DOE/EA-0898

ENVIRONMENTAL ASSESSMENT

PROPOSED FERMILAB FIXED TARGET EXPERIMENT:

KAONS AT THE TEVATRON

U.S. Department of Energy

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December 1993

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Finding of No Significant Impact

Proposed Fixed Target Experiment:

Kaons at the Tevatron

Fermi National Accelerator Laboratory

Batavia, Illinois

AGENCY: U. S. Department of Energy

ACTION: Finding of No Significant Impact (FONSI)

SUMMARY: The U. S. Department of Energy (DOE) has prepared an Environmental Assessment (EA), DOE/EA-0898, evaluating the impacts associated with the proposed fixed target experiment at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, known as Kaons at the Tevatron (KTeV). The proposed KTeV project includes reconfiguration of an existing target station, enhancement of an existing beam transport system connected to existing utility facilities, and construction of a new experimental detector hall area. The study of the K meson, a type of subatomic particle, has been going on at Fermilab for 20 years. The proposed KTeV project advances the search for the origins of a violation of a fundamental symmetry of nature called charge parity (CP) violation.

Based on the analysis in the EA, the DOE has determined that the proposed action does not constitute a major Federal action significantly affecting the quality of the human environment, within the meaning of the National Environmental Policy Act (NEPA) of 1969. Therefore, the preparation of an Environmental Impact Statement is not required.

DESCRIPTION OF THE PROPOSED ACTION:

The proposed action consists of modifying the existing Neutrino Area Muon beamline by upgrading the NM2 target hall, changing the beamline to accommodate a new decay enclosure, and constructing a new experimental hall including a control room area. The approximately 2000 $ft.^2$ NM2 area would accommodate a new target station with increased radiation shielding. Utility extensions needed for the primary beam target system include: radiation monitoring, water flow and water temperature monitoring, electricity, remote computer controls and communications. The proposed new experimental hall and counting house would require construction in a previously disturbed area of less than one acre with the spectrometer equipment located north of a nearly 3200 $ft.^2$ decay enclosure. The experimental hall (approximately 23 feet below grade) would require destruction of the existing NM4 underground blockhouse and excavation of soil, totalling 35,000 $yd.^3$.

ALTERNATIVES:

Four alternatives were considered: (1) construction within existing fixed target areas, (2) construction at another Fermilab site, (3) use of other DOE facilities, and (4) no action.

Construction Within Existing Fixed Target Areas:

This alternative was rejected due to the infeasibility of reconfiguring the primary beam switchyard system for new beamlines, and as well as the difficulty of avoiding undisturbed areas.

Construction at Another Fermilab Site:

The Meson East, Meson Polarized, and NuMuon experimental sites were considered infeasible due to the difficulty of relocating the beamline further underground to achieve adequate shielding from radiation.

Use of Other DOE Facilities:

This alternative was found unreasonable due to the limited beam energies available at facilities other than Fermilab, thus limiting the goals of the project.

No Action:

The no action alternative is a continuation of the ongoing study of the K meson under current management practices.

ENVIRONMENTAL IMPACTS:

The EA analyzes the impacts of construction and operation of the proposed KTeV facility. The environmental impacts are summarized below.

Impacts of Construction:

Some excavated soil north of the existing target station near the beamline is expected to be activated above the natural radioactive background. Such soil would be segregated from non-radioactive soil and protected to prevent creating small amounts of airborne radioactivity or radioactive runoff from precipitation. In order to minimize the creation of additional radioactive soils, this excavated soil will be reused as backfill at the site. It is expected that the construction will disturb the existing earthen berm. Siltation and erosion controls will be instituted during construction. There are no protected species or known archeological resources in the project impact area. Construction noise levels would be typical of previous fixed target construction activities, due to the occasional operation of excavation equipment, trucks, and cranes. Minimal impacts are anticipated.

<u>Human Health - Workers</u>:

<u>Construction Impacts</u>. The 12 technical workers involved with the reconfiguration of elements in the target enclosure, as well as the 12 workers involved in the excavation of activated soils, will be monitored for possible exposure to low level radiation. Generally each worker will be expected to have an exposure rate of much less than 100 mrem per year for this 3-month activity; this is significantly less than the DOE applicable exposure limit of 5000 mrem per year for radiation workers. In comparison, the average dose from natural sources is over 300 mrem per year. A risk assessment based on the maximally exposed worker (NM2 configuration workers, assuming a dose of 25 mrem per year) indicates that there would be no induced fatalities or health effects attributable to this exposure level.

<u>Operational Impacts</u>. Experimental personnel and operation workers will also be monitored to control exposure to low level radiation. An estimated population of 50 experimental workers are expected to be involved in a non-continuous 10-year operation of the proposed experiment. Following the same type of analysis used in the construction section above, there will be no induced health effects attributable to operation activities of this experiment.

Impacts of Normal Operation of KTeV:

Penetrating radiation will be present only during the operation of the isolated KTeV beamline due to the interaction of the beam with objects such as targets, collimators, beam absorbers or other material the beam might strike. The radiation particles will be shielded by combinations of soil, concrete, steel and by keeping many of the particles below grade level. The amount of shielding is determined by the requirements for containing the full intensity loss of the beam and the maintenance of desired radiation limits outside the shield. The soil surrounding the target station can become activated due to the neutron component of the penetrating radiation. The subsequent leaching of this radioactivity and transport to the underlying aquifer will not result in ground water concentrations above the Environmental Protection Agency (EPA) limits. Calculations have been performed to determine the amount of steel and concrete shielding necessary to protect the soil and aquifer around the target station to a level below the EPA limits that insure that the resulting committed effective dose equivalent is no more than 4 mrem per year.

KTeV cooling water will be kept separate from all other circulating water. This "closed-loop" circulating water in a system for thermally cooling the target station magnets and beam absorbers, will become activated due to the targeting of the beam. The primary isotope is tritium. Calculations indicate that the concentrations in this water will be five times greater than the DOE surface water discharge limits. Consequently secondary containment for this proposed facility will be provided. Experience with existing systems in the experimental area provides for an effective design that diverts any leaking closed-loop water to a retention pit for analysis. If the concentration is below allowable limits, it will be released via surface ditches to Casey's Pond, a recirculative cooling system for the Fermi Main Injector, the Tevatron, and other existing fixed target experiments. Casey's Pond is the primary source of water for fire protection sprinkler systems, cryogenic compressors, air conditioning for research areas, and heat exchangers throughout the fixed target areas. If the concentration exceeds allowable limits, the water will be collected for disposal as radioactive waste. No significant impacts are expected.

The air inside the target station can become activated due to the passage of the beam through it. The expected airborne activity released by the proposed KTeV operations was determined by scaling from the measured activity released at the intensity of protons delivered during the previous NM2 target operations, to the intensity of protons expected to hit the KTeV target. The increase is anticipated to be 58.7 Curies, from 21.3 Curies released from the existing NM2 target station in CY 1991, to 80 Curies anticipated for the KTeV target. Consequently, the KTeV experiment can be expected to contribute about 0.02 mrem per year to the off-site dose due to airborne activity. The allowable limit is 10 mrem per year, based upon the EPA standard for airborne radionuclide emissions from DOE facilities. No health effects to the public are expected.

<u>Impacts of Off-Normal Operation of KTeV</u>:

The target and beam absorbers will be designed to accept the full machine intensity without going beyond radiation guidelines. Based upon Fermilab Radiological Control Manual criteria, sufficient shielding exists along the beamline to protect workers and the environment in the event the <u>full</u> primary proton beam from the

Fermilab accelerator is transported to some region other than the normal targeting area. The geometry of the primary beam transport also eliminates the possibility of proton pulses reaching the experimental hall or striking the experimental apparatus. Control room occupants could have an exposure rate of 0.0087 mrem/hr in the event of inadvertent transport of a single full intensity pulse to the KTeV target, which is six times the normal operating dose. Off-normal events are extremely rare, less than one pulse in 10,000 based on operating history. No excess health effects are expected to workers from off-normal operations.

Cumulative Impacts:

While the proposed action will result in an increase in air activation due to the NM2 target station, this increase will be largely offset by a corresponding reduction in the number of target station sites at the laboratory (i.e., elimination of kaon physics at the MCenter site), and by improvements in radiation protection at the NM2 target station. The cumulative effect due to air activation has been calculated as an increase in the maximum effective dose rate to a member of the public residing off-site, from 0.028 to 0.039 mrem per year. This results in a cumulative increase over the CY 1991 fixed target run of 0.011 mrem, which is 0.1% of the allowable limit of 10 mrem per year. The cumulative effects of not using the MCenter target station, and reconfiguring the NM2 target station also include improved containment of the penetrating radiation and decreasing the rate of soil activation around the target. Minimal cumulative impacts are expected.

DETERMINATION:

Based on the analysis in the EA, the DOE has determined that the proposed construction and operation of the KTeV facility at Fermilab does not constitute a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969. Therefore, the preparation of an Environmental Impact Statement on the proposed action is not required.

PUBLIC AVAILABILITY: Copies of this EA (DOE/EA-0898) are available from:

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Assistant Secretary
Environment, Safety and Health

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LIST OF ABBREVIATIONS AND ACRONYMS

AGS	Alternating Gradient Synchrotron
APO	Antiproton Target Hall
^{41}Ar	Argon 41 isotope
BNL	Brookhaven National Laboratory
CP	Charge and Parity
cm	centimeter
^{11}C	Carbon 11 isotope
CY	Calendar Year
DOE	(U.S.) Department of Energy
EA	Environmental Assessment
ES&H	Environment, Safety, and Health
EPA	(U. S.) Environmental Protection Agency
^{3}H	Tritium
HEPAP	(DOE) High Energy Physics Advisory Panel
IEPA	Illinois Environmental Protection Agency
KTeV	Kaons at the Tevatron
kW	kiloWatts
MCenter	Meson Center Area
MEast	Meson East Area
MPolarized	Meson Polarized Area
ml	milliliter
mrem	millirem
^{22}Na	Sodium 22 isotope
^{13}N	Nitrogen 13 isotope
NEPA	National Environmental Policy Act
NM	Neutrino Muon
NM2	Neutrino Muon Enclosure #2
NM5	Neutrino Muon Enclosure #5
NuMuon	Neutrino Muon Experimental Area
NMS	Neutrino Muon Lab Experimental Hall
NMR	Neutrino Muon Lab Enclosure R
NESHAP	National Emission Standard for Hazardous Pollutants
^{15}O	Oxygen 15 isotope
pCi	picoCurie
μCi	microCurie
SSC	Superconducting Super Collider
Bq	Becquerel

1.0 INTRODUCTION

The Fermi National Accelerator Laboratory (Fermilab) is a Federal research laboratory owned and supported by DOE and operated by Universities Research Association, Inc. a consortium of 72 universities. The Fermilab complex includes a village, an office center, research centers, underground structures and equipment for performing physics experiments. Figure 1.1 shows a schematic layout of the main Fermilab accelerator, called the Tevatron, the experimental areas and the location of the Fermilab Main Injector Project.

The high energy physics program at Fermilab investigates the structure of matter by using the collisions of particles to create new matter which is studied using complex and large detectors. Two complementary ways of study using the Tevatron are the "fixed target experiments" and the "collider experiments." The Tevatron accelerates a collimated collection of particles called a "particle beam" or commonly "beam." In the fixed target experiments this beam of protons from the Tevatron strikes a stationary target made of ordinary matter. The collision produces subatomic particles which survive for short periods of time (very small fractions of a second). Various techniques allow particular forms of the newly formed matter to be selectively examined by collecting specific particles into other well-defined beams directed into experimental detectors. In the collider mode of operation, two counter rotating beams in the Tevatron pass through each other at a point in the middle of a detector. A few particles from each beam strike each other producing new forms of matter which are then studied by this detector.

The long and arduous task of starting an experiment at Fermilab requires a number of stages. Scientists, most of whom are physicists, collectively consider investigating a particular physics topic. These independent groups called experimental collaborations, can have 50 to 500 people working on a single experiment, and typically contain representatives from many universities throughout the world. The collaboration proposes to perform an experiment at Fermilab. This proposal includes a specified topic, experimental detector design, and operational requirements. Next, an independent review committee composed of a few physicists from many Universities and laboratories, evaluates the proposal and submits a recommendation to the Director of Fermilab. This process can take up to one year. Subsequently, with the Director's approval, the collaboration can begin in earnest to collect resources, design and build the apparatus, and test many parts of the detector, at their home institutions and at the test facilities at Fermilab. This stage also can take more than a year to complete. With several experiments approved to operate at the same time, each collaboration must be prepared to perform their experiment at the agreed scheduled time, and for the agreed duration to effectively utilize the Fermilab accelerator. The duration of experiments can vary, but many experiments last for a number of years depending on the programmatic constraints of the laboratory program and the experiment.

2.0 PURPOSE AND NEED

The continuing efforts of the DOE in technological and academic work has led to a vigorous research program in physics. The main effort of the DOE's high energy physics program during the next several years investigates the basis of the current understanding of subatomic matter and what lies beyond it.[1]

The peer review process described in Section 1.0 has lead to a proposed new experiment called KTeV (Kaons at the Tevatron). The collaborating scientists propose to search for an understanding of the violation of a fundamental symmetry in nature, which depends on the electric charge of the particles and their properties under spatial reflection. These collective properties are called CP, where C stands for charge and P stands for parity.

Nearly 30 years ago a violation of this symmetry was discovered in the study of the K meson. It appeared as a rare (one in a thousand) decay of a neutral (uncharged) K meson into two particles rather than into the usual three particles. At the time of its discovery this violation was not understood. Although some current concepts of the structure of nature incorporate this phenomena, scientists would like to distinguish between the alternate explanations of the source of this symmetry violation; perhaps the truth lies outside of all the current ideas.

The study of the neutral K meson has been going on at Fermilab for nearly 20 years. The proposed KTeV project advances that line of study by continuing the search for the origins of the symmetry violation. Additionally other aspects of neutral K meson decays could be studied in greater detail, further testing in other ways, the current concepts of the structure of matter.

To continue the study, scientists require an improved source of kaons (the beam) and a more sensitive instrument to measure them (the detector). The beamline would contain more high energy kaons and fewer particles other than kaons. The detector, which consists of several subsystems, would be constructed according to improved designs based on the previous years of experience in the earlier experiments. KTeV would remain the forefront facility for studying kaons well into the next decade.

3.0 THE KTEV FACILITY (PROPOSED ACTION) AND ALTERNATIVES

3.1 Description of the Proposed Action

The U. S. Department of Energy (DOE) proposes to modify one of the existing fixed target beamlines at Fermilab to accommodate an experimental research program involving the study of a particular subatomic particle, the neutral K meson (kaon) produced with the main Fermilab accelerator, the Tevatron. The proposed action is to construct and bring into operation a new experiment called Kaons at the Tevatron (KTeV). The KTeV facility would be the facility dedicated to the KTeV experiment. The KTeV experiment would be the only approved experiment allowed or scheduled for running in this facility. Any future use of this facility would require the administrative approval of the Director of Fermilab, and would undergo a separate NEPA review.

3.1.1 Location of the Proposed Action

The KTeV facility would be constructed by modifying the existing Neutrino Area Muon beamline to accommodate the planned kaon experimental program. A layout of the area of this proposed action is illustrated in Figure 3.1. Appendix A is an aerial photograph of Fermilab showing the same region of the experimental areas where the proposed action would be located. Both the figure and the photograph show existing buildings, roads, and enclosures; a dotted outline of the proposed new construction is included in Figure 3.1. Included in the project are changes to the elements of the existing NM2 target hall, a new decay enclosure, a new experimental hall, and a new counting house (control room/computer and electronics area). Different elements in the existing target hall would provide increased radiation protection, improved handling of the Tevatron beam, as well as enhanced control of background muon rates in the KTeV detector. The experimental hall and counting house would be constructed in the previously disturbed area downstream of the NM2 target hall.

3.1.2 Construction

The proposed project site is in a 2.5 to 3.0 acre region that contains the existing NM beamline which was associated with a previous fixed-target experiment. The primary particle beam transport system would be assembled entirely within existing beamline enclosures that are located below grade and have radiation shielding that conforms to the criteria specified in the Fermilab Radiological Control Manual. Where possible the new beamline would use components from other beamlines on site that no longer require them.

Figure 3.2 shows the existing NM2 target hall and a conceptual layout of the improved target hall for this proposal. This design does not require structural changes to the enclosure. The targeting station for the proposed experiment would be assembled within the existing enclosure (NM2) that currently contains the target station for the Fermilab muon beam. This approximately 2000 square foot area would accommodate a new target station and increased shielding. The existing target station within the enclosure would be disassembled and its components, which include target components, magnets, support stands, and surrounding steel and concrete shielding, would be removed for storage elsewhere on-site or incorporated into the new target station, where possible, to minimize the creation of new radioactive material. Any excess (low level) activated components or materials removed would be transferred to an approved DOE disposal facility. Temporary storage, if necessary, is available at the Fermilab railhead, more than 2 miles from Wilson Hall. The railhead is an 11 acre restricted-access (fenced) area with sensor alarms, locks and interlocks, which is continuously patrolled by Fermilab security personnel.

Concrete and steel shielding would be installed within the enclosure to keep soil and ground water activation, primarily ^{3}H and ^{22}Na, within the limits prescribed by the Fermilab Radiological Control Manual[2] (i. e. for community drinking water supplies of 20 pCi per ml for ^3H and 0.4 pCi per ml for ^{22}Na, and the discharge limits for surface waters of 2000 pCi per ml for ^3H and 10 pCi per ml for ^{22}Na.), and within the limits prescribed by DOE Orders, and EPA regulations.

Utilities needed in this area would include extensions of the services already present and needed for a primary beam target system including: radiation monitoring, water flow and water temperature monitoring, electricity, remote computer controls and communications.

The proposed new KTeV experimental hall and counting house would require new construction on the proposed site using an area approximately 6/10 of an acre, with the experimental equipment located downstream of a nearly 3200 square foot decay enclosure. This new decay enclosure (containing the evacuated tube where particles decay to photons) would utilize an existing building by extending both the south and the north ends of the 50 foot long NM3 enclosure. The proposed civil construction plan is illustrated in Figure 3.3. The dashed lines indicate new construction, while the solid lines indicate existing structures. The counting house would be constructed at ground level, separated from the experimental hall by appropriate shielding. According to the current (preliminary) design, the experimental hall would be approximately 55 feet high, with the floor approximately 23 feet below grade. The beam would pass through the experimental hall approximately 8 feet above the floor, with appropriate shielding to ensure that all areas conform to the Fermilab ES&H policies on shielding, which meet DOE requirements. Utilities of the experimental hall would include water, sanitary, electric, safety monitoring and communication utilities, and would be extended from existing enclosures.

The experimental hall would require destruction of the existing 24 foot long NM4 enclosure. The NM4 enclosure is an underground blockhouse, 8 feet x 6 feet x 24 feet (see Figure 3.1), containing a quadrupole magnet previously used in the focusing system for the muon beam. The volume of slightly radioactive (see Section 5.1.1) concrete block waste which would be generated by demolition of the 1 foot thick walls is estimated at 80 cubic yards.

3.1.3 Pre-Operation

Prior to KTeV operation, all facility construction would be completed as well as installation and commissioning of the new particle beamline and detector components. Shielding designs at Fermilab are done using standard computer programs (see Section 5.2.1) which have been extensively verified experimentally at Tevatron energies up to 900 GeV. Prior to commissioning, the beamline and experimental hall shielding would be certified as complete and sufficient to allow KTeV operation within the required safety envelope, according to DOE Order 5480.25, Safety of Accelerator Facilities and DOE Order 5480.11 Radiation Protection for Occupational Workers, the Fermilab Radiation Control Manual, and Fermilab Research Division safety and beam operation Guidelines.

An approved laboratory operational readiness clearance, experimenter training as defined by laboratory Conduct of Operations requirements, and subsystem safety reviews must be completed before beam could be used for KTeV operation.

3.1.4 Operation

Operation of the KTeV facility would comply with standard Fermilab safety and beam operation guidelines. Beam interlock safety systems, approved running conditions, and on-shift Operations personnel would be required for KTeV beam operation.

Beam intensity for the primary proton beam and secondary particle beam would be maintained within normal operation levels approved by the Laboratory Director in accordance with Fermilab Radiation Control Manual requirements. The maximum primary proton beam intensity achieved to date at Fermilab is 3×10^{13} protons. Normal operation of the KTeV primary proton beam would be 5×10^{12} protons on target. The expected secondary particle beam (downstream of the target) would be on the order of 2×10^{9}. The target enclosure would be adequately shielded to accept off-normal conditions in which the entire beam is delivered to the KTeV primary target without exceeding Fermilab radiation safety guidelines. These conditions are discussed in Section 5.

The operation of a fixed target beamline at Fermilab begins at the extraction region of the accelerator and through the switchyard. The switchyard is a system of electrostatic and magnetic elements that split the Tevatron primary proton beam into separate primary proton beams for the three primary experimental areas (Meson, Neutrino, and Proton) of the fixed target laboratory, as shown in Figure 1.1 . These elements can manipulate the particle beams because the protons have an electric charge. In general, each separate primary proton beam is transported to an individual target station or experiment. Before hitting the targets, the proton beams are usually distinguished only by their size and intensity, and are often matched to a particular target type and size for that experiment. Targets are usually a small piece of metal and the beam spot size can range from less than 1 millimeter to 1 or 2 centimeters. In this proposed action, for example, the target would be approximately 1 millimeter thick, 2.5 centimeters high and 30 centimeters wide. After the proton beam hits the target, it is dumped. The secondary particle beam is selected from the particles produced by the interaction of the primary proton beam and the target, and is selected in the direction of the experimental detector in the experimental hall to perform the experiment.

Some of the beam elements necessary for transporting the primary beam from the switchyard to the proposed NM2 KTeV target station are shown in Figure 3.2. The first element is a device that allows the operators to determine the beam size at the entrance to the enclosure, followed by a string of electromagnets. The dipole magnets provide the capability of moving the beam in a plane, i.e. east and west or up and down. These devices therefore position the beam on the target. The "quads" or quadrupole magnets allow the beams to be focused on the target. The effect of the quadrupole magnet on a charged particle beam is a direct analogy to the focus of a visible light beam through an optical lens. The target pile would consist of a target 30 centimeters long followed by a series of magnets and a large piece of material that absorbs the primary beam. The magnets located after the target, sweep away many of the charged particles that are produced leaving primarily a neutral particle secondary beam. The kaons for use in the experiment are allowed to pass through holes in absorbers known as collimators, and thus define the kaon beam which finally reaches the experimental detector.

The operation cycle occurs when beam is scheduled or when beam is being extracted to the area. Operation of the beamline amounts to turning on or turning off the systems that control the electromagnets and monitoring devices. Operation of the computer controlled power supplies and detection equipment is accomplished remotely. Cooling water systems and radiation are also remotely monitored. Loss monitoring connected to the interlock system would discontinue beam extraction if the ambient radiation levels exceed a preset dose rate based upon the Fermilab Radiological Control Manual.[2] These operation activities occur at the beginning of the operation cycle and this cycle, generally called a "run", can last for several months. The beamline enclosures are all physically searched, secured, interlocked and finally approved for accepting beam in the area. No access is expected or allowed during operations while the beam is present in an enclosure. The experimental detector apparatus, power systems, and other computer controlled systems would be continuously monitored by the experimenters and the operators throughout the operation cycle. Routine <u>scheduled</u> maintenance activities include repair of inoperative equipment, radiation surveys during periods that the beam is off, changing filters for the gas and water systems, and adjustments of the air conditioning and vacuum systems for the detector and the beamlines. Generally, due to continued operations, maintenance of many systems do not follow routine schedules. It is not anticipated that any of these activities are extensive or lead to an impact on personnel or the environment.

The hazardous materials which could be used in the KTeV experiment are lead and beryllium. Parts of various individual detectors (the vacuum veto ring counters and the spectrometer anti counters) would be lead. This lead will not intercept the particle beam, and will not become activated. The total amount of lead is estimated to be 39.4 cubic feet. The proposed target described in Section 3.1.4 is presently .0003 cubic feet of beryllium. Non-hazardous alternatives are being actively pursued.

Kaon physics would continue for the duration of the accelerator operation as long as there is useful physics to be performed and with approved experimental proposals. New ideas and new detector equipment may be used in the future as experiments progress.

3.1.5 Decommissioning of Proposed KTeV

Information necessary for future decommissioning of KTeV experiments would be maintained in compliance with Laboratory safety policies. The primary target area would contain most of the residual radioactivity, the bulk of which is short lived isotopes. If not to be reused, the radioactive materials, the hazardous materials (lead), and the activated beryllium would be removed and disposed of at the time of decommissioning in accordance with DOE Order 5820.2A, Radioactive Waste Management and DOE Order 5400.3 Hazardous and Radioactive Mixed Waste Program.

3.1.6 Project Schedule

Construction of the proposed KTeV facility would be carried out during calendar years 1993 and 1994. The facility would be completed in time for KTeV operation in the next Fermilab fixed target run currently scheduled for the 1st quarter of the year 1995. The activities scheduled for the proposed project include the NM2 modifications; the pre-decay enclosure, decay enclosure, experimental hall and counting house construction; and the experimental detector components assembly, testing and installation.

The NM2 modifications include: design work on the new target station components to be completed December, 1993; installation and testing during CY 1994 with a completion date December, 1994.

Site preparation, excavation and construction of the pre-decay enclosure and the decay enclosure would start March 1994, and be completed August 1994.

Site preparation, excavation, and construction of the experimental hall and counting house, including demolition of the underground blockhouse NM4, would start November 1993 and be completed December 1994.

Some of the experimental components would be procured, staged in a laboratory assembly building and tested prior to installation in the detector hall also scheduled for December 1994. Many of the activities could be carried out simultaneously since the areas are physically well separated.

3.1.7 New or Modified Permits and Licenses

There are no new or modified permits and licenses anticipated for this project. The NESHAP permit, which expires 8/28/94, would be maintained continuously prior to the commissioning of KTeV in 1995. The anticipated increase in air emissions (see Section 5.2.5) from KTeV emissions would fall within the limits set by the existing NESHAP permit, which are 100 Curies per year average and up to 900 Curies per year maximum. The permit includes the existing stack for the NM2 target hall.[3]

3.2 Alternatives

Several alternatives for the KTeV facility were considered, besides the Muon beamline site. These were determined to not be feasible because of beam intensity limitations, close proximity to other fixed target experiments, and limiting the physics capability due to other program commitments.

3.2.1 No Action Alternative

The no action alternative would be no construction or operation of the KTeV facility. Since there are no other experiments approved for the NM beamline or the MCenter beamline, the no action alternative assumes no use of these beamlines in the next fixed target run. Although the future of the MCenter beamline, where the Kaon Physics program has been located, is independent of KTeV, increased intensity needs of the kaon experiments and improved muon rejection requirements make continuing kaon experimentation in the MCenter beamline not feasible. Also the close proximity of beam facilities adjacent to the MCenter beamline, and limited berm shielding for higher intensity experiments, also preclude the use of this area for experiments similar to the proposed action. As previously discussed in Section 1.0, use of beamlines is determined by new proposals and the programmatic needs of the laboratory. Current schedules during the next operation period include using the MPolarized beamline as a test beam for collider detector development. The MCenter beamline and the MPolarized beamline are not designed to operate simultaneously.

3.2.2 Construction within Existing Fixed Target Areas

Construction of KTeV at new sites in the meson areas: MCenter, MEast, and MPolarized beamlines was considered, (see Figure 1.1). These beamlines are all located near the surface of the ground. Although they have different features, their location near the surface is a common, compelling characteristic that limits each beam as an alternative. Relocating any of them further below the surface to achieve adequate shielding from muons in the relatively congested meson area would be infeasible.

The Neutrino Muon Experimental Hall (enclosure NMS) is an existing experimental hall located at the end of the existing below-grade NM beamline about 5000 feet north (downstream) of the proposed action. Siting the proposed action in NMS would require use of the NMR target station or construction of a new target station. In over a dozen areas along the NM beamline, extra earthen shielding would have to be added to upgrade the current secondary particle beam shield to accommodate the transport of primary proton beam to a new downstream target station. The position of the new target station for the Neutrino Muon Hall would be close to an existing commerce access roadway, thus requiring not only the increased shielding, but possibly the relocation of the roadway.

3.2.3 Construction at Another Site at Fermilab

A new site for KTeV outside of the fixed target areas was rejected due to the increased resources which would be required, and complications of adapting the primary beam Switchyard system for new beamlines. The Switchyard system provides the mechanism for splitting the beam from the Tevatron into a number of proton beams, and redirecting them to the three beam areas and subsequently as many as 15 secondary beamlines. Readapting this system for a new beamline would require shutting off the fixed target areas, and reconfiguring the Switchyard. This would require an interruption in the ongoing experimental program and thus is considered infeasible. Use of an existing beamline for KTeV provides the best solution for these concerns.

3.2.4 Other DOE Facilities

Siting of the KTeV program at another DOE facility with an existing kaon physics program, such as the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL), is not feasible due to the limited kaon beam energies available at facilities other than Fermilab. The advantage of KTeV at Fermilab arises primarily from the higher energy of the particles produced. The sensitivity is a measure of the capability of distinguishing the signals for study from the signals due to background. For a lower energy BNL experiment, there is a notable loss in sensitivity, increased particle background, and degraded resolution.

The secondary beam energy comparable to that existing at Fermilab and necessary for the proposed experiment, would require the construction of a new facility producing a particle beam which has nearly 30 times the energy available at any other existing DOE accelerator facility. Without such energy the experimental compromises would preclude the ability of KTeV to reach its fundamental physics goals if staged at another DOE facility. Modification of such a facility to match the Fermilab fixed target facility was considered not feasible. Therefore this alternative was not considered further.

4.0 THE AFFECTED ENVIRONMENT

4.1 Site Description

Fermilab is located about 38 miles west of downtown Chicago, IL (Figure 4.1) in western DuPage and eastern Kane counties. The entire laboratory site consists of approximately 6800 acres, and is situated in an area of mixed residential, business and agricultural land use. Figure 4.2 summarizes the population data in the vicinity.[4]

The 2.5 to 3.0 acre site for the KTeV project includes existing enclosures and 6/10 of an acre for construction of the proposed new experimental hall, counting house and decay enclosure. The site is located in the muon beamline of the Fixed Target Area, between roads A, and C-West, and bordered on the south by the NM2 target hall and on the north by the NM5 enclosure. This area is currently occupied by various buildings and earthen structures associated with the high energy physics program at Fermilab (see Figure 3.1 and Appendix A). All original contours in this area have been disturbed, and replaced by shielding berms, paved areas, buildings and artificial waterways. Surveys have identified no archeological resources in the project area. Vegetation consists primarily of introduced eurasian grasses, cover species for bank stabilization (e.g., crown vetch) on berm surfaces, and some isolated trees. Fish and Wildlife Service has confirmed that no endangered or threatened species inhabit the project area, and there are no critical habitats or wetlands present.[5]

The laboratory has 2200 employees, including physicists, administrators, clerical staff, engineers, technicians, etc. In 1991, the laboratory had approximately 74,000 day visitors, not including 1400 temporary experimenters. The vast majority of the employees are located in Wilson Hall (adjacent to the Linac, Figure 1.1), approximately 2 miles southwest of the NM area. The visitors go to Wilson Hall for activities, self-guided tours, and business. The experimenters are not localized in any one area, but are distributed throughout the site, e.g. the fixed target and colliding beams experimental areas. The construction areas are confined to construction workers and laboratory personnel who are engaged in the administration or monitoring of construction activities.

4.2 Climatology and Air Quality

Extensive weather data for the Fermilab site were reported in the SSC Site in Illinois Proposal [6]. The predominant wind direction is southerly; wind direction from the southwest quadrant occurring with almost a 50% frequency (Figure 4.3). Average annual precipitation at Fermilab is 30 to 35 inches, with roughly 2/3 of the total falling in the period from April 1 to September 3, primarily associated with thunderstorm activity.

Airborne radionuclides are released from target stations in the Fixed Target Experimental areas as well as the Antiproton source. During 1991, total airborne radionuclide emissions amounted to 45.3 Curies from monitored stacks in the Fixed Target Area, and an additional estimated 11.8 Curies from unmonitored stacks. The Antiproton Source accounted for 50.0 Curies in 1991.[4] However, this stack is not within or adjacent to the proposed project site.

A computer program called CAP88-PC was used to model the radioactive sources and calculate dose assessments from these data, in accord with EPA regulations. The maximum effective dose equivalent to a member of the public at the site boundary for 1991 was 0.028 mrem, well below the standard of 10 mrem per year set by the National Emission Standard for Hazardous Air Pollutants (NESHAP). These data are representative of data for the previous four years.

There are no important sources of non-radiological airborne emissions, either in the proposed project site, or at the laboratory as a whole. Fermilab holds radiological air release permits and air pollution permits from the Illinois Environmental Protection Agency to cover open burning for land management and prairie restoration, nitrogen oxide emissions from boilers, and total organic emissions from degreasers. There have been no known instances of non-compliance.

4.3 Ground Water

The hydrogeologic regime at the Fermilab site can be characterized by an upper aquifer comprised of a thick glacial till hydraulically connected to the underlying Silurian dolomite at approximately 60-100 feet below ground level. Beneath the dolomite is the Maquoketa Shale which acts as a hydraulic barrier isolating the upper aquifer from lower water- bearing units. The glacial till consists primarily of low permeability clays and isolated pockets of silts, sands and gravels. A basal layer of sand and gravel combined with a fractured upper bedrock unit typifies the interface between glacial sediments and the bedrock. This basal layer and the lower dolomite are highly productive and are commonly used for ground water extraction. The water table is located in glacial till within 10 feet of the ground surface. Perched water zones are common within the glacial till and may result in local water levels near the ground surface. Hydraulic permeability in the glacial till is typically low, generally from 10^{-e} to 10^{-8} cm per second.[8] Permeability within the basal till and dolomite are considerably greater. The ground water gradient is roughly north to south with a possible east-west divide occurring in the southern one-third of the site. Limited testing confirms the general hydraulic properties of the glacial sediments as described above. However, there is a lack of knowledge of specific hydraulic properties at specific locations due to the sporadic occurrence and irregularity of layers of silt, sand, and gravel.

During 1988, Fermilab investigated possible downward migration of radioactivity from activated soils in the vicinity of the Neutrino Area primary target (the highest intensity target in the experimental area). At the depth of boring S-1059, located approximately 40 feet directly under the target area, some soil samples were found with evaporated soil moisture concentrations of tritium as high as 43 pCi per ml, well above the standard (20 pCi per ml) for community drinking water supplies.[7] The Silurian aquifer is the most shallow aquifer used as a source of ground water and it lies at a depth of between 65 feet and 225 feet.[8] Studies of radionuclide production cross sections and leaching characteristics of Fermilab soil have shown the principal accelerator-produced radionuclides of concern are ^{3}H and ^{22}Na.[9] These radionuclides have relatively short half-lives of 12.3 years and 2.6 years, respectively. The Fermilab model[10] assumes that the entire leachable fraction of each radionuclide produced in "unprotected" regions of soil will migrate vertically to the aquifer at rates of 7 feet per year for ^{3}H and 3.1 feet per year for ^{22}Na. No soil activated at Fermilab has ever caused any aquifer contamination to a detection limit of 1 pCi per ml.[7]

In order to verify that no significant migration of ^{3}H and ^{22}Na into the surrounding soil and groundwater has occurred, Fermilab has conducted a comprehensive program of groundwater monitoring for radioactivity since 1972, the results of which are contain in Fermilab's annual Site Environmental Reports. The samples are analyzed in a manner which would detect levels resulting in a dose of 0.4 mrem per year to an individual consuming 2 liters per day of drinking water, which is one tenth of the U.S. EPA's drinking water standard for members of the general public. This monitoring program has found no measurable accelerator-produced radioactivity in any of the groundwater monitoring wells on the Fermilab site. Fermilab on-site monitoring wells are located between the sources of potential contamination and the site boundary.

4.4 Soil

Soil in the proposed project site is highly disturbed, consisting largely of fill materials deposited during construction of the existing buildings, roads, and other structures in the area. Fermilab analyzes soil samples from several locations to detect the possible accumulation of contaminants from the deposition of airborne and/or waterborne radioactive effluents released by Fermilab activities. Sampling procedures are documented in the Environmental Protection Procedures Manual. Soil excavated from regions within a few feet of the existing beamline may be slightly activated, with the regions closest to the beamline being the most radioactive. Previous experience from other excavations near beamlines on site indicates that the radioactivity in the soil can range from natural background levels (0.01 mrem per hour) up to about 2 mrem per hour on contact depending on the proximity to a beam loss point and the intensity and duration of such losses.[11]

4.5 Surface Water

There are no naturally occurring surface water systems within the proposed project site. In the KTeV experimental area, the only surface water consists of stormwater runoff ditches. These ditches convey stormwater in a northeasterly direction to Casey's Pond, where the runoff is incorporated into the recirculative cooling system. Casey's Pond discharges into surface ditches which discharge into Kress Creek, a tributary of the DuPage River. The ditches are depicted in Figures 3.1 to 3.4. Evaporation from Casey's Pond is the primary means of cooling for the fixed target experimental area and the Tevatron. Future expansion of Casey's Pond is needed to support other proposed fixed target and Tevatron experiments, as well as to correct exceedences of Illinois water quality thermal effluent standards. The expansion is not directly connected to the proposed KTeV, which would use existing air towers to cool the water in the closed loop circulating system rather than cooling water from Casey's Pond. Storm water runoff collects in a series of constructed open ditches and is conveyed in a northeasterly direction to Casey's Pond, and ultimately into Kress Creek and off-site. The ditches already in place are shown in Figures 3.1, 3.2, and 3.3, indicating their relative location to the proposed site. Analysis of Kress Creek samples taken in June, 1991 indicated that all water quality parameters were within general use water quality standards.[12] The Fish and Wildlife Service has confirmed that there are no jurisdictional wetlands in or around the proposed site, and this site is not in a floodplain.[5] Although the KTeV is outside the 100-year floodplain, Casey's Pond and the proposed expansion site are within the floodplain.

5.0 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES

This section describes the anticipated environmental consequences of the construction, operation, and decommissioning of the KTeV beamline and experimental hall at the proposed action located along the existing NM beamline in the fixed-target experimental areas at Fermilab.

5.1 Construction

The proposed modification of the existing facilities north of NM2, the decay region and the proposed new experimental hall are expected to follow conventional construction activities for previously disturbed experimental areas at Fermilab. Safety and environmental monitoring of materials, handling of activated soils, noise and personnel activities and equipment must comply with established safety procedures.[13] Due to their distance away from the proposed action, Fermilab employees, visitors and non-KTeV experimenters would not be impacted by the construction activities.

5.1.1 Radiological Effects

Excavation activities at the proposed site would be confined to the region north of the target station for the purpose of constructing the secondary beamline and experimental hall. Excavation activities would include uncovering and demolishing the existing NM4 blockhouse, which is currently located at the site proposed for the experimental hall. The volume of concrete to be removed is estimated at 80 cu. yards. A recent radiation survey (May 1993) of points on the wall, floor and ceiling <u>inside</u> of the NM4 enclosure indicated that the levels of radiation were less than 0.5 mrem per hour, and typically less than 0.2 mrem per hour on contact.

The total material (soil and concrete) to be excavated is expected to be approximately 35,000 cubic yards. The slightly activated material includes the concrete from the NM4 blockhouse as well as the adjacent soil. The volume of activated soil has been very conservatively estimated to lie in an annular region 3 feet around the enclosure and buried beam pipes, spanning the length of the excavated areas. The activated material (soil and concrete) amounts to less than 800 cubic yards, or roughly 2.5% of the total soil excavated for the project. Due to absorption by the concrete walls, radiation levels in the soil that surrounds the enclosure will be much less than (less than 10% of) the levels found inside the enclosure. The concrete, removed in large chunks remotely (by backhoe) would be trucked to the secure railhead area (see Section 3.1.2). The soil would be segregated if the measured radioactivity exceeds background (0.01 mrem per hour) by approximately 0.020 mrem (twice background and therefore reasonably measurable). The 3 foot perimeter, however, is only used for purposes of estimating the amount of radioactive soil; however, given the imprecise methods used in the excavation, the total amount of soil segregated (clean mixed in with contaminated) likely would be more.

This slightly activated soil would be stockpiled on a closed asphalt road at the work site, isolated from personnel and road traffic, and kept covered with a few inches of non-radioactive soil or a layer of plastic to prevent possible creation of small amounts of airborne radioactivity due to resuspension or waterborne radioactivity due to run-off from rainfall. Previous experience with activated soil from other excavations has shown that no airborne radioactivity is detected for soil activation levels below about 2 mrem per hour. Similarly, water samples taken of run-off from excavated soil piles or from significant pools of standing water following rainfall showed concentrations less than 10 pCi per ml for ^{3}H and 0.3 pCi per ml for ^{22}Na. These are below the limits for community drinking water supplies of 20 pCi per ml for ^{3}H and 0.4 pCi per ml for ^{22}Na, and well below the discharge limits for surface waters of 2000 pCi per ml for ^{3}H and 10 pCi per ml for ^{22}Na.[14] The remainder of the excavated nonradioactive soil would be stockpiled in a location within the experimental area previously disturbed.

In order to minimize the creation of additional radioactive soil during subsequent operation of the beamline, the excavated radioactive soil would be reused as backfill at the site, with the most radioactive soil being returned to the excavation first so that it is closest to the beamline. The activated soil is equally efficient in radiation shielding as non-activated soil, so that this practice of reusing the slightly activated soil in the same area effectively limits (and minimizes) the total amount of soil impacted in this area. Monitoring of the area before and after reconstruction ensures that this practice does not lead to any cumulative environmental impact. Conventional health physics practices such as monitoring of equipment and personnel would prevent the potential spread of any low-level contamination beyond the work site.

Personnel associated with the construction phase of the project would include subcontractor construction workers, and radiation safety and conventional safety technicians. There would be a crew estimated at 12 workers involved in the replacement of the pencil-sized target and reconfiguration of shielding in NM2, intermittently for a estimated total time of 3 months. There would also be a crew of 12 workers for a period of 3 months involved with excavation (including removal of the underground NM4 blockhouse).

Technical workers involved with the removal and reconfiguration of the elements in the NM2 enclosure would have limited exposure to radioactive materials. The activated areas would be identified prior to initiation of activities. Movement of shielding would be performed remotely using overhead cranes in the enclosure, after the target has been removed by Fermilab radiation safety personnel following guidelines and procedures for handling radioactive materials (e.g. using long tongs and placed into a shielded box for removal). Moreover, each worker would be continuously monitored for radiation exposure (e.g. using film badges, dosimeters, and audible monitors indicating unacceptable dose rates), and limited to a level of exposure in compliance with Fermilab radiological safety rules which comply with DOE standards.[2] Generally each NM2 worker would be expected to receive an exposure of far less than 100 mrem per year for this activity, which is less than the DOE applicable exposure limit of 5000 mrem per year for radiation workers. The average dose from natural sources is over 300 mrem per year.[15] If a worker were exposed to a radiation area for a period of time that would potentially produce a dose in excess of 100 mrem per year (i.e. 25 mrem in the 3-month construction period), the worker would be reassigned. Using the dose-to-risk factor of 4×10^{-4} latent cancer fatalities (LCF) per person-rem, health effect of a maximum dose of 25 mrem to 12 workers would be 1.2×10^{-4} (12 workers x 4×10^{-4} x 25 mrem).

Based upon relevant experience with other construction projects, workers involved with excavation where there would be possible exposure to low level activated soil, concrete, and other material would also be expected to receive less than 25 mrem in the 3 month construction period. Worker exposures to radiation under normal construction activities would be controlled under established procedures that constrain doses to be limited as required and kept as low as reasonably achievable. These controls could include personal monitoring, if necessary, as well as continuous monitoring by Fermilab radiation safety personnel of the concrete and every shovelful of dirt.

Workers engaged in both of the construction activities discussed above would not be expected to incur any harmful health effects from radiation exposures they receive during this construction phase of the proposed project. The term "risk factor" is used in the following analysis to quantify health effects and specifically fatal cancer. An assessment of the dose of the maximally exposed worker was performed using the following ultraconservative assumptions: that 2.5% of the material (soil and concrete) is contaminated (and therefore exposure 2.5% of the construction period); that activation levels in the soil are the maximum inside the NM4 blockhouse (i.e. 0.05 mrem per hour); and assuming constant physical contact with the soil and concrete during the 120 hours during the construction period (8 hours per day, 5 days per week). Based upon these assumptions, the maximum dose was estimated at 0.15 mrem (0.025 x 120 hours x .05 mrem per hour). Using the dose-to-risk factor of 4×10^{-4} latent cancer fatalities per person-rem,[16] would result in an estimated annual probability of fatal cancer health effects induced by radiation of approximately 7.2×10^{-7} latent cancer fatalities among the 12 workers (12 workers x 4×10^{-4} LCF/person-rem x 1.5×10^{-4} rem). In other words, it is most likely that there would be no induced fatalities or health effects attributable to even this unexpected exposure level for the proposed project. Moreover, the dose used in this calculation is much higher than actual, since the activity of the soil outside the blockhouse would be much less than the activity inside the blockhouse; since the activity inside the blockhouse was closer to .15 mrem per hour except in two hot spots; and since the workers would actually be a distance of 10 to 20 feet from the soil, rather than in constant physical contact. The actual dose to excavation workers would only be minimally, if any, over background. Inhalation of dust, although a possible exposure pathway, would make an insignificant contribution to the maximum exposure rate, based upon the expectation of low activity in the soil, the distance (approximately 20 feet) of the equipment operators from the soil, and the non-confined (outdoors) air volume.

New construction material would not contain any accelerator radioactivity; however, workers involved in the construction of new buildings would also be monitored if appropriate.

5.1.2 Noise

Construction noise levels would be typical of those associated with previous fixed target area construction activities on site. This would consist of noise close to the site due to the occasional operation of excavating equipment, trucks, and cranes. Miscellaneous automobiles and light duty trucks would also be used. The estimated maximum noise level at the site boundary (greater than 200 feet away) would be less that 65 dB.

5.1.3 Storm Water Runoff

It is expected that the proposed action would disturb the existing earthen berm during the construction phase. Erosion and sediment controls would be instituted according to ES&H procedures for soil erosion and sediment activities.

5.1.4 Cumulative Effects: Construction

The practice of reusing the slightly activated soil in the same area effectively limits (and minimizes) the total amount of soil impacted in this area. This also eliminates the potential production of additional waste. Handling of the slightly activated soil would be limited to excavation and reconstruction activities only. Personnel exposure levels would still be maintained and kept as low as reasonably achievable without any exposure accumulation beyond the limit set by restricting the number of times individuals would handle the slightly activated soils. Monitoring of the area before and after reconstruction ensures that this practice does not lead to any cumulative environmental impact or cumulative health effects.

Due to a direct separation of over 2.5 miles and between the proposed action and the Fermilab Main Injector project, the two concurrent construction efforts would not interfere or collectively enhance noise levels outside of their respective project sites. Likewise, due to the independent locations of the proposed action and the Fermilab Main Injector project, no cumulative effects are expected to occur regarding storm water accumulation or control, air quality effects. In the Fermilab Main Injector area, surface water drainage is to the southwest, while the proposed KTeV project drainage is to the northeast. The distance between the separate construction forces for the two projects preclude cumulative worker health and safety impacts.

5.2 Normal Operation of KTeV

5.2.1 Penetrating Radiation

Radiation would be produced during the operation of the KTeV beamline. It would be generated by the interaction of the KTeV beam with objects such as targets, collimators, beam absorbers or other material which the beam might strike. This radiation, known as prompt radiation, would be present only when the beam is operating and consists primarily of neutrons and muons. The neutrons can be produced in all directions relative to a beam interaction point while the muons are produced primarily along the direction of the beam.

The neutrons would be shielded by combinations of soil, concrete, or steel surrounding the beamline. Muon radiation, because it is produced in the forward direction, can be most effectively shielded by keeping the muons below grade level. The amount of shielding required depends on the duration, energy, and amount of beam that interacts and the desired level of precaution to be taken outside the shield. The shielding thicknesses required for KTeV operations are driven by a potential off-normal, full-intensity loss of the beam from the accelerator which would produce higher prompt radiation dose rates than normal operation. (A discussion of the off-normal operation is found in Section 5.3 below).

The KTeV primary and secondary beam intensities during normal operations (5×10^{12} protons per spill primary beam, 2.3×10^{9} secondary beam), are similar to those found in other existing fixed target experiments at Fermilab. Shielding for neutrons would be designed to comply with the dose rate requirements of the Fermilab Radiological Control Manual. The design goal for the primary beamline and target shielding is specified assuming the worst case accident scenario in which the full Tevatron intensity of 3×10^{13} protons per spill for 60 spills per hour at 900 GeV is lost in a beamline enclosure or in a buried beam pipe or at any point in the target enclosure. The design goal was a worst case accident rate of no more than 10 mrem per hour outside this shield. To meet this goal, at least 19.5 feet of earth equivalent shielding is required (e.g. roughly 18.3 feet of concrete, or 5.6 feet of steel, based upon material density). The KTeV target shield would be constructed of steel, 40 feet long x 11 feet high x 9 feet wide. Fermilab radiation guidelines limit dose rates due to normal intensity targeting of 5×10^{12} protons on target to 2.5 mrem per hour in accessible areas (outside of fenced areas). Since this rate is a factor of 4 less than the accident rate, while the normal intensity is a factor of 6 less than the accident intensity, it is the accident rate that is the determining factor in the amount of shielding required. The amount of shielding necessary has been calculated using a computer program called CASIM[17].

Because of the design, muon radiation would remain below grade level. The target station would be located below grade, while the beam angle at the target would be directed downward. The target station primary beam absorber would be magnetized to deflect muons downward and insure that the muons remain below grade. By keeping the muons below grade level, it is possible to absorb the bulk of them in the earth downstream of the experimental hall before they reach the site boundary so that off-site radiation doses from KTeV operation would remain below the limit of 10 mrem per year. The direction of the muons would be away from Wilson Hall, thereby limiting the potential for employee and visitor exposure to prompt radiation.

5.2.2 Soil and Ground Water Activation

The soil surrounding the target station can become activated due to the neutron component of the prompt radiation. The two isotopes of potential concern are ^{3}H and ^{22}Na. The subsequent leaching of this radioactivity and transport to the underlying aquifer must not result in ground water concentrations above the DOE/EPA limits, which insure that the resulting committed effective dose equivalent is no more than 4 mrem per year.

The amount of activation produced in unprotected soil depends on the amount of steel and concrete shielding installed in the target station. The amount of shielding necessary has been calculated using a computer program called CASIM,[17] combined with a model for the transport of all the leachable radioactivity[8] (see also Section 4.3) to the underlying aquifer and subsequently to a single well. The CASIM program produces the fraction of time that the isotopes are produced and the fraction of time that isotopes leach toward the aquifer. The model used (the single well residence model) makes the conservative assumptions that all the leachable radioactivity reaching the ground water is pumped by a single well at the rate of 40 gallons per day and that the water from that well is consumed by a single individual at the rate of 2 liters per day.Sufficient shielding would be installed to insure that the calculated dose to an individual drinking that water would not exceed the 4 mrem per year limit. No radionuclides were detected in the nearest well to the boring under the target station discussed in Section 4.3. Note that no accelerator-produced radionuclides have been detected to date in any well samples taken on the Fermilab site.[18]

Water in the zone immediately outside the target station enclosure would be collected through a system of underdrains and piped to sump pits within the enclosure. Water in the sump pits would be periodically analyzed to determine the concentration of accelerator-produced isotopes. In addition, samples would be obtained quarterly from a monitoring well located in the vadose zone below the target station to provide advance indication of the movement of any radioactivity downward to the aquifer.

5.2.3 Closed-loop Cooling Water

The target station magnet and beam absorber would be cooled by circulating closed-loop water through them similar to existing target stations. Typical cooling system volumes are 50 to 250 gallons. The cooling water becomes radioactive due to targeting of the beam, and the primary isotope of concern is tritium. Concentrations of tritium in existing fixed target area closed-loop systems are typically less than 10,000 pCi per ml which is about five times greater than the surface water discharge limit. Similar levels would be expected for KTeV operation. Consequently, secondary containment for possible leaks would be provided for the KTeV system. Leaking closed-loop water within the enclosure would be diverted to the existing lined retention pit for sampling and analysis. If the concentration is below allowable limits it is released to surface ditches discharging into Casey's Pond, part of a recirculating cooling system which supports the entire fixed target experimental area and the Tevatron. Casey's Pond is the primary source of water for fire protection sprinkler systems, cryogenic compressors, air conditioning for Research Division and Feynman Computing Center, and heat exchangers throughout the fixed target area. A future 6-acre expansion of Casey's Pond is needed to correct exceedences of Illinois water quality thermal effluent parameters. The KTeV discharge would comply with DOE Order 5400.5 and is included in the scope of Fermilab's pending NPDES permit application. If the concentration is above allowable limits, the water would be collected for disposal as radioactive waste.

The system would be composed of copper piping. Low conductivity water is necessary for best cooling; therefore, the closed loop system would use water from which the metals and minerals have been removed, not industrial cooling water (Casey's Pond water), and no corrosion inhibitors can be used. Since the water might pick up lead or copper molecules from the piping and solder, the system would include a filter system through which the water cycles to remove metals. The filters are changes periodically. Segments of the pipe are routed through air cooled heat exchangers to provide cooling; there is no contact with the heat exchanger metals. The water is periodically sampled for contaminants.

A low pressure alarm on the closed loop system would shut down the beam to the target station if water pressure fails. To refill the system, low conductivity water would be diverted manually from other pipes. The laboratory radiation safety officer must identify the cause of the low pressure and assure that it has been corrected before allowing restart of experiment (beam to target).

Based upon the maximum capacity of the closed loop system, the maximum volume of this purified water which would sent to Casey's Pond in the event of a leak would be 250 gallons. Since 1976, when the interlock system was installed, there have been two leaks to closed loop systems at Fermilab: one involved 30 gallon of water (a leaking pump) and one involved 10 gallons of water (a flow regulator failure).

Due to the higher intensity beam on the proposed target station, it is expected that a greater load on the cooling system would occur. The closed-loop circulating water is cooled by cycling it through a heat exchanger system currently existing for the present beamline. No modifications to this system are anticipated for the new target station and beam dump. The current system has 60 kW of heat removal capability, and the load on the system due to the KTeV beam is calculated to be less than 1/2 of the system's capacity.

5.2.4 Air Activation

The air inside the target station can become activated due to the passage of the beam through it. The activity produced consists primarily of the short-lived isotopes ^{15}O, ^{13}N, ^{11}C, and ^{41}Ar, with half-lives from 2 minutes to 1.8 hours. The air would be exhausted through a small stack associated with the target station enclosure and comply with NESHAP standards. All releases are annually reported to the Illinois Environmental Protection Agency (IEPA) and the U. S. Environmental Protection Agency (EPA).

The total airborne activity released by KTeV operations can be estimated from the activity released during the operation of the existing NM2 target station. The total airborne activity released from the NM2 target station in CY 1991 was 21.3 Curies for 5.4 x 10^{17} protons on target. This should be compared with the total activity released from all Fermilab stacks during the fixed target run of CY 1991 which was approximately 107 Curies, including the 21.3 Curies from NM2. This total laboratory amount led to a maximum effective dose equivalent to a member of the population residing off-site of 0.028 mrem, compared to the allowed limit of 10 mrem per year. Scaling from the previous NM2 activity released, the estimated total airborne activity released per year for KTeV would be approximately 80 Curies for a targeted beam intensity of 2 x 10^{18} protons per year. This 80 Curies estimate is directly correlated with this expected increase in beam intensity for KTeV. Consequently the KTeV experiment can be expected to contribute about 0.02 mrem to the off-site dose due to airborne activity, (See Section 5.2.7). Again, the allowable limit is 10 mrem per year. At 4 x 10^{-4} latent cancer fatalities per person-rem, the health effect attributable to the off-site dose from KTeV operations is 3.2 x 10^{-6} LCF.

Using the population distribution shown in Figure 4.2, the collective latent cancer fatalities in a region 2 miles from the site is 1 x 10^{-4} based upon an approximate population of 4000 persons. This number includes the 2200 full-time Fermilab employees.

5.2.5 Residual Activation

Residual activation of beamline components is produced when high energy beams strike those components. This residual radioactivity remains after the beam is turned off. Residual activity in beamline components and shielding within KTeV beamline enclosures, would not produce detectable dose rates above ground because the amount of shielding required for prompt radiation is more than sufficient to shield the residual radiation.

5.2.6 Worker Exposures

After the experiment is configured according to the design parameters and meets all the safety requirements, beam would be extracted and the data collection would begin. Operation of the experiment amounts to collecting the data and remotely monitoring the equipment during standard working shifts. Sufficient shielding of the beam areas would be achieved to limit the radiation exposure to workers continuously occupying the counting house and service buildings along the beamline, in accordance with the Fermilab Radiological Control Manual.[2]

Areas where the proton beam may interact (or is designed to interact) with materials are greatly restricted due to the creation of radiation. During the operation cycle of the experiment with the proton beam being extracted, no access to these areas is allowed. Life safety access control into any of these areas is maintained by a series of locks and interlocks that disable the primary beam if any locks are breached. The process of setting the locks and interlocks to operational readiness requires that all enclosure be searched and secured by a two-person operation crew that sets the interlocks for each enclosure after an exhaustive visual search. Inherent in the process are periodic tests of the system in which a dummy is placed in an enclosure by supervisory safety personnel to evaluate the effectiveness of the operation crews' search and secure training and procedures. No secondary kaon beam is possible without the primary proton beam.

During the fixed target run of CY 1991, the vast majority of experimenters had no exposure to radioactivity. Of the monitored experimenters, about 22% received a dose above 10 mrem. Of this group, the average individual dose fell in the 40-50 mrem per year range. Lower levels would be expected for the proposed action, because the detector would be below ground and thus the muon dose rates at the counting house would be eliminated. Applying the same latent cancer fatality analysis outlined in Section 5.1.1, for a 50 mrem exposure in one year, and using the same dose-to-risk factor leads to a annual probability of induced cancer fatality of 2×10^{-5}. The number of experimental personnel will vary over the duration of the experiment. Scheduling constraints of the experimental program of Fermilab do not allow for an accurate estimate of the future experimental cycles of operation. However, considering the length of past kaon physics experiments, one can estimate a non-continuous 10 year operation length for the proposed experiment. It is also estimated that 50 experimenters would be involved each receiving an average 20 mrem per year thus producing 1 person-rem per year. Thus the number of fatal cancers induced among this group would be .004. That is, it is most likely that there would be no induced health effects attributable to this exposure level for the duration of the experiment.

5.2.7 Cumulative Effects: Normal Operation

As mentioned in Sections 1.0 and 3.2.1, the future of the MCenter target station depends on the programmatic needs of the laboratory and the outcome of new proposals for this beamline. The proposed action would reduce the number of target station sites at the laboratory by eliminating the use of the MCenter target for Kaon Physics. The MCenter beamline contributed 7.2 mrem of dose in a localized region at the site boundary due to muons in CY 1991, which was the single largest contribution to the site boundary dose from a fixed target beamline during that year. The proposed action would locate the detector and beamline below ground, thus eliminating the muon plume associated with the MCenter beamline which was above ground. The combination of these two configurations would reduce the radiation dose at the site boundary. The cumulative effect resulting from not using the MCenter target station, and modifying the NM2 target station (to handle the proposed action's beam intensity) would result in improved containment of the prompt radiation dose and lowering the Fermilab site boundary radiation dose in a localized region, downstream of the MCenter beamline.

As a result of the increased shielding at the improved target station, the cumulative effect of the proposed action would be a decrease in the rate of activation of the soil around the NM2 target station, (see Figure 3.2).

During the normal operations mode of KTeV with the beam on, the instantaneous increase in the heat load would be 11 kW over the non-operating mode of 43.5 kW. The cumulative effect would require 25 % more heat removal from the closed-loop circulating water system, that is within the limit of the heat removal capacity of the current heat exchanger system.

The cumulative effect expected due to air activation is calculated by using the total activity released in the fixed target run of CY 1991 from all Fermilab stacks (107 Curies), less the activity released from NM2 (21.3 Curies), plus the activity expected from a KTeV target at NM2 (80 Curies), less the activity released from the MCenter target, which would not be used (15.4 Curies), yielding an estimated total of 150.3 Curies. This sum leads to a maximum effective dose equivalent to a member of the population residing off-site of 0.039 mrem. The increase from 0.028 mrem to 0.039 mrem results in a cumulative increase over the CY 1991 fixed target run of 0.011 mrem, which is 0.1% of the allowable limit of 10 mrem per year. Using the population (4000 persons) within 2 miles of the KTeV facility as the affected population, the increase in maximum effective dose from all Fermilab sources (0.028 mrem to 0.039 mrem), would increase the LCF from 4.5 $\times 10^{-6}$ to 6.2×10^{-6}, a difference of 1.7×10^{-6}.

The Main Injector EA presumes that construction would be complete approximately 1997. Main Injector operation would not commence prior to that time. The fixed target run for KTeV would begin in 1995. The duration of the next fixed target run is not currently scheduled. Fixed target runs alternate with collider runs. If the KTeV experiment coincides with operation of the Main Injector, the KTeV experiment would limited to 900 GeV energy primary protons of the Tevatron, at an intensity of 5×10^{12} particles. The operation of the Main Injector would not affect these limits for the KTeV experiment.

5.3 Off-Normal Operation of KTeV

Two cases must be considered. The first is a loss of the normal operating intensity beam. The second is the loss of a full intensity beam from the Tevatron that has managed to be accidentally delivered to the KTeV target station.

As stated in Section 5.2.1, the prompt radiation shielding for the KTeV project would be designed to meet the Fermilab Radiological Control Manual criterion. That is, sufficient shielding must exist to protect against the full beam intensity deliverable from the Fermilab accelerator when the beam is transported to some other region than the normal targeting area. The target and beam absorbers would be designed to accept the full machine intensity pulse of 3×10^{13} protons, without going beyond radiation guidelines. The normal operating intensity would be a factor of six below that.

The design criterion for the primary beam transport also takes advantage of a geometry that does not allow the primary proton beam to point in the same direction as the secondary kaon beam used for the experiment. The location of magnets would have to be changed to redirect the proton beam to the experimental hall. This additional safety measure eliminates the possibility of any proton pulses striking the experimental apparatus.

The inadvertent transport of a single full intensity pulse from the accelerator to the KTeV target station would produce air and soil activation equivalent to six normal intensity pulses. Since this type of off-normal condition is a very rare occurrence, probably below 1 pulse in 10,000 based on operating history, it would not have an effect on the overall airborne emissions or production of soil activation. As discussed in Section 5.2.6, the beam areas are restricted and isolated so that these rare off-normal conditions will have no effect on personnel or the environment. Shielding to protect operators occupying the counting house, located at ground level (in the current design) 10 feet from the experimental hall (see Figure 3.1), would consist of a 10 foot concrete wall between the two buildings. The shielding design criteria indicated an exposure of 0.0087 mrem per hour to the control occupants in the event of the worst case accident scenario. The normal operating dose would be less than 1/6 of that amount. The LCF for the dose rate under off-normal conditions would be 1.2 x 10^{-7}, assuming (see Section 5.3.1) 40 off-normal spills per year, at 60 seconds (1/60 hour) per spill, and 50 workers in the exposed worker population.

5.3.1 Cumulative Effects: Off-Normal Operations

The full intensity beam loss pulses would be very infrequent and designed to stay within the shielded area for the full duration of the experiment. Thus the number of rare occurrences would probably total less the 40 pulses at 3 x 10^{13} protons on target. This amounts to 0.06% of the total beam intensity delivered to the target station. Even under these most extreme conditions, no cumulative impacts are anticipated.

5.4 Decommissioning of KTeV

Decommissioning activities associated with the KTeV project are difficult to define in detail at the present time. They depend on the future use of the KTeV beamline and experimental hall, which would be dictated by the goals of the physics research program at that time. The apparatus, beamline, and experimental hall could be used for future experiments at their present location. It is presently anticipated the experimental apparatus would be of use well into the 21st Century. However to decommission, the experimental apparatus and beamline would be disassembled and their components reused elsewhere at Fermilab, or shipped to other Laboratories for use, or surplused if there is no longer a use for them at Fermilab according to standard procedures for disposition of government properties.

Each component of the experimental apparatus would be surveyed by health physics personnel to identify, label and isolate all activated components. It is anticipated that all components, except the target and beam dump material would be free of radioactivity. Radioactive components for which there is no longer a use would be packaged for shipment and disposed of as radioactive waste according to DOE specifications. Additional NEPA review would be performed for this activity at that time.

5.4.1 Cumulative Effects: Decommissioning

Since it is anticipated that most of the materials would be used in other current or new experiments, it is expected that minimal impact would be made on the collective amounts of disposable material.

5.5 Impacts of Alternatives

5.5.1 No Action Alternative

The environmental consequences of no action would lead to a reduction of 7.2 mrem in the muon dose in a localized region of the site boundary, discussed in Section 5.5.2, as well as a reduction in the estimated air activation of 21.3 curies from the NM2 target station, discussed in Section 5.2.4 and a reduction of 15.4 Curies from the MCenter target station discussed in Section 5.2.7. These consequences are contingent on no further experiments in the MCenter and Neutrino Muon beamlines. It should be added that this alternative would not fulfill the objectives of the U. S. High Energy Physics Program.

5.5.2 MCenter

Without substantial shielding improvements, siting the KTeV experiment along the existing above-grade MCenter beamline, which was used for previous kaon experiments, would cause increased radiation doses both on-site and at the site boundary when compared to the proposed NM site which has a beamline below-grade. Because of its proximity to other operating beamlines and the fact that the MCenter line is above grade, the necessary shielding improvements required for KTeV in M-Center would be more extensive. The MCenter beamline contributed 7.2 mrem of dose in a localized region at the site boundary due to muons in CY 1991, which was the single largest contribution to the site-boundary dose from a fixed target beamline during that year. The permitted beam intensity for Mcenter in 1991 was 2×10^{12}; the beam intensity for KTeV would be 2.5 times greater, thereby causing a correspondingly higher boundary dose without increased shielding. Significant enhancement of shielding in this location would be limited by space.

5.5.3 Neutrino Muon Experimental Hall (NMS)

The Neutrino Muon Experimental Hall was originally designed and used for a series of experiments with a secondary beam of muons, which are not strongly interacting particles and therefore produce little prompt radiation when they interact with targets or other materials in the beamline. Therefore it required essentially no shielding between the counting rooms, occupied by experimenters, and the beamline. Using the hall for an experiment with a strongly interacting kaon beam which also has a substantial neutron component would result in increased prompt and muon radiation, and require the addition of shielding between the beamline and the counting rooms.

The existing enclosure NMR immediately upstream of the experimental hall is also not shielded adequately for a strongly interacting beam nor is it compatible with the design requirements of the KTeV experimental apparatus. The muon radiation field in both the NMR area and the experimental hall would be prohibitive for the expected experiment. In addition the difficulties of a much longer transport to these locations would demand increases in the earth shielding over much more of the NM line to permit the safe transport of primary beam. Thus this option would result in the creation of another target station on site with the associated concerns about increases in the cumulative soil activation and ground water exposure.

5.5.4 Cumulative Effects: Alternate Sites

Choosing any one of these sites without improved shielding would result in a potential increased radiation dose. The cumulative effects of each of the alternate sites discussed above would lead to additional muon radiation in the experimental area and at the site boundary. The no action alternative would contribute dose only if the experimental program included additional experiments in this area.

The requirements for the proposed experiment must not be restricted in operations by existing conditions, as they would be if developed in an existing building within the alternate sites.[19]

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2 Fermilab Radiological Control Manual, April 1993, Fermi National Accelerator Laboratory.

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4 Site Environmental Report for Calendar Year 1991, Fermilab 92/150 1104.100 UC-41, May 1992.

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6 Site Proposal - Superconducting Super Collider in Illinois, August 1987.

7 Cossairt, J.D. and D. W. Grobe. Summary of Subsurface Exploration near the Neutrino and Meson Target Areas. E.P. Note #2, March 1990.

8 Environmental Assessment, Proposed Fermilab Upgrade Main Injector Project, DOE/EA-0543, April 1992.

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15 National Council On Radiation Protection and Measurements (NCRP) 1987, Ionizing Radiation Exposure of the Population of the United States, Report No. 93, Bethesda, MD.

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18 Chapter 5.4.2, Site Environmental Report for Calendar Year 1991, Fermilab 92/150, 1104.100 UC-41, May 1992.

19 Siting of KTeV, Communication: Director Fermilab to the KTeV collaboration, January 18, 1993.

LISTING OF AGENCIES AND PERSONS CONSULTED

Consultants	Consultation Requested
Mr. John Rogner Assistant Field Supervisor Chicago Metro Wetlands Office U. S. Fish and Wildlife Service 1000 Hart Road, Suite 180 Barrington, IL 60010	Review of Project Site and determination of Wetlands Threatened and Endangered Species and Critical Habitats

GLOSSARY

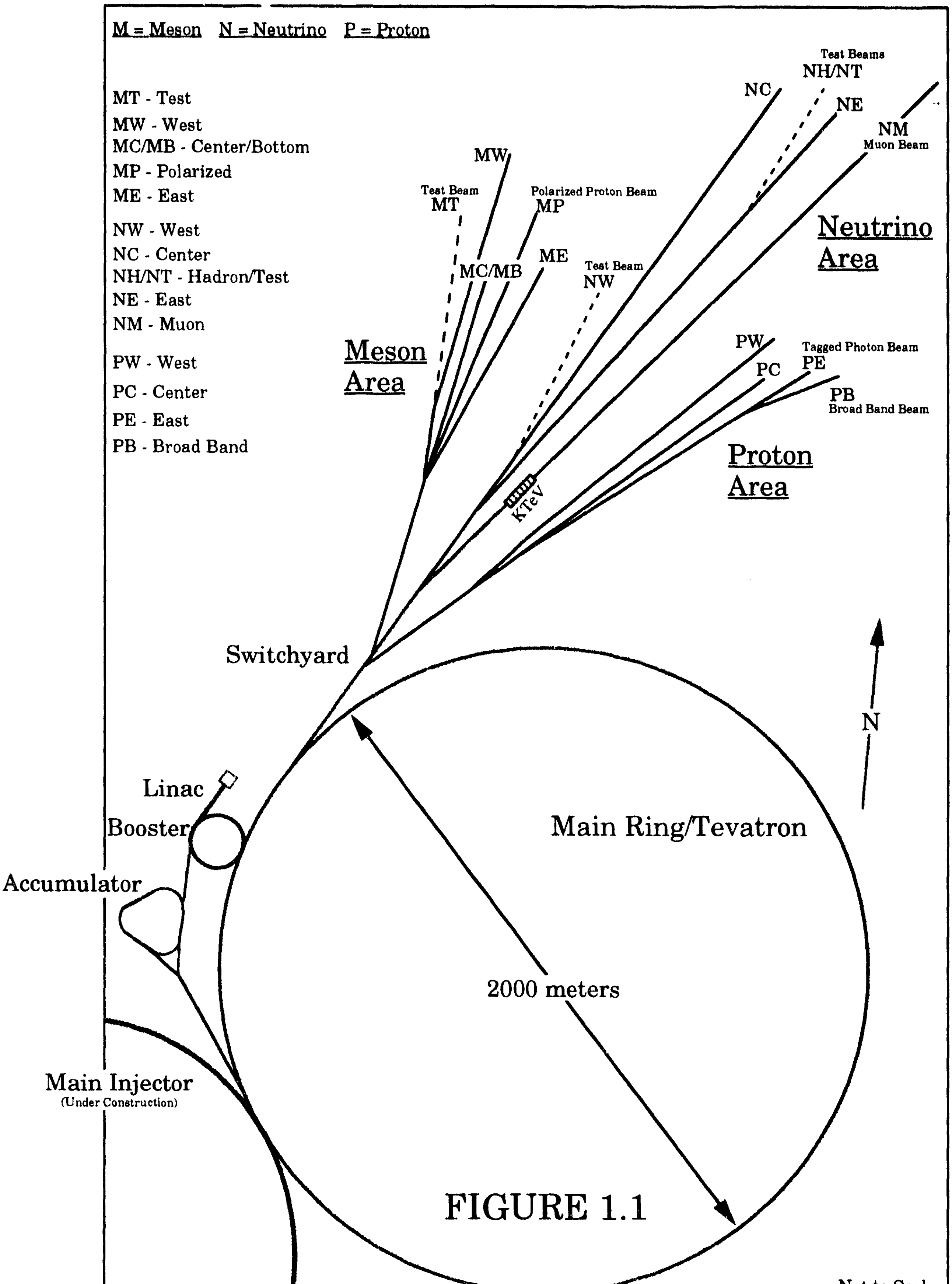
accelerator	A device for increasing the velocity and energy of charged particles, for example electrons or protons, through application of electrical and/or magnetic forces. Accelerators have made particles move at velocities approaching the speed of light. Types of accelerators include cyclotrons, synchrotrons, and linear accelerators.
Alternating Gradient Synchrotron	A type of synchrotron characterized by the change in the magnetic field gradient of the magnets.
antiproton	Matter in which the ordinary nuclear properties of the proton are replaced by correspondingly opposite properties of the antiproton. An anti-hydrogen atom, for example could be conceived as a negatively charged antiproton with a positively charged orbital positron.
beam	A stream of particles or electromagnetic radiation, going in a single direction.
beam loss	A situation in which some portion of the beam intensity is not transported from an upstream measured point to a downstream measured point. A loss can occur when the beam (or a portion of the beam) is misdirected from the beamline in which it should be located. Loss of beam can also occur when a material is placed in the path of the beam.
beamline	A collective term referring to all the devices used to control, monitor, and produce a beam. The common elements of a beamline are magnets, intensity monitors, beam position monitors, and collimators.
Becquerel	The special name for the unit of activity equivalent to 1 per second.
berm shield	A mound of soil over an accelerator or beamline designed to provide shielding against possible ionizing radiation.
charge	Electric charge carried by an elementary particle.
closed-loop	A system of circulating water in completely enclosed pipes where the water is isolated from any external surfaces.

collimator	An adjustable aperture, capable of absorbing the beam outside of the aperture opening, and permitting the transport of the beam within the aperture.
Collider	Oppositely-directed particle beams brought together at a small angle to produce high energy collisions.
commission	The task of bringing into operation a designed system for the first time.
CP	Charge and Parity symmetry properties. This combination of the properties of charge and parity, defines characteristics of systems that remain the same when the charge of a system is reversed at the same time that the spatial reflection of the system is changed.
Curie	The basic unit to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A Curie is also a quantity of any nuclide having 1 Curie of radioactivity. Named for Marie and Pierre Curie, who discovered radium in 1898.
decay	The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the number of the original radioactive atoms in a sample. It involves the changing of the nucleus by emission, absorption or fission.
decommission	The completion and disassembly of a system.
dipole magnet	A device used to generate a magnetic field that will bend charged particles that pass through it. The field is oriented such that the particles bend in a single geometric plane.
electromagnets	A device that generates a magnetic field by passing an electric current through a conducting coil.
half life	The time in which half of the atoms of a particular radioactive substance disintegrates to another nuclear form. Measured half-lives vary from millionth of a second to billions of years.
interlock	A locked device engaged to beam components such that changes in the device will permit or not permit the components to operate.

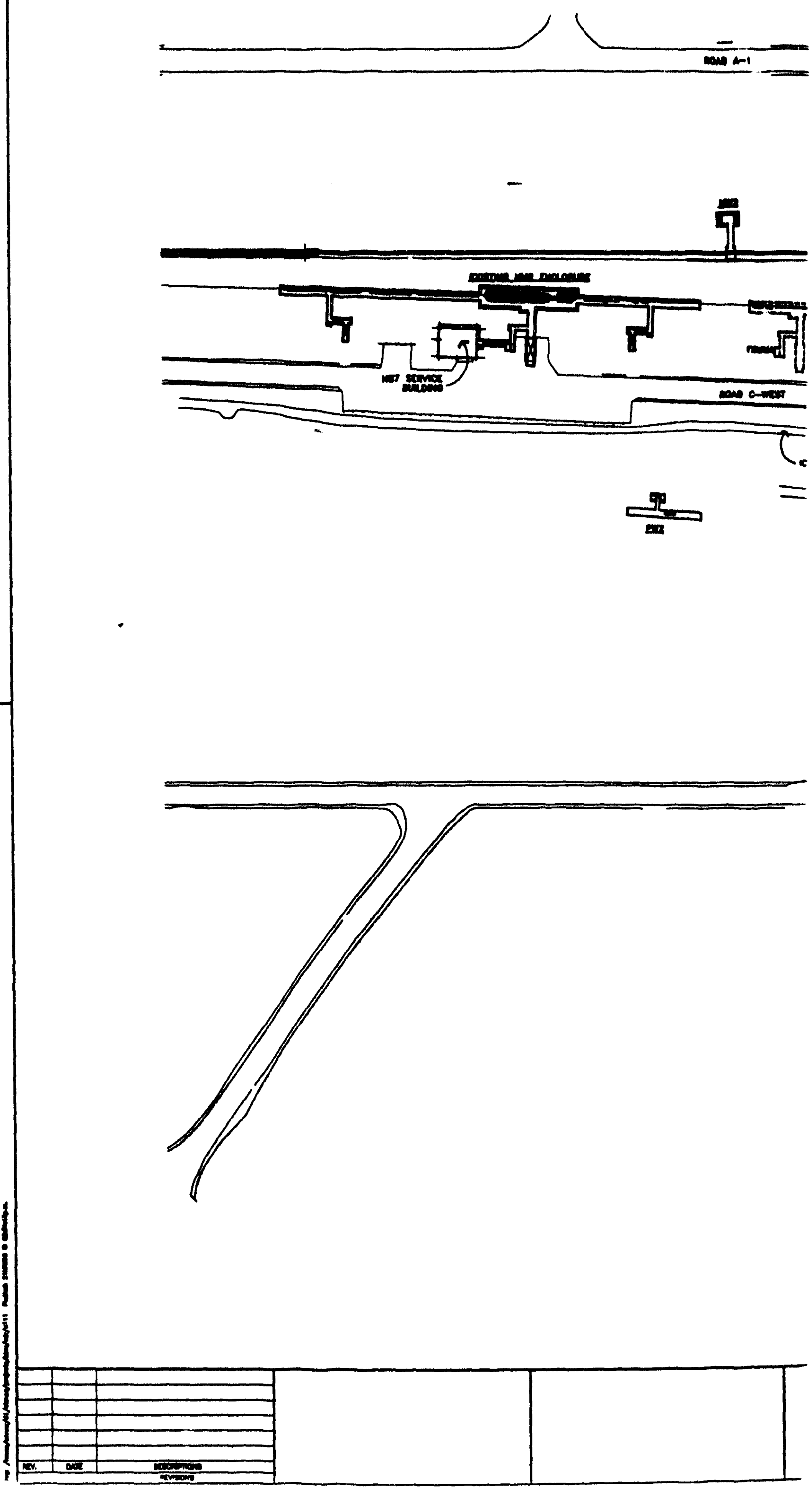
isotope	One of two or more atoms with the same atomic number (the same chemical element) but with different atomic weights. An equivalent statement is that the nuclei of isotopes have the same number of protons but different numbers of neutrons. Thus ^{12}C, ^{13}C, and ^{14}C are isotopes of the element carbon, the superscripts denoting the differing mass numbers, or approximate atomic weights. Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties.
kaon	An elementary particle (contraction of K-meson). A heavy meson with a mass about 970 times that of an electron.
meson	One of a class of medium-mass, short-lived elementary particles with a mass between that of the electron and that of the proton. Examples: pi-meson (pions) and K-mesons (kaons).
millirem	One one-thousandth of a rem (10^{-3}. Rem is an acronym for roentgen equivalent man. The unit of dose of any ionizing radiation which produces some biological effect, such as a unit of absorbed dose of ordinary X rays.
muon	(Contraction of mu-meson.) An elementary particle, classed as a lepton (not as a meson), with 207 times the mass of an electron. It may have a single positive or negative charge.
neutrino	An electrically neutral elementary particle with a negligible mass. It interacts very weakly with matter and hence is difficult to detect. It is produced in many nuclear reactions, for example, in beta decay, and has high penetrating power; neutrinos from the sun usually pass right through the earth.
neutron	An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen. A free neutron is unstable and decays with a half-life of about 13 minutes into an electron, proton, and neutrino. Neutrons sustain the fission chain reaction in a nuclear reactor.
parity	The property of symmetry between left handedness and right handedness. As in a mirror the reflection reversal of left and right.
pico	A prefix that divides a basic unit by one trillion (10^{-12}). Same as micromicro, $(10^{-6})(10^{-6})$.
prompt radiation	Radiation produced by the interaction of the beam with materials such as a target and consisting primarily of neutrons and muons, also considered as penetrating radiation.

quadrupole magnet	A device used to generate a magnetic field that will focus or defocus charged particle beams that pass through it.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation. (Often shortened to "activity.")
radionuclides	A radioactive nuclide.
resolution	The resolution of a detector depends on the accuracy of the individual components of the detector and the number of these components. This property may allow the detector to distinguish between numbers of particles or in some cases individual particles.
Silurian dolomite	A continuous layer found beneath the site composed of limestone rich in magnesium which serves as one of the primary aquifers
spill	An event in which the beam is extracted from the accelerator, usually lasting 60 - 120 seconds.
subatomic	Any of the constituent particles of an atom: electron, neutron, proton, etc.
Switchyard	A system of devices through which the primary beam is removed from the Tevatron and transported to the external targeting stations.
Tevatron	A synchrotron at Fermilab which is designed to accelerate protons and antiprotons to an energy of one trillion electron volts, (1 TeV).
tritium	A radioactive isotope of hydrogen with two neutrons and one proton in the nucleus. It is man-made and is heavier than deuterium (heavy hydrogen). Tritium was used in industrial thickness gauges, and as a label in experiments in chemistry and biology. Its nucleus is a triton.

FIGURES



Layout of the Fermilab Accelerator Areas and the Fixed Target Beamlines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SERVICE BUILDING
ROAD C-WEST
REV.
DATE
DESCRIPTIONS
REVISIONS

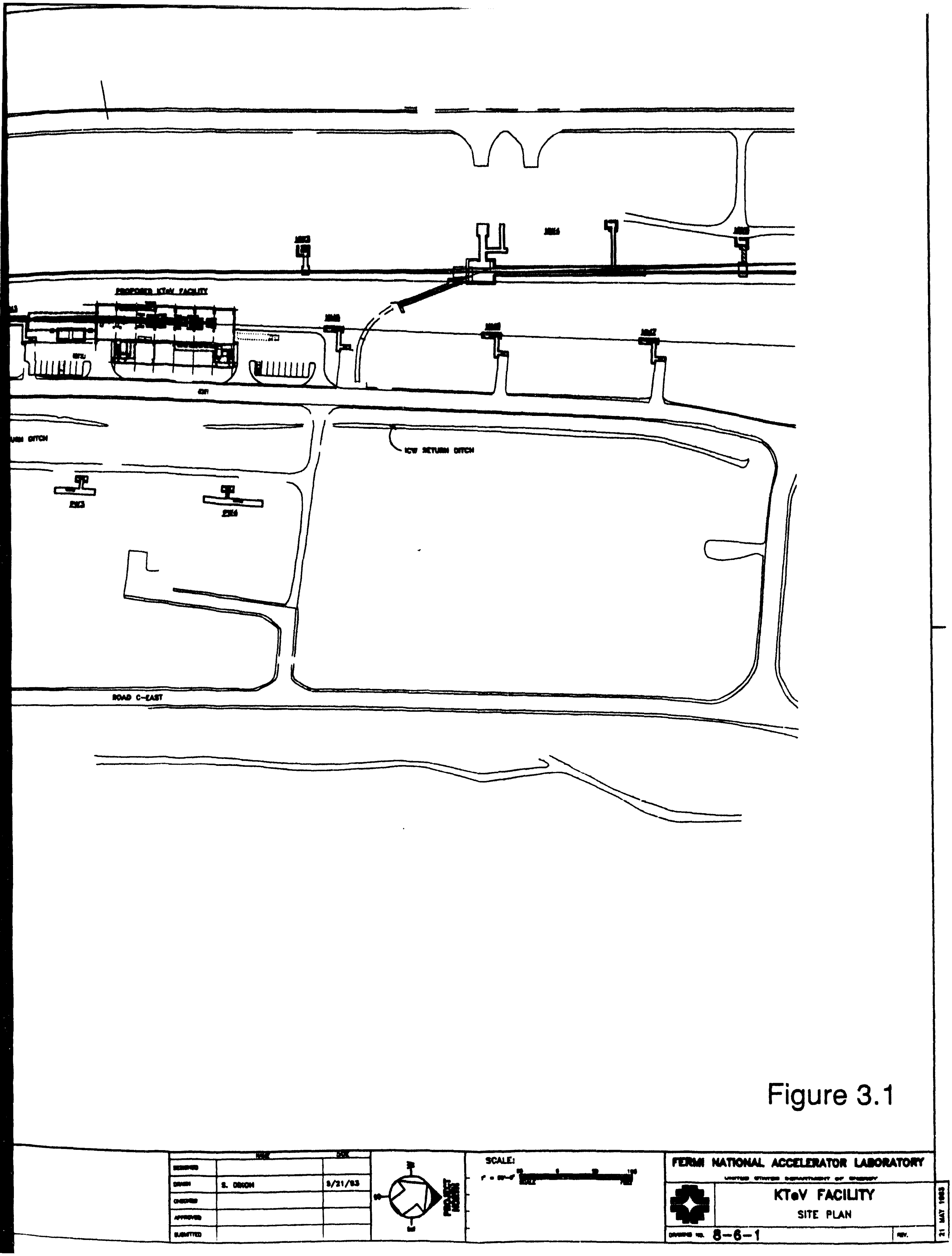
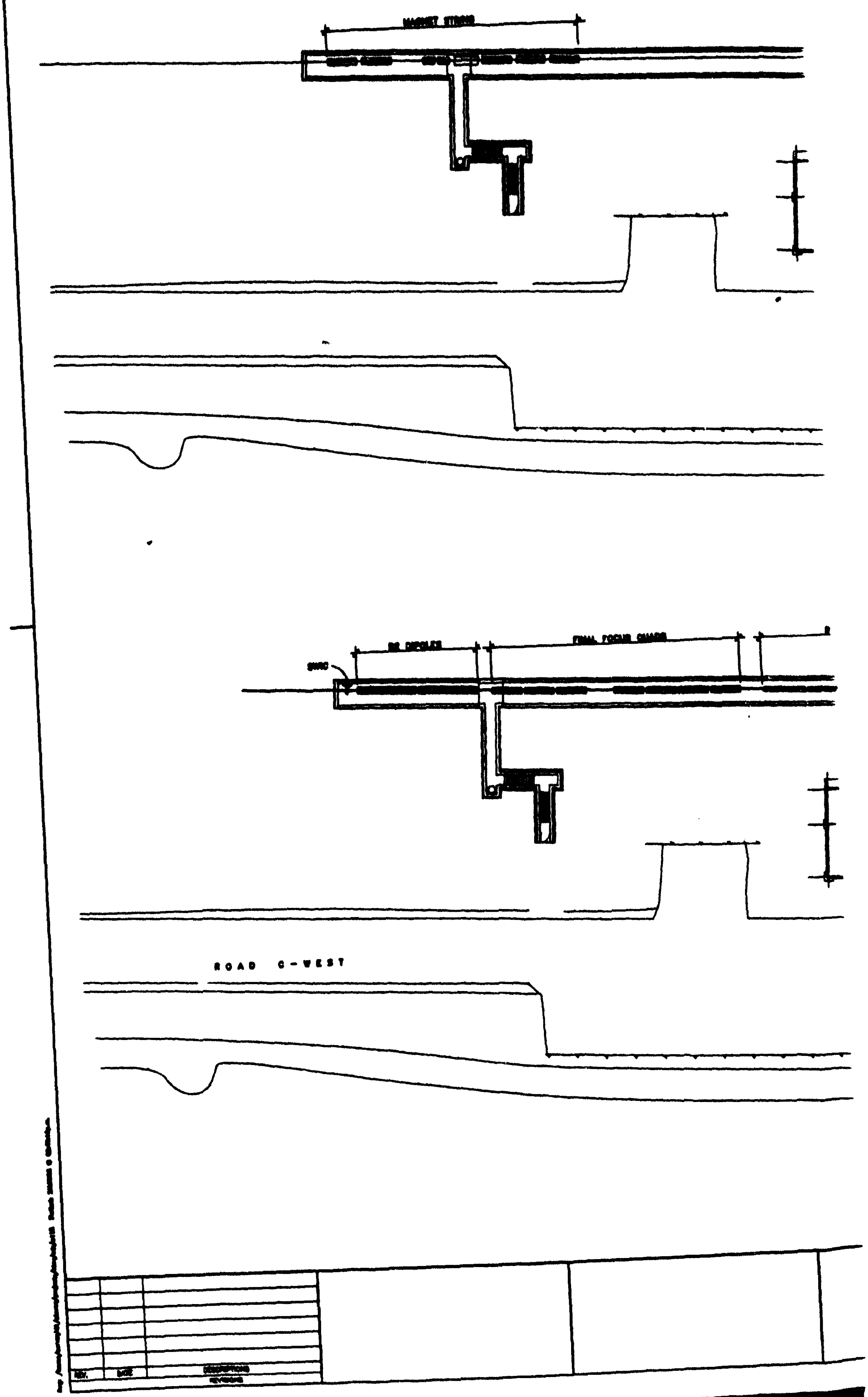

PROPOSED KTeV FACILITY
ICW RETURN DITCH
ROAD C-EAST
SCALE:
DRAWN
S. DIXON
APPROVED
SUBMITTED
PROJECT NORTH
FERMI NATIONAL ACCELERATOR LABORATORY
KTeV FACILITY
SITE PLAN
8-6-1
REV.
21 MAY 1993

Figure 3.1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ROAD C-WEST
REV.
DATE
DESCRIPTIONS
REVISIONS

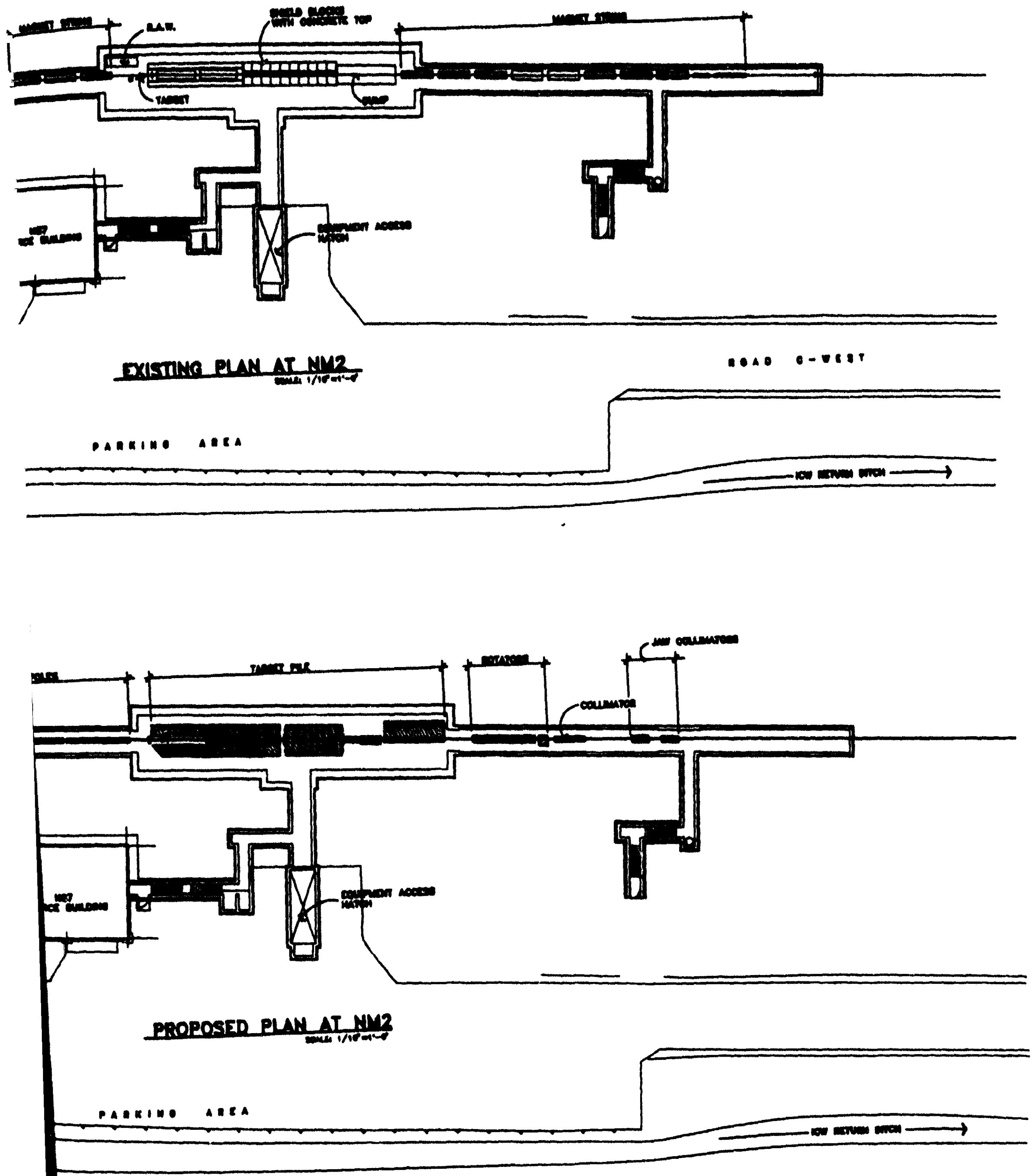


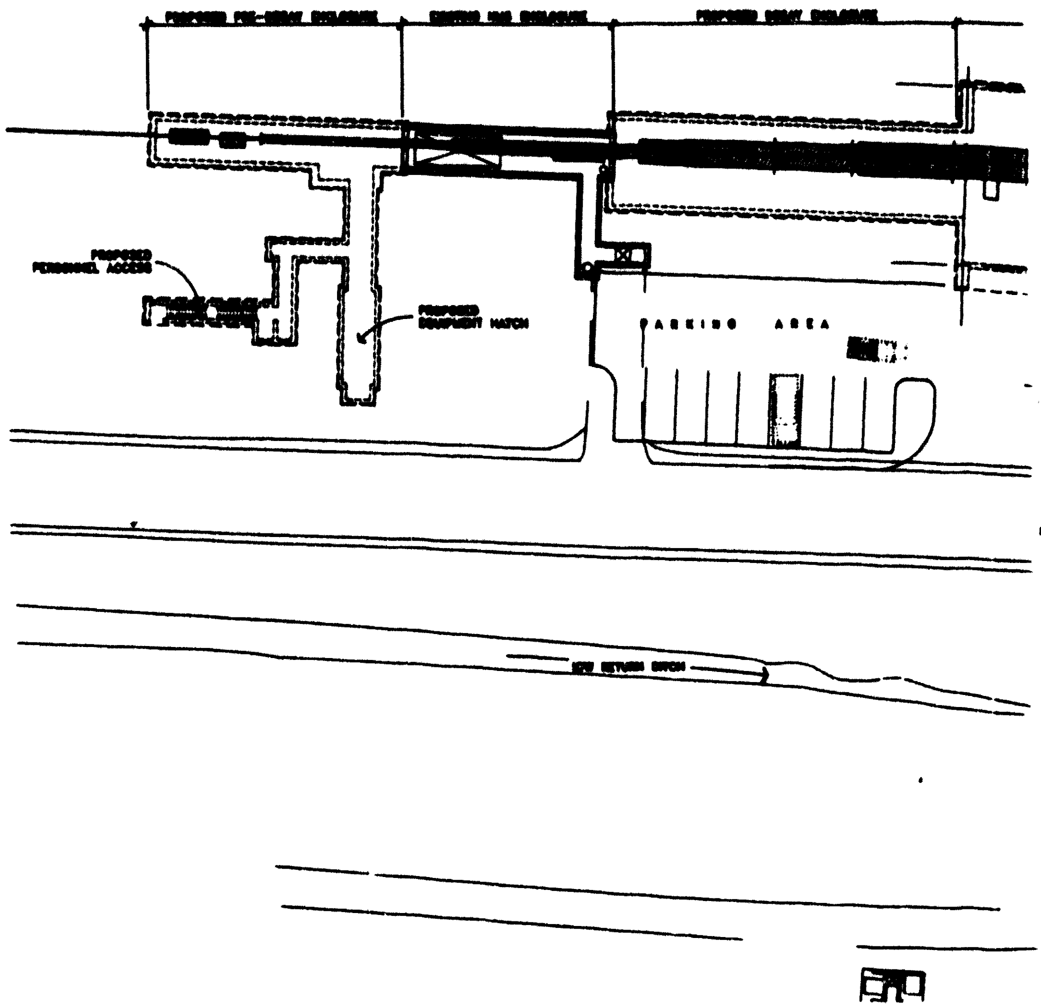
Figure 3.2

FERMI NATIONAL ACCELERATOR LABORATORY

KTeV FACILITY

NM2 ENCLOSURE

DRAWING NO. 8-6-1


PROPOSED
PERSONNEL ACCESS
PROPOSED
EQUIPMENT HATCH
PARKING AREA

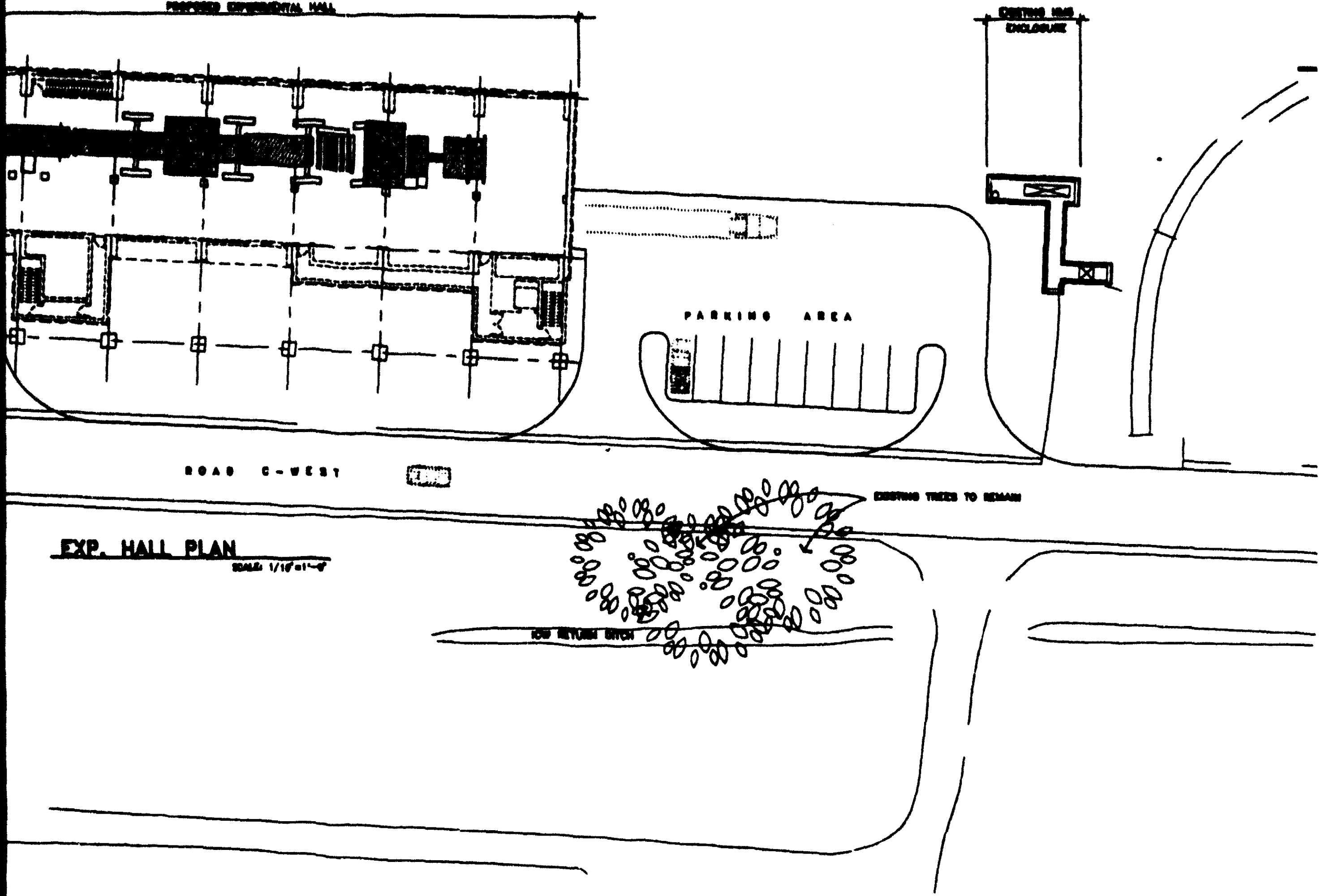
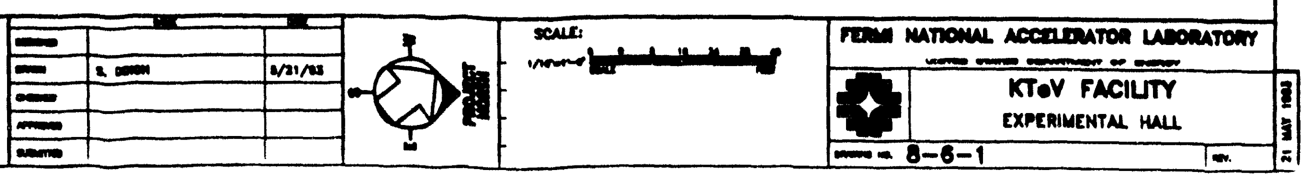
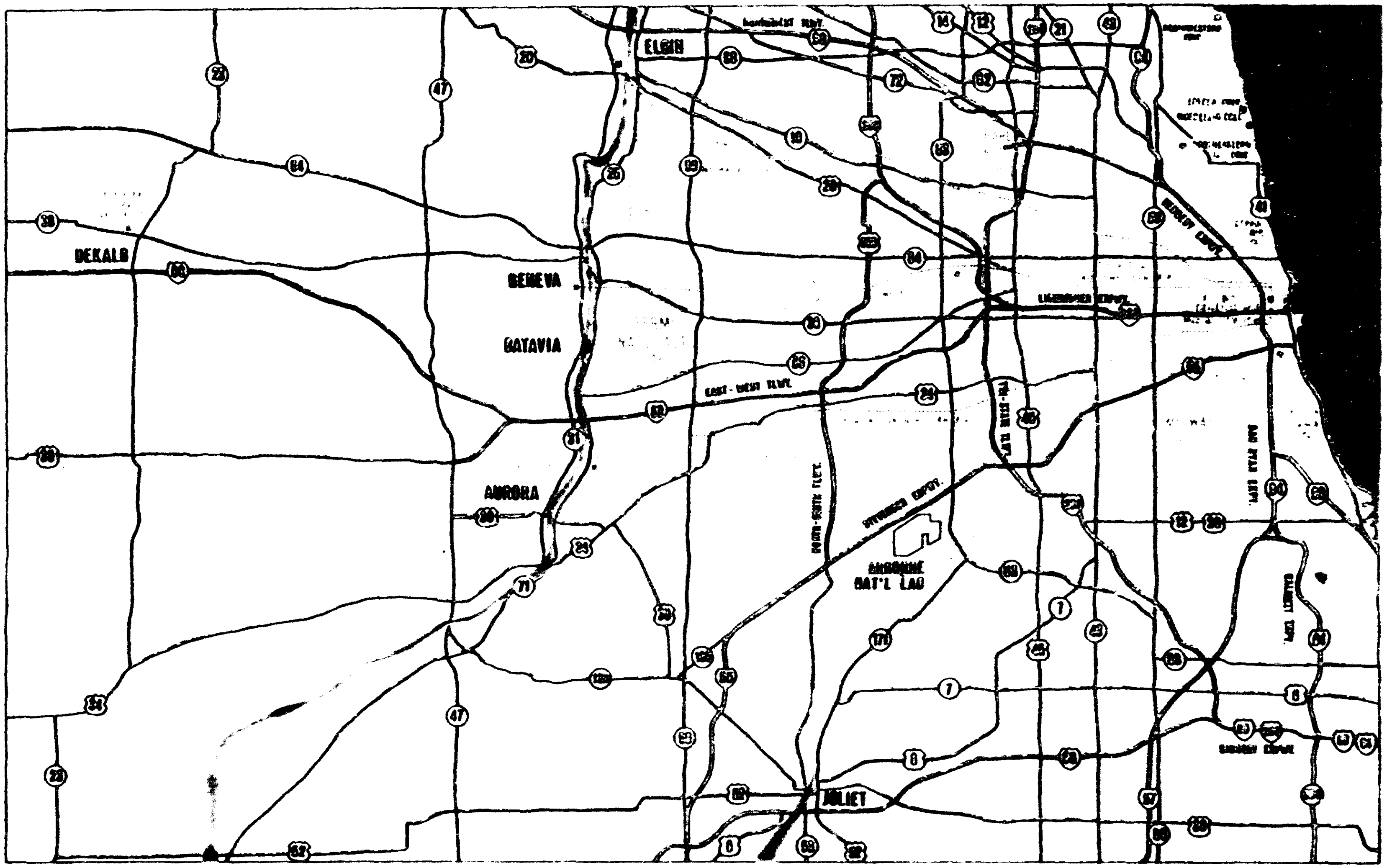

PARKING AREA
ROAD C-WEST
EXISTING TREES TO REMAIN
EXP. HALL PLAN

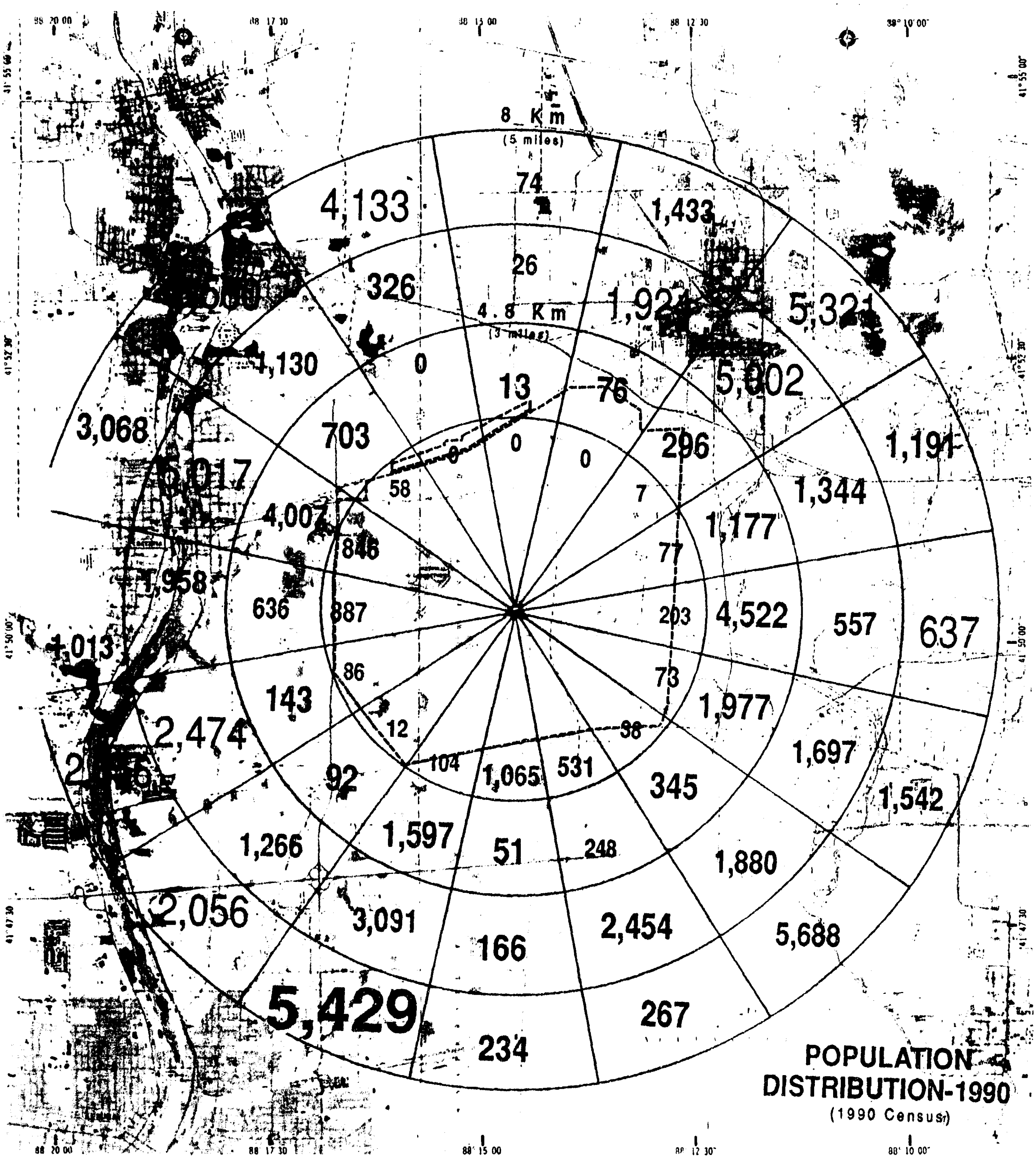
Figure 3.3


S. DESIGN
SCALE:
FERMI NATIONAL ACCELERATOR LABORATORY
KTeV FACILITY
EXPERIMENTAL HALL
8-6-1
REV.



REGIONAL MAP

Figure 4.1



BASE 3

0.0 1.0 KILOMETERS 3.0
0.0 0.5 MILES 1.0 1.5 2.0

FERMI NATIONAL ACCELERATOR
LABORATORY AND VICINITY

41° 50' 30"N, 88° 14' 30"W
(SITE CENTER)
MAP DATED 1954-64

PREPARED IN 1981
FOR DOE
BY EG&G

Figure 4.2

Wind Direction Structure

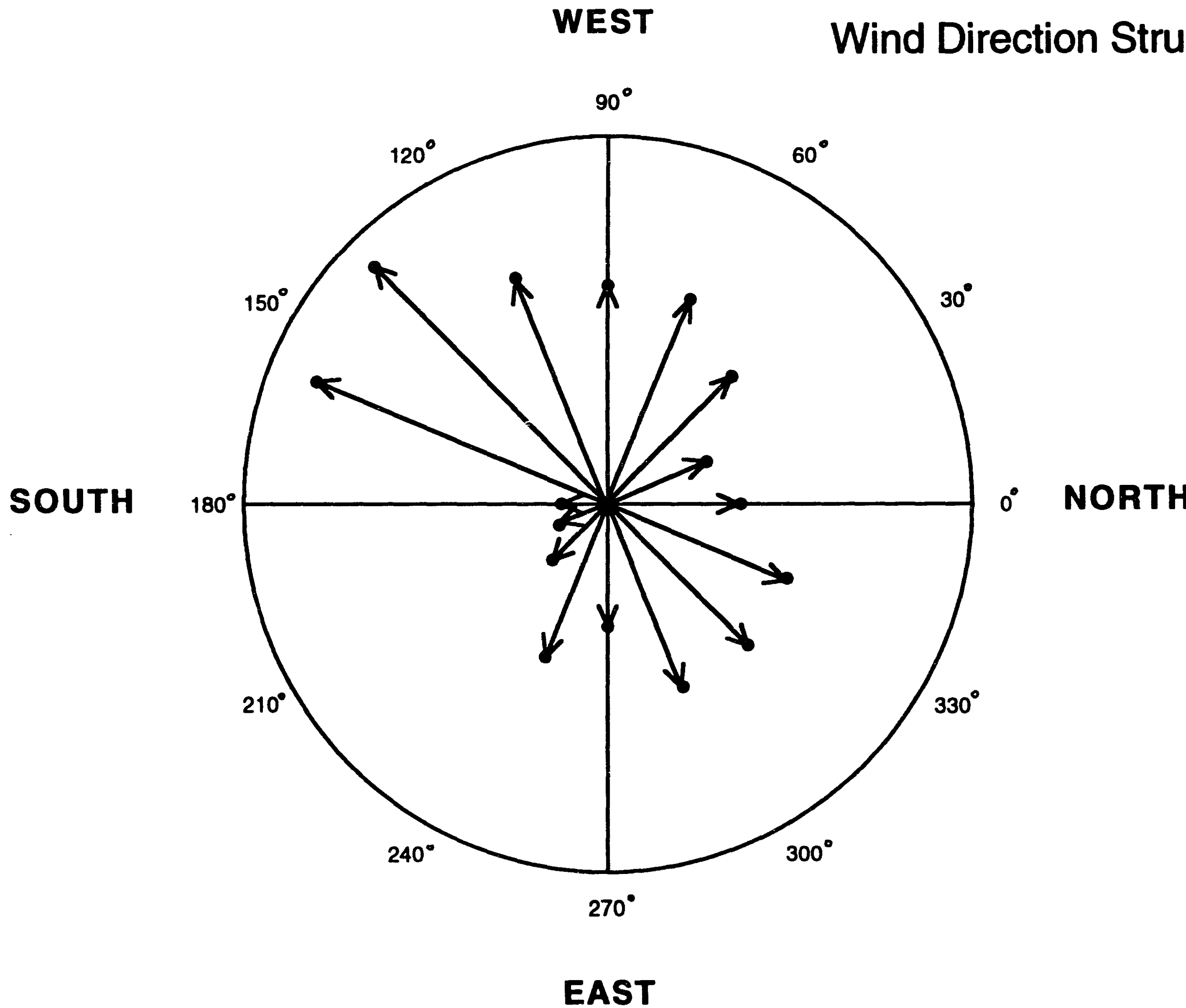
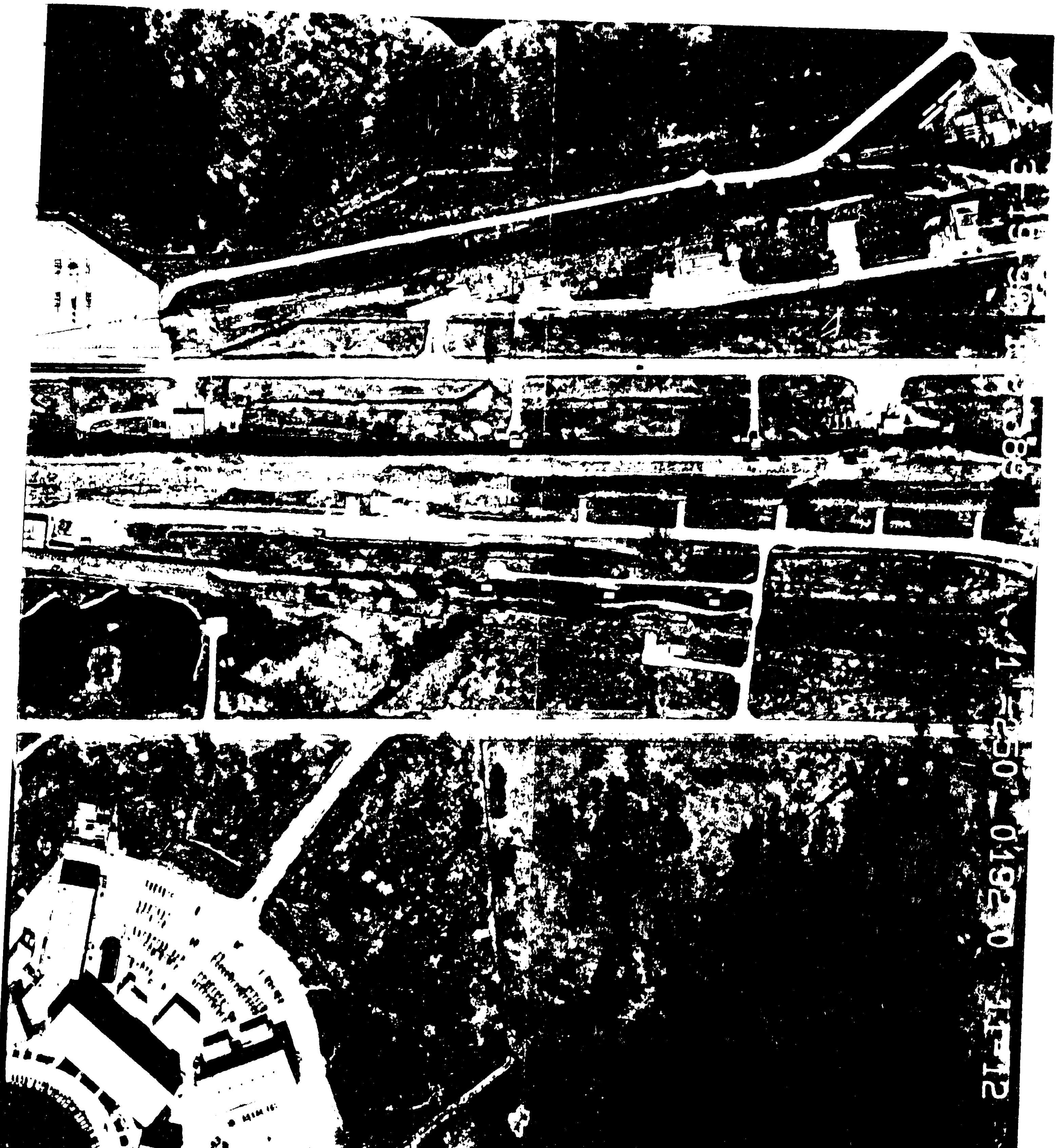


Figure 4.3

Relative wind frequencies in the speed class of 11-16 knots.
Frequency maximum: 40,000

APPENDIX A: Aerial Photograph of the Proposed Site

Drawing No. 3-19-92 152.389



Refer to Figure 5-1
for details

APPENDIX B: CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chicago Metro Wetlands Office
1000 Hart Road · Suite 180
Barrington, Illinois 60010
708-381-2253

IN REPLY REFER TO:

FWS/AES-CIFO

July 28, 1993

Andrew E. Mravca
Department of Energy
Batavia Area Office
Post Office Box 2000
Batavia, Illinois 60510

Dear Mr. Mravca:

This letter provides response to your letter of July 7, 1993 requesting a review of a report by Rod Walton assessing wetlands within Fermilab's KTeV project site.

Our review of the Walton report indicates that the small wet areas described would not be considered wetlands by the Service. All of the soils described in the report have high chroma colors, which are not indicative of hydric soils or saturated conditions. Since the soils are disturbed and may consist partially of fill material the amount of inundation recorded becomes important. Soils that are frequently ponded or flooded for long duration (7 to 30 days, single event) or very long duration (greater than one month, single event) during the growing season can qualify as hydric, even without other hydric characteristics. Review of the description given and consideration of recent heavy rainfall, suggests that under normal circumstance these sites do not have sufficient ponding to render these disturbed soils hydric. This assertion is supported by the lack of observed gleying, mottling, or other hydric soil characteristics.

Thus, it is our opinion that the small pockets of wetland vegetation are not wetlands because the hydric soil criterion is not satisfied. As a practical matter, areas this small are seldom considered during site visits because they do not offer any wetland functional value and are nearly impossible to map reliably on an aerial photograph.

I hope this provides you with the needed information. If you have any questions, please contact Mr. Jeff Mengler at 708/381-2253.

Sincerely,

John D. Rogner

John D. Rogner
Assistant Field Supervisor

cc: R. Walton, Fermilab

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chicago Metro Wetlands Office
1000 Hart Road - Suite 180
Barrington, Illinois 60010
(708)381-2253

IN REPLY REFER TO:

FWS/AES-CIFO

August 4, 1993

Andrew E. Mravca
Department of Energy
Batavia Area Office
Post Office Box 2000
Batavia, Illinois 60510

Dear Mr. Mravca:

This letter is provided in response to the phone request of John Cooper of your staff on August 3, 1993.

Our review of the Walton report, the color aerial photograph, and other available resources indicates that the proposed KTeV project is not likely to affect any federally endangered or threatened species. This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. Should the project be modified or new information indicate that endangered or threatened species may be affected, consultation should be initiated.

If you have any questions, please contact Mr. Jeff Mengler at 708/381-2253.

Sincerely,

Benjamin N. Tuggle, Ph.D.
Field Supervisor

Batavia Area Office

	A. [illegible]
	J. Miller
	E. [illegible]
	C. [illegible]
2	J. Cooper
	R. [illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]

cc: R. Walton, Fermilab

8/9 fwd to J. Jesse, 8.16
C Hickey, 8.17

Department of Energy
Washington, DC 20585

SEP 2 9 1993

Ms. Terri Moreland
Associate Director of
Science and Technology
State of Illinois Office
444 North Capitol Street
Washington, D.C. 20001

Dear Ms. Moreland:

The U.S. Department of Energy (DOE) is considering a proposal to design, construct, and operate a new fixed target experiment called the "Kaons at the Tevatron (KTeV) at Fermi National Accelerator Laboratory (Fermilab)" located in Batavia, Illinois. The proposed action would modify an existing fixed target beamline in the Fermilab Neutrino Area. It would include reconfiguring and modifying existing facilities and construction of a new experimental detector hall area. This would provide for an improved higher energy source of neutral K mesons (kaons) and a more sensitive detector to measure them, thus advancing the study of kaons well beyond that currently available at Fermilab.

The DOE has prepared an Environmental Assessment (EA) to analyze the potential environmental consequences associated with the construction and operation of the facility. This EA has been prepared in accordance with the requirements of the National Environmental Policy Act (NEPA), the Council on Environmental Quality regulations implementing NEPA, and the DOE NEPA regulations (10 CFR Part 1021).

Section 1021.301(d) of the DOE NEPA regulations requires that DOE provide a state and any American Indian tribe that would host a proposed DOE action with an opportunity to review and comment on an EA for that action before DOE's approval of the EA. This process is intended to foster early and open communication between DOE and affected states and Indian tribes. Accordingly, I am providing you with an advance copy of this EA.

If you have any comments on this document, please send them to me within 30 days from receipt of this letter. Comments sent within this period will be considered before approval of the EA. Comments sent after that will be considered to the extent practicable. Please inform me if the State of Illinois does not have any comments.

If you or your staff wish to receive further information about this proposal, please contact James K. Farley, Office of Energy Research NEPA Compliance Officer, at (301) 903-2314. For further information about the DOE NEPA process, please contact Carol Borgstrom, Director, Office of NEPA Oversight, at (202) 586-4600 or (800) 472-2756.

Sincerely,

James F. Decker
Acting Director
Office of Energy Research

Enclosure

ENR

Illinois Department of Energy and Natural Resources

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John S. Moore, Director

October 7, 1993

fax # 202-586-4120

708-840-2939

Dr. James F. Decker
Acting Director
Office of Energy Research
U.S. Department of Energy
Washington, DC 20585

Dear Dr. Decker:

This is in response to your September 29, 1993 letter to Terri Moreland regarding the "Kaons at the Tevatron" at Fermi National Accelerator Laboratory, and the Environmental Assessment that was provided for State of Illinois review.

Based upon an evaluation of the information provided, the State of Illinois has concluded that the referenced project should not result in significant impacts on the environment, on regional ecology, or on cultural, historical or archaeological resources. We therefore have no concerns or comments about the Environmental Assessment, and hope that Fermilab will gain approval to move forward with the project as soon as practicable.

Please contact me at (217) 785-2009 if you have any questions. Thank you very much for your consideration.

Sincerely,

Frank M. Beaver

Frank M. Beaver
Deputy Director

cc: Terri Moreland
Director John S. Moore

DATE

FILMED

5/24/94

END