed state-of-the-art facility that would provide high-energy-proton-beam cancer therapy. The State of Texas would operate the facility in conjunction with the University of Texas—Southwestern Medical Center. The RMTC would make extensive use of the partially constructed linear accelerator (linac) for the SSC facility.

Funding of the RMTC by DOE is independent of other actions related to closure and reclamation activities at the SSC site.

ALTERNATIVES: DOE considered the no-action alternative and alternate sites for the RMTC. If no action is taken, $65 million would not be disbursed to the State of Texas for the RMTC. The use of alternate sites for the RMTC was dismissed from consideration because the SSC linac assets are available at only the proposed location for the RMTC.

ENVIRONMENTAL IMPACTS:

Air Quality

Construction of the RMTC would disturb approximately 10 acres of previously disturbed land at the SSC site. Excavation, grading, and other earth-moving activities would generate fugitive dust [particulate matter (PM)], which would temporarily degrade local air quality at the site. Ambient PM concentrations would not exceed air quality standards, and off-site air quality would not be degraded. Construction and commuter vehicle emissions would be temporary and localized at the SSC site.

Water Resources

Construction activities would disturb soils, increasing the potential for erosion, seepage, and sedimentation during periods of heavy precipitation. Earthen and straw berms, plastic liners and covers, and other runoff barriers would be used to minimize the potential for runoff to the nearest stream, Boz Creek. Existing french drains near the linac would provide a groundwater sink that would minimize seepage to the deeper confined aquifer system during both construction and operation.

Water consumption during construction would be 4% or less of the reserve capacity of the Waxahachie and Ennis surface water supply.

Floodplain/Wetlands

The proposed site is above the 100-year floodplain of Boz Creek. There are no wetlands on the site. Two small palustrine wetlands less than 1 acre in size are located about 0.5 mile south-southwest of the site. Sediment could temporarily degrade water quality in these areas during periods of heavy precipitation.

Biota

The RMTC would be constructed on a very small, previously disturbed portion of the former SSC site. Because of this, impacts to on-site biotic resources would be minimal. No federally listed threatened and endangered species would be affected by the proposed action.

Noise

The nearest resident to the proposed site is located about 0.8 miles away. Noise from construction vehicles and equipment would be well-above ambient levels at the RMTC site and may be audible at the nearest residence. This may be perceived as nuisance noise by some individuals. No public health effects would be expected because noise levels would attenuate to acceptable levels off-site. Workers would be equipped with personal protective equipment, in accordance with regulatory requirements.

Socioeconomics

Construction of the RMTC would have a small positive impact on the local economy and infrastructure. A workforce of approximately 190 would account for 0.7% of total employment in Ellis County. Jobs provided by the RMTC project would offset a percentage of jobs lost due to termination of the SSC project.

Surveys conducted in support of an environmental impacts analysis for the SSC project found no archaeological or historic resources at the site. Discovery of artifacts during construction would be subject to mitigation requirements defined in an interagency programmatic agreement (DOE, Texas Historical Commission, Advisory Council on Historic Preservation, and TNRLC) for the SSC project.

Environmental Justice

In accordance with Executive Order 12898, DOE evaluated the potential for adverse impacts to minority and economically disadvantaged populations within the zone of impact of the proposed RMTC. As there are no adverse impacts in general from the proposed action, no special populations would be adversely affected.

Health and Safety

Radionuclides emitted from the RMTC heating, ventilating, and air-conditioning stack present a potential hazard to occupational and public health. Calculations indicate that, during RMTC operation, the maximum dose rate to an individual located 300 ft to the north of the stack would be 0.0086 millirem/year, which is less than 0.1% of the Environmental Protection Agency's public exposure limit for atmospheric radionuclide releases. Occupational exposure to radiation would occur during patient treatment. Workers would be rotated in jobs to minimize exposure, protected by shielding, and monitored frequently to ensure that their dose is within acceptable industry limits.

The imported red fire ant can be a hazard to sensitive construction workers; worker training and pest control would minimize this hazard.

DETERMINATION: Based on the findings of this EA, DOE has determined that the proposed disbursement of $65 million to the State of Texas for construction of the Regional Medical Technology Center would not constitute a major Federal action that would significantly affect the quality of the human environment within the context of the National Environmental Policy Act. Therefore, preparation of an environmental impact statement is not required.

Issued at Oak Ridge, Tennessee, this 16th day of May, 1995.

James C. Hall
James C. Hall
Acting Manager
Oak Ridge Operations Office