ENVIRONMENTAL ASSESSMENT
FOR

NOνA

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APPENDIX A: MINNESOTA ENVIRONMENTAL ASSESSMENT WORKSHEET 77

1. Introduction

The U.S. Department of Energy (DOE) is proposing to conduct a new experimental research program in neutrino physics. The research program is called NOνA (**N**uMI **O**ff-**A**xis ν_e **A**ppearance Experiment). NuMI is an acronym for Neutrinos at the Main Injector. The Main Injector is a 120 GeV proton accelerator at Fermi National Accelerator Laboratory.

In accordance with the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations at 40 CFR Part 1500, and DOE NEPA Implementing Procedures at 10 CFR Part 1021, DOE has prepared this assessment of the direct, indirect, connected, and cumulative impacts of this research program. Proposed actions evaluated in this Environmental Assessment include (1) excavation; (2) construction of facilities; (3) assembly of detectors; (4) operation of an accelerator at an increased power; (5) and future decommissioning activities. Some of the actions would be performed by or for Fermilab Research Alliance, LLC, on behalf of the Department of Energy, at the site of the Fermi National Accelerator Laboratory (Fermilab) in Illinois; some of the actions would take place in Minnesota under the auspices of the University of Minnesota through a Cooperative Agreement with DOE.

NOvA proposes to capitalize on the Department of Energy's investment in the existing Neutrinos at the Main Injector (NuMI) beamline at Fermilab. The NuMI beamline brings 120 GeV protons extracted from the Main Injector into a graphite target. Two parabolic magnetic horns focus the resulting secondary beam which produces neutrinos from pion and kaon decay. The neutrino beam is aimed at the MINOS far detector in the Soudan Mine located in Tower, Minnesota.

Whereas MINOS technology was optimized for detecting muon neutrinos, the NOvA design is optimized for detecting electron neutrinos. NOvA would require a Near Detector at Fermilab to understand the NuMI neutrino beam composition before oscillations occur, and a Far Detector in northern Minnesota to measure the oscillations after the neutrino beam travels through several hundred kilometers of the earth's surface.

The NOvA Near Detector would be located in the existing NuMI underground experimental hall. The NOvA Far Detector would be positioned approximately 12 km from the central axis of the NuMI neutrino beam in the area of Ash River, Minnesota. The neutrino beam would pass underground from Fermilab to northern Minnesota. No tunneling is required since the neutrinos simply pass through the earth's crust.

Information on the environmental impacts associated with construction and operation of the Far Detector Facility has been incorporated from a Minnesota Environmental Assessment Worksheet (EAW) (Appendix A) submitted by the University of Minnesota in accordance with State of Minnesota procedures. The University of Minnesota is acting as the State of Minnesota Responsible Governmental Unit (RGU) for this process. The EAW has been submitted to the Minnesota Environmental Quality Board (EQB).

Using the University of Minnesota as the RGU to follow the Minnesota EAW process is similar to the process used for the NuMI project (DOE/EA-1198). In the NuMI EA, the Minnesota Department of Natural Resources acted as the RGU for the Sudan Underground Laboratory EAW. In both the NuMI and NOvA EAs, the use of the Minnesota EAW follows the Council on Environmental Quality regulations regarding elimination of duplication with State and local procedures (Section 1506.2).

The steps that are still required to finalize the Minnesota EAW process are as follows:

1. The RGU is responsible for issuing a press release briefly describing the project and anticipated distribution and public comment period schedule.
2. A notice is required to be posted in the EQB publication known as the EQB Monitor, which is published bi-weekly. Upon publication in the EQB Monitor a 30-day public comment period begins.
3. When the 30-day public comment period ends, the RGU will issue a findings-of-fact determination and initiate a response to comments process. The RGU has 3 to 30 days after the comment period ends to prepare a findings-of-fact and responses to comments.
4. At the end of the 30-day findings of fact/response to comments period, the 30-day judicial appeal period begins.
5. Upon the completion of the judicial appeal period the RGU distributes a notice of decision that will then be published in the EQB Monitor 7 to 21 days after receipt.

A gap analysis has been completed comparing the DOE Environmental Assessment Checklist to the State of Minnesota Environmental Assessment Worksheet (EAW). Issues that have been identified as not being fully addressed in the Minnesota EAW are addressed in this EA.

2. Purpose and Need

The purpose of the NOvA experiment is to advance human understanding of the physics of the neutrino particle. The neutrino particle has no electric charge and is a million times lighter than the lightest charged particle, and therefore cannot be studied directly with accelerator beams. By studying neutrino oscillations, physicists can determine whether they have mass. Although other neutrino oscillations from one type to another have been observed, the muon-type to electron-type oscillation has not yet been observed. The NOvA experiment is designed to study this neutrino oscillation.

The observation of neutrino oscillations means that neutrinos have non-zero masses. Knowledge about these oscillations is needed to determine the ordering of the neutrino masses and to search for the effects of neutrino oscillations violating Charge Parity (CP) conservation. CP violation by neutrinos could provide information leading to an understanding of why the Universe is composed solely of matter, rather than equal amounts of matter and antimatter. Understanding of these particles is an important goal of the worldwide physics community.

3. Proposed Actions and Alternatives

This section describes the proposed action and alternatives to the proposed action, including the No-Action Alternative. Facility design and construction details described for the proposed actions are based on conceptual plans described in the NOvA Conceptual Design Report [1]. The final design for construction may differ from that discussed within this EA. However, the nature, scope, and environmental impacts of these proposed actions described in this document are expected to substantially reflect and bind those associated with actual construction and operation of the facility as described in the NOvA Technical Design Report.

The proposed action consists of four main elements: construction/excavation; detector assembly; operation of the NOvA experiment, and decommissioning at two sites: Fermilab in Illinois and Ash River in Minnesota.

The schedule for the proposed actions has construction and assembly starting in October, 2008. Construction and assembly would continue through 2013. Operations would begin on parts of the devices during the construction period, but sustained operations would begin in 2013 and continue through at least 2019.

3.1 Fermilab Site Proposed Actions

3.1.1 Construction / Excavation at Fermilab

The construction of the proposed NOvA facilities at Fermilab would follow conventional construction practices for both surface and tunneling. To address the tunneling portion of the project, engineering services with experience in such construction projects would be procured. All construction activities would be conducted in accordance with applicable State, Federal, and Local regulations to assure safety to workers and the public and to provide protection for the environment.

Controls would be instituted as part of a Storm Water Pollution Prevention Plan according to guidance from the Illinois Environmental Protection Agency (IEPA, 1987). Proper soil erosion barriers would be erected and maintained around all disturbed soil and rock stockpile areas. A combination of silt fences, hay bales and excavated temporary waterways would be used to direct storm water away from wetlands and sensitive resources and to detain water long enough for the sediment to settle prior to flowing into surface water.

These areas would be restricted to construction workers and those Fermilab and U. S. Department of Energy employees who would be engaged in the administration and monitoring of construction activities. Protection of the latter individuals would be assured through conformance to standard construction safety regulations promulgated by the U. S. Occupational Safety and Health Administration (29 CFR 1926 and 10 CFR

851). Outdoor work is itself a concern and work plans would be developed to allow for excessively cold and hot days when worker time outdoors may be limited.

3.1.1.1 NOvA Near Detector

The NOvA Near Detector would be located on the Fermilab site at a distance of about 1 kilometer from the NuMI target in the NuMI access tunnel down stream of the MINOS access shaft. This site can meet the size requirements for the near detector and the necessary services exist. It has the clear advantage of requiring minimal civil construction. Figure 3.1 shows the NuMI underground access tunnel in elevation and plan view. The NOvA Near Detector site is indicated in red stripes just downstream of the vertical shaft from the MINOS Surface Building. The distance from the Target Hall to the MINOS shaft is about 960 meters, and the NOvA Near Detector site is about 75 meters long. The entire shaded area is on a level grade, but 340 feet underground.

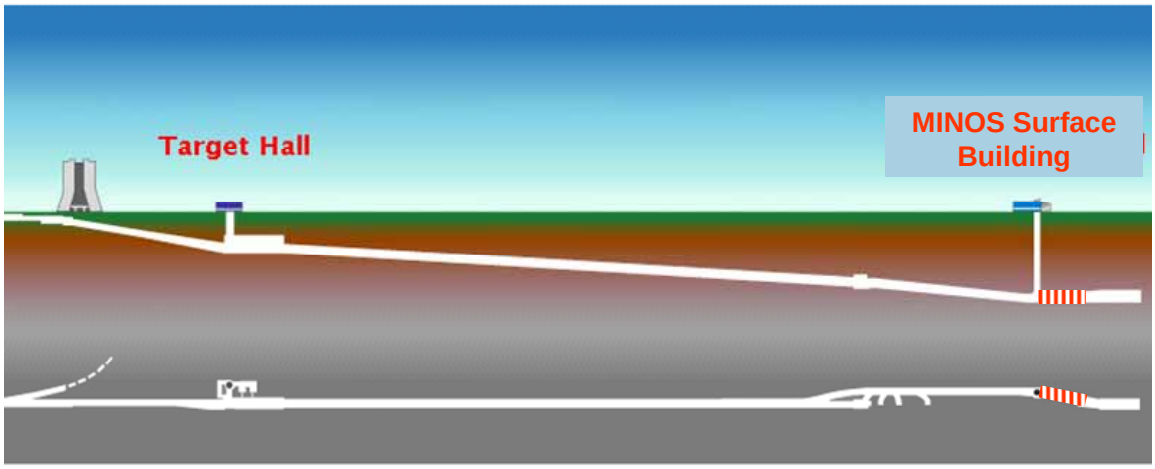

Figure 3.1: Elevation (top) and plan (bottom) views of the NuMI beam line at Fermilab. The location(s) for the NOvA Near Detector would be in the red striped sections 105 meters beneath the MINOS Surface Building at the bottom and downstream of the access shaft to the NuMI tunnel.

Civil construction would be needed at the Fermilab site to house the NOvA near detector. Excavation of the NuMI tunnel in the passage way between the access shaft and the MINOS experiment hall would be required to create additional space for the installation of the NOvA near detector. This would require excavation into the side of the NuMI underground tunnel as shown in Figure 3.2. The excavation would provide space so the NOvA Near Detector can be located at the optimum angle relative to the NuMI beam for data taking. The excavation would remove less than 1000 cubic yards of rock. Removal of the waste rock would involve precautions to ensure that particulates would not be introduced into the NuMI tunnel sump which empties into the Fermilab ICW system. Spoils removed from tunnel would be put into stock piles at Fermilab in accordance with existing permits. The raw exposed rock would be covered with shotcrete.

The construction area in Figure 3.2 would have an interior 100% secondary containment volume sized to hold the liquid scintillator in the NOvA Near detector. The new excavation would be separated from the existing tunnel by a full floor to ceiling wall to separate the two fire protection areas. The new area requires an appropriate fire protection system since liquid scintillator is lighter than water. A water mist (fog), or water foam, or inert gas system (with breathable levels of oxygen) would be used. Fire protection is relevant since PVC outgases Chlorine byproducts in the event of a fire.

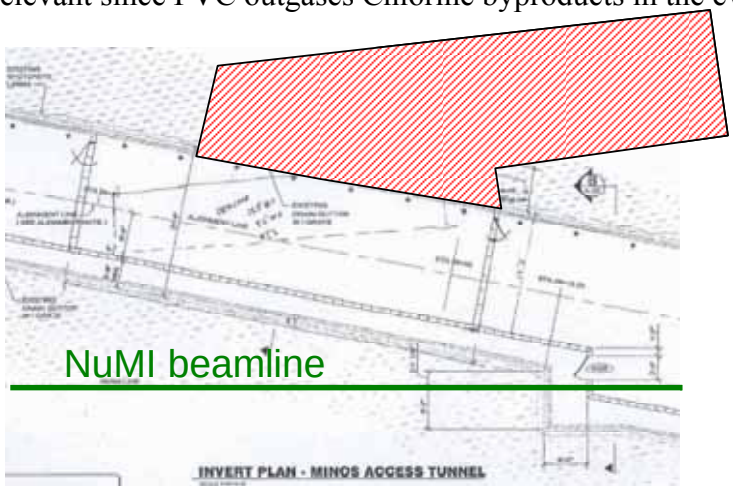

Figure 3.2: View of the NuMI access tunnel near the vertical MINOS shaft. The red area shows the location of the needed excavation. The area is about 20 meters along the long axis of the excavation.

During the R&D period, NOvA intends to build an Integration Prototype Near Detector (IPND) to test all construction techniques. The IPND would be located in the MINOS Service building on the surface at the top of the MINOS shaft (see Figure 3.1). This structure internal to the existing service building would be of steel stud and drywall construction and have a temporary containment structure. The area would have a fire protection system based on inert gases with breathable levels of oxygen. Figures 3.3 and 3.4 illustrate this IPND enclosure construction area.

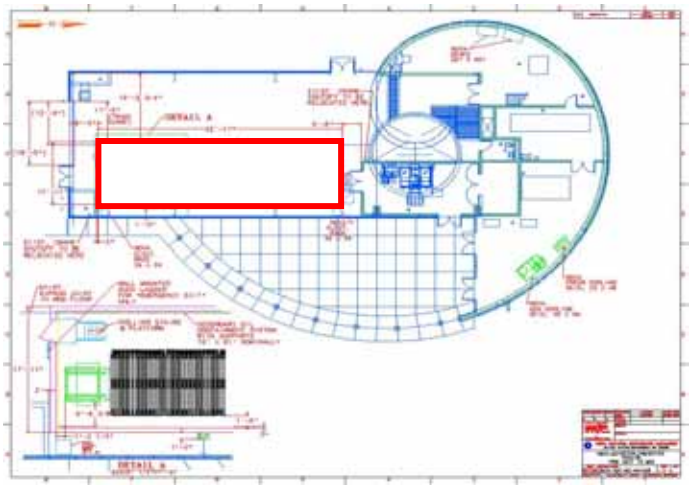

Figure 3.3: View of the IPND enclosure construction area in the MINOS Service Building. The red outlined area is 19 meters by 5 meters and contains the IPND.

Figure 3.4: Example commercial secondary containment system which would be attached to the interior side of the drywall walls of the INPD structure inside the existing MINOS Service Building.

3.1.1.2 Scintillator Blending Facility

A liquid scintillator blending facility would be built at an existing site at Fermilab. The facility would be used to blend the materials that are needed to fill the NOvA detectors. The blending facility would be in an outdoor area similar to a neighborhood gasoline station with an overhead canopy as shown in Figure 3.5. Sites have been identified near the Fermilab railhead (see Figure 3.6) and each of the sites is a previously disturbed level area that is not currently in use. The Fermilab railhead is an optimum location because the dominant component of liquid material would arrive in railcars. Additional electric power would be needed at the blending site. The blending facility would require 100% secondary containment, so a curbed concrete area under the canopy would be sized for containment of all liquids including the volume of 24-hour rainfall as determined by a 25-year storm. Additional containment is commercially available for railcars as shown in Figure 3.7.

Figure 3.5: Example of a small blending facility. This picture is of a facility located at the DuPage County (Illinois) airport.

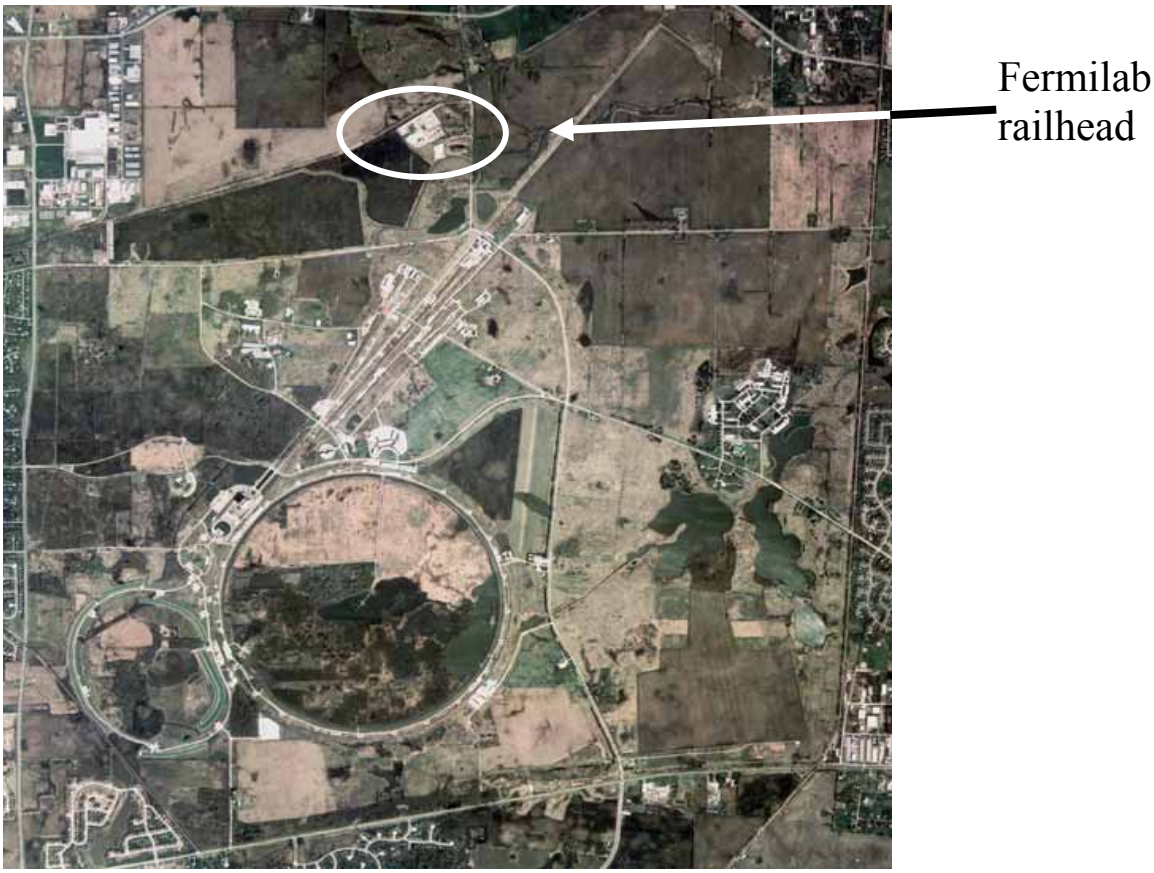

Figure 3.6: Aerial view of Fermilab showing the location of the Fermilab railhead near the northern site boundary of the laboratory.

Figure 3.7: A commercial solution for secondary containment of railcars. The pans around the rails are connected and route spills to the concrete bunker to the side of the tracks.

3.1.2. Installation / Assembly at Fermilab

3.1.2.1 Recycler, Main Injector, and NuMI Neutrino Line

An overview of the Fermilab accelerator complex is shown in Figure 3.8.

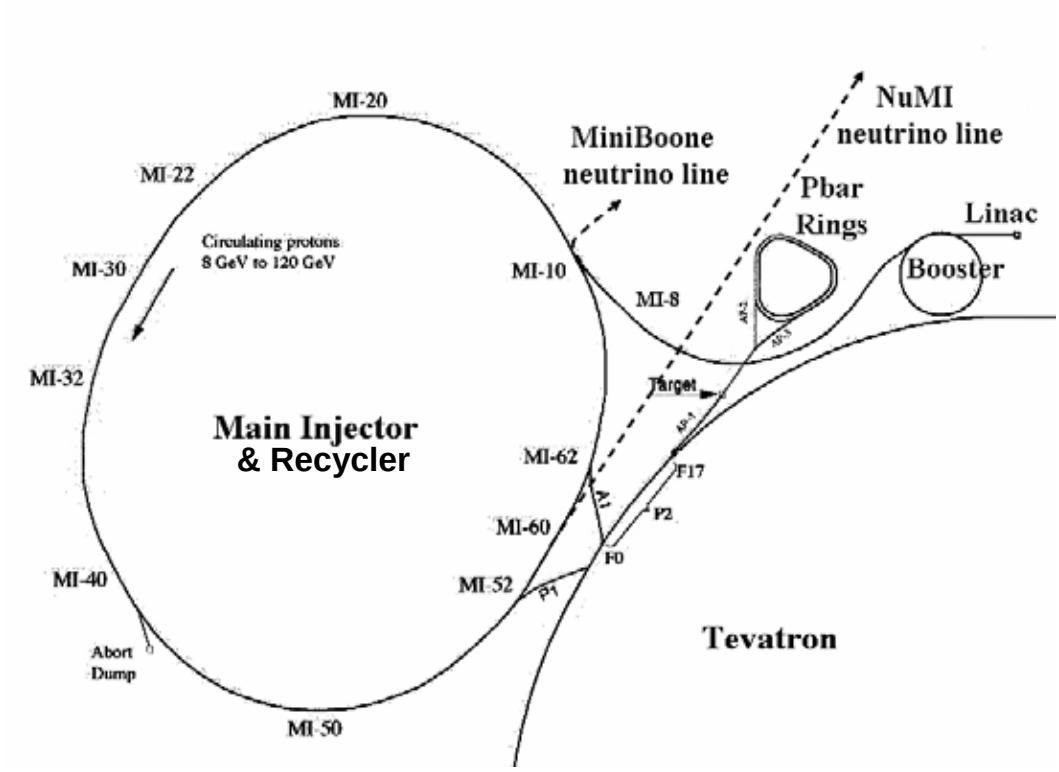

Figure 3.8: The Fermilab accelerator complex

The Recycler would be converted from an anti-proton to a proton storage ring, starting with the decommissioning all anti-proton specific devices. A new proton injection line (MI-8) from the Fermilab Booster directly into the Recycler and a transfer line from the Recycler into the Main Injector are needed. All this work takes place in existing tunnels and requires new or re-arranged beamline components such as magnets, radio frequency stations, and power supplies.

The ability of the NuMI neutrino line to accept an increase in power to 1500 kW, over its design value of 400 kW, mainly involves improvements to the primary proton line to handle a faster repetition rate and new designs for the target and the horn focusing systems.

3.1.2.2 Near Detector

A 212 metric ton liquid scintillator filled Near Detector would be constructed and placed in the existing NuMI underground access tunnel at Fermilab, at a depth 105 meters below grade. The Near Detector would be assembled in a vessel that will provide 100% secondary containment for the liquid scintillator. The beam from Fermilab would pass

through the NOvA Near Detector towards the MINOS detector in the Soudan Underground Laboratory in Minnesota.

The Near Detector design is based on rigid polyvinyl chloride (PVC) extrusions, each extrusion with 32 cells of 6.6 cm by 3.9 cm cross section. The extrusions serve as the primary containment system for the active detector made of liquid scintillator with an immersed wavelength shifting fiber. The extrusions get capped at one end by an endplate and at the other end by a fiber manifold. Both ends must contain the liquid scintillator since horizontal modules have liquid touching both ends of the module. The detector system for two side by side extrusion modules is illustrated in Figure 3.9.

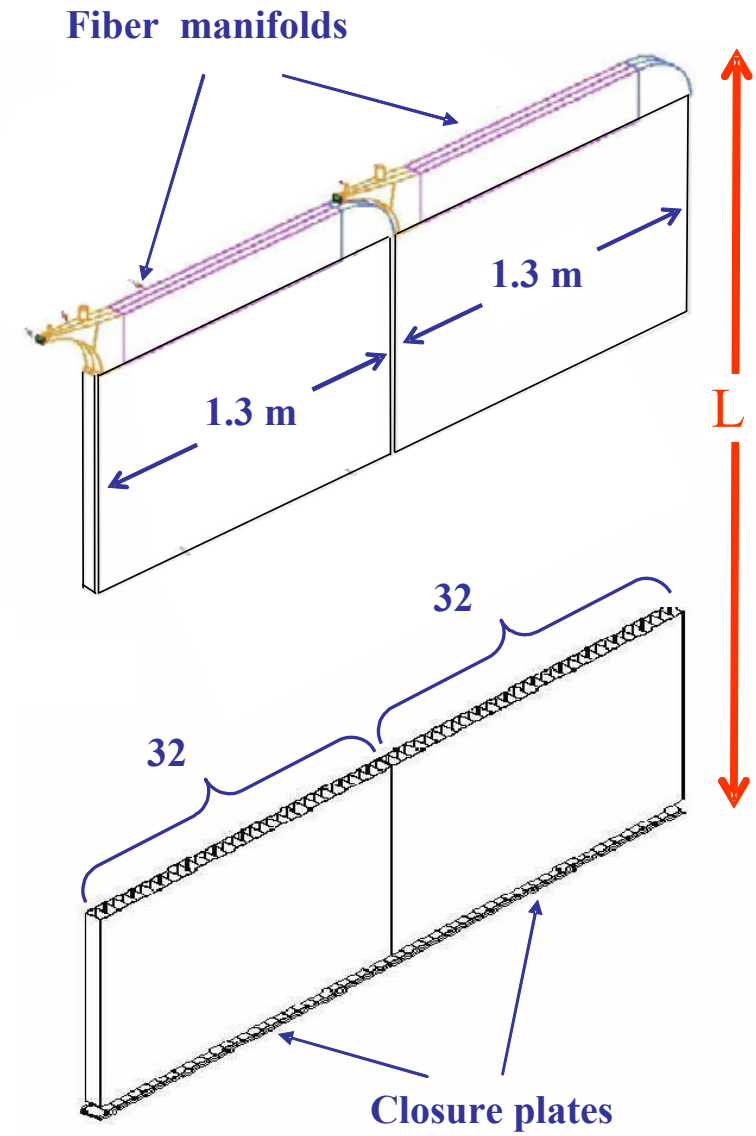

Figure 3.9: Two side by side NOvA extrusion modules with 32 cells in each. Each module serves as a primary containment volume. In the NOvA Near Detector vertical modules have length L = 4.1 meters and horizontal modules have L = 2.3 meters.

The Near Detector would be assembled with alternating planes of horizontal and vertical extrusion modules. A vertical plane contains two 32 cell extrusions and a horizontal plane contains three 32 cell extrusions. The detector would have 200 planes of extrusions in total. The detector would be assembled in six 31 plane blocks for uniformity with the Far Detector. A steel muon ranger forms a last 7th block. The Near Detector parameters are summarized in Table 3.1

Parameter	**Parameter Value**
Total mass	*211.7 metric tons*
Active detector mass	*128.9 metric tons*
Total Liquid Scintillator	*29,641 gallons*
Liquid Scintillator in primary containment	
Vertical extrusion modules	*74 gallons*
Horizontal extrusion modules	*49 gallons*
Muon ranger mass	
Steel	*81 metric tons*
Scintillator planes	*6.5 metric tons*

Table 3.1 Near Detector Parameters

As discussed in section 3.1.1.1, an alcove would be cut into the side of the MINOS access tunnel to permit the Near Detector to be installed at the proper angle to the NuMI beam. Each of the six detector blocks would be constructed at Argonne National Laboratory within a steel framework cradle. The cradle is used to transport the empty block to the Fermilab MINOS Service Building and then to lower it down the vertical MINOS access shaft. A forklift would be used to move the block from the bottom of the shaft to the detector location in the NuMI tunnel.

Once assembled, the Near Detector would be filled with liquid scintillator. The liquid scintillator distribution would be designed to accept liquid scintillator from delivery tankers parked within the MINOS Service building at the top of the shaft. During fill, a large volume of vapor would be displaced from the extrusions and the scintillator distribution system would return this displaced gas volume from the modules back to the tanker. The plan is to fill the planes from a tanker truck on the surface that is fitted with a double walled pipe the length of the shaft and extending to the detector location. A pressure reducing valve would be used to reduce the liquid pressure of the long vertical pipe. A separate pipe would vent pseudocumene vapor back to the tanker. The vapor from tankers might eventually be vented elsewhere at Fermilab and this would require a preconstruction air permit and a revision to the Fermilab Lifetime Operating Permit [2].

The delivery system would include components that ensure that filling of the PVC modules is done at a precisely controlled flow rate. During the fill all piping from the tanker trucks to the detector would be protected with appropriate secondary containment

systems. Spill control plans, counter measure materials, personal protective equipment (PPE) and working procedures would be developed for each process that involves work with the blended liquid scintillator.

The detector would need a certain amount of infrastructure. In particular the readout electronics would require one standard 7 foot relay rack and a cooling system. These fit easily in the access tunnel downstream of the detector. Power is readily available.

As also discussed in section 3.1.1.1, an early detector prototype called the Integration Prototype Near Detector (IPND) would also be assembled and installed in the MINOS service building on the surface at Fermilab. The IPND is also filled from tanker trucks but without the complication of a long vertical pipe since this detector remains on the surface. Any vapors released at Fermilab would require a preconstruction air permit and a revision to the Fermilab Lifetime Operating Permit [2]. The IPND itself would be installed inside of a secondary containment vessel as shown in Figure 3.4.

3.1.2.3 PVC Module Assembly

The NOvA Far Detector (see section 3.2.2) requires 15,624 modules like those shown in Figure 3.9, each with length L = 15.7 meters. These modules would be assembled at two PVC module assembly factories, each performing different tasks. The first factory would be at Fermilab and would perform both visual and quantitative quality assurance on the extruded PVC parts. The second factory adds the fiber, bottom closure plate, and fiber manifold and tests the final module for leaks.

The Fermilab factory would be located in the existing WideBand laboratory building in the Fermilab Proton Area. The factory glues two 16 cell extrusion parts together to form the basic 32 cell unit for NOvA. This step involves use of Devcon-60 Plastic Welder, a two part (1:1 mix) methyl methacrylate (MMA) based adhesive with the components listed in Table 3.2

Devcon-60 Activator component	**CAS Number**	**% by weight**
Methyl Methacrylate Monomer	80-62-6	60 – 100
Trade Secret	N/a	5 - 10
3,5-Diethyl-1,2-dihydro-1-phenyl-2-propylpyridine	34562-31-7	1 – 5
Other ingredients	N/A	10 - 30
Devcon-60 Adhesive component		
Methacrylic acid	79-41-4	5 - 10
1-chloro-1,3 butadiene	9010-98-4	5 - 10
Methyl Methacrylate Monomer	80-62-6	60 - 100
Chlorosulfonated polyethylene	68037-39-8	5 - 10
Trade Secret	N/A	10 - 30
2,6-Di-tertiary-butyl-para-cresol	128-370	1 - 5
Paraffin wax	64742-43-4	1 - 5

Table 3.2: Composition of Devcon-60 Plastic Welder adhesive.

Use of Devcon-60 would require appropriate ventilation of Methyacrylic acid vapors, Methyl Methacrylate Monomer vapors, and 2,6-Di-tertiary-butyl-para-cresol vapors. Approximately 2000 gallons of Devcon-60 Plastic Welder would be used at Fermilab spread over an assembly period of several years. The maximum rate of Devcon-60 use is expected to be about 4 gallons (33 pounds) per day.

3.1.2.4 Blending Liquid Scintillator

The NOvA experiment proposes to purchase the scintillator component ingredients in Table 3.3 and blend them at Fermilab over a period of several years. Spill control plans, counter measure materials, personal protective equipment (PPE) and working procedures would be developed for each process that involves the component ingredients and the blended liquid scintillator. Table 3.4 shows the chemical names of the ingredients in Table 3.3.

component	purpose	mass fraction	volume (gal)	tot mass (kg)
mineral oil	solvent	94.4%	4,079,841	13,127,298
pseudocumene	scintillant	5.5%	230,057	762,875
PPO	waveshifter #1	0.1%		16,788
bis-MSB	waveshifter #2	0.002%		235
Stadis-425	antistatic agent	0.0003%		62.6
tocopherol (Vit.E)	antioxidant	0.0010%		139
Total		**100.0%**	**4,309,899**	**13,907,259**

Table 3.3: Composition of NOvA liquid scintillator.

Component	Chemical name
Mineral Oil	NOvA would use a Technical grade White Mineral Oil. Chevron ParaLux 701 is an example.
Pseudocumene	1,2,4-Trimethybenzene
PPO	2,5-diphenyloxazole
Bis-MSB	1,4-di-(2-methylstyryl)-benzene
Stadis-425	Proprietary mixture, but primarily composed of kerosene and toluene
Tocopherol	Tocopherol

Table 3.4: Chemical names and hazards of NOvA Liquid Scintillator components.

Mineral oil and pseudocumene are both liquids. The wavelength shifters are in powder form. The wavelength shifters do not dissolve in mineral oil and must first be dissolved in the pseudocumene. This mixing operation is not a chemical reaction, but instead

involves dissolving wavelength shifter powders in pseudocumene in one step and then combining the mixture with mineral oil in a final step. The mixing operation would be done with a closed loop system to capture all vapors. The vapor might eventually be vented elsewhere at Fermilab and this would require a preconstruction air permit and a revision to the Fermilab Lifetime Operating Permit [2]. The use of pseudocumene in amounts over 25,000 pounds in any year would be reported on the Toxic Release Inventory Form R in compliance with the Fermilab toxic release inventory requirements.

The wavelength shifting powders would be delivered to Fermilab in 5 – 25 kg fiber drums. The mineral oil would arrive at Fermilab by rail car. Pseudocumene would arrive at Fermilab by stainless steel tanker trucks. The mineral oil from the rail cars would be transferred into tanker trucks. Only one tanker truck would be filled at a time and only one railcar would be used at a time. This operation is expected to occur at the outdoor rail head storage area located at the north end of the Fermilab site.

The blending is done in two steps: First the wavelength shifting powders are dissolved in pseudocumene. This blending can be done with in-line blenders in a second closed loop system. The second step blends the concentrate with the mineral oil. As discussed in section 3.1.2.3., full secondary containment would be provided for the rail cars and for the tanker trucks of pseudocumene and pseudocumene/waveshifter concentrate mix.

The Integration Prototype Near Detector (IPND) discussed in section 3.1.2.2 also requires blended scintillator, but only a total of 20,000 gallons. This blending would be done in a prototype facility using only tanker trucks of liquids with each tanker truck surrounded by commercial secondary containment like that shown in Figure 3.10. Venting of any vapors from this prototype blending facility would require a preconstruction air permit and a revision to the Fermilab Lifetime Operating Permit [2].

Figure 3.10: A commercial solution for secondary containment of tanker trucks that will be used in the IPND prototype blending. Various types exist with drive-in bumpers of appropriate height for containment.

3.1.3 Operations at Fermilab

Operation of the proposed NOvA experiment on the Fermilab site would follow the requirements of the Fermilab Environment, Safety and Health Manual (FESHM) [3].

Fermilab has a Ground Water Protection Management Plan (GWPMP). The purpose of the plan is to ensure that all federal, state, county, local and other requirements pertaining to ground water protection and management are occurring in an effective manner.

Fermilab has a fully developed Environmental Management System. Environmental monitoring is part of that system and consists of two elements: effluent monitoring and environmental surveillance. Surface water monitoring includes outfall, sump, ditch, sanitary discharge, storm water, sediment, pesticide, and off-site monitoring.

Written work plans and emergency response procedures would be developed for all tasks that could pose a hazard.

3.1.3.1 Beamline Operations.

Operation of the proposed upgraded beamline and NOvA experiment on the Fermilab site would comply with standard Fermilab safety and beam operations procedures and guidelines as required by the Fermilab Radiological Control Manual (FRCM, 2005) [4]. These procedures are based on the principle of As Low As Reasonably Achievable (ALARA) in the area of radiation protection. Written access procedures would be developed for all areas. A Safety Assessment Document would be written and approved before operation starts.

Everyone that works in the NuMI tunnel would be required to take the Fermilab Underground safety course (NuMI/MINOS Underground Safety Training, Course Code FN00034/CR) and would be required to use appropriate personal protective equipment.

Total releases would be reported annually to the Illinois Environmental Protection Agency (IEPA) and the U.S. Environmental Protection Agency (EPA) in accordance with conditions of the relevant NESHAP permit [2]. No revisions would be necessary to the laboratory's permits or monitoring methodologies for operation of NuMI for the NOvA experiment. In the event that radionuclide air emissions would be higher than expected, Fermilab would take measures to mitigate the release of radionuclides to keep the levels below regulatory limits.

3.1.3.2 NOvA Near Detector Operations

Specific parts of the NOvA Near detector would be subjected to a safety analysis and operational readiness review by an ES&H Review Panel. A subject matter expert would be assigned the task of environmental review, to address any potential issues associated with a proposed activity. This would be done in order to ensure that permits are secured prior to commencement of any permit required activities. All proposed activities which

will utilize chemicals and the proposed installation/utilization of any equipment or process that would result in an emission to the internal or external air would be included in the environmental review process.

Everyone that works in the NuMI tunnel would be required to take the Fermilab Underground safety course (NuMI/MINOS Underground Safety Training, Course Code FN00034/CR) and would be required to use appropriate personal protective equipment.

3.1.4 Decommissioning / Disposal at Fermilab

3.1.4.1 Beamline Elements

Each component of the beam line would be surveyed by health physics personnel in order to identify, label and isolate all components made radioactive by beam operations. 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 and Federal, State, and Local regulations in effect at the time of disposal. Non-radioactive wastes would be properly disposed, in accordance with applicable regulatory requirements. There are no disposal sites for any waste materials on the Fermilab site and none would be planned for the future.

During the period of decontamination and decommissioning, radioactivity previously produced in the vicinity of the NuMI tunnel would continue to be collected and discharged to the Fermilab surface ponds and ICW system to remove them from the aquifer. The monitoring program would continue and results evaluated to determine measures needed to adequately protect workers, members of the public, and the environment. Studies are already underway to evaluate the measures to be taken in the context of the present operations of the NuMI beamline in support of the MINOS experiment and possible upgrades to higher beam intensities [5].

3.1.4.2 Near Detector

When the NOvA Near Detector at Fermilab is to be decommissioned, the experimental apparatus would be disassembled. The components would be reused elsewhere at Fermilab, shipped to other laboratories for use, or made available as surplus equipment according to standard procedures for disposition of United States Government properties. The PVC extrusion modules would be drained of liquid and disposed of as waste. The liquid scintillator could be used as an alternative fuel for incineration plants if it is not reused. The underground Near Detector enclosure would remain in place for future use. For the duration of the proposed NOvA experiment, information necessary for eventual decommissioning of the NOvA experiments would be collected, documented, and retained for future reference in accordance with existing Fermilab policies. This information would include the details of the design, the history of operation, and records of environmental monitoring.

The parts from the Integration Prototype Near Detector (IPND) would be reused in the construction of the Near Detector. Parts that are not reused would be decommissioned as described above. The drywall enclosure in the MINOS Service building would be dismantled.

Each component of the Near Detector and IPND would be surveyed by health physics personnel in order to identify, label and isolate all components made radioactive by beam operations. It is anticipated that all Near Detector and IPND components would be free of radioactivity since they will only be used in a neutrino beam.

3.1.4.3 Blending Facility

Decommissioning of the Fermilab Blending Facility would require removal of all the tanker trucks, pumps, and piping used in the blending process. These items can all be cleaned by commercial vendors and offered for recycling via the DOE surplus system.

3.2 Ash River Site Proposed Actions

The proposed action would require a new building and detector on a site near the US-Canadian border in Ash River, Minnesota to house the NOvA detector. This site is 810 kilometers from Fermilab and is referred to as the Far Detector site. Figure 3.11 shows the location of the Ash River site in Minnesota. Figure 3.12 shows details of the Ash River area. International Falls, Minnesota is about 30 miles from Ash River, and Voyageurs National Park is to the north of the Ash River NOvA site.

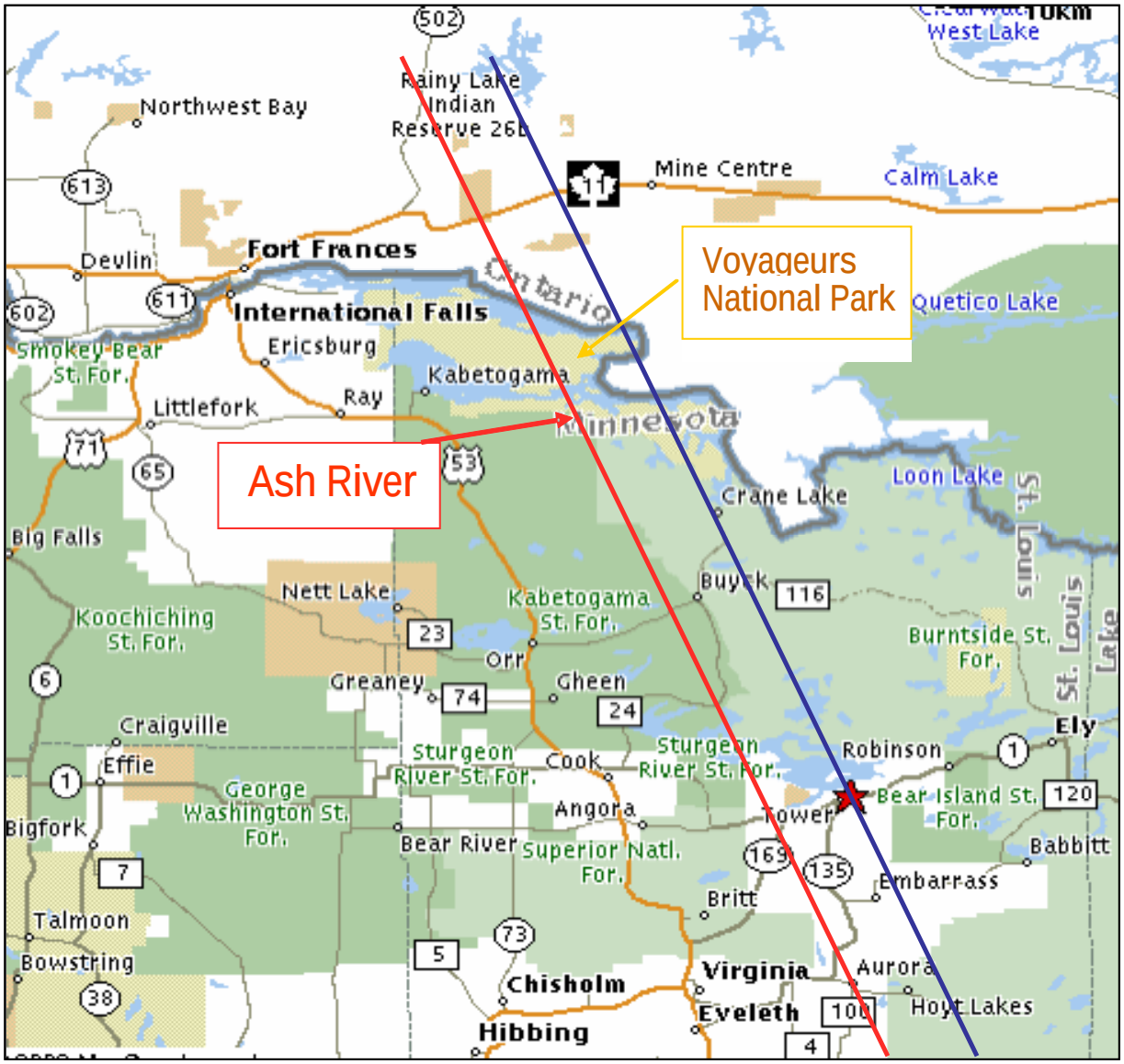

Figure 3.11: Map showing the Ash River site in Minnesota. Voyageurs National Park and the US-Canada border are just north of the Ash River site. The NuMI beam centerline (blue) passes through the MINOS detector at Soudan (red star). The NOvA Ash River site is on the red line to the west of the NuMI beam centerline about 12 km off-axis. The distance between Soudan and Ash River is about 75 km.

3.2.1 Construction / Excavation at Ash River

Local details of the Ash River area are shown in Figure 3.12. Proposed NOvA construction consists of an access road running east-west to the south of St. Louis County Road 129 and a Far Detector building on a hilltop at the end of the access road.

Figure 3.12: Details of the NOvA Ash River Site. A new access road would be constructed off St. Louis County 129 and a new building would be constructed at the end of the access road. The full scale at the bottom of the figure is about 1 kilometer.

3.2.1.1 Access Road and Utilities

The 3.5 mile long access road in Figure 3.12 follows an existing logging road and passes through a wetland area just off St. Louis County Road 129 (Ash River Trail). U. S. Army Corps of Engineers permitting would be required for the road construction.

The road work would include grading, excavation, potential dewatering and re-vegetation activities. Possible equipment to be used includes standard construction machinery such as trucks, backhoes, graders, compactors, skid-steers, cranes, loaders, compressors and possibly dewatering pumps.

The proposed site work includes the extension of existing electric and communication utilities and the installation of domestic water well and septic system. Electric utilities and fiber optic communication lines would be extended from Ash River Trail along the improved access road. Improvements to the existing transmission system serving the site would also be required, but include only upgrades to existing transmission lines to increase capacity.

3.2.1.2 Detector Building

The proposed building is a structure 358 feet long and 63 feet wide. The structure is constructed approximately 40 feet below the existing grade into granite rock at the site. From the base of the excavation, the structure is 67 feet high. A cross section through the building is shown in Figure 3.13. The below grade portion of the building or "bathtub" would be used to provide 100 % containment for the liquid scintillator oil used in the detector as well as the water used for fire suppression.

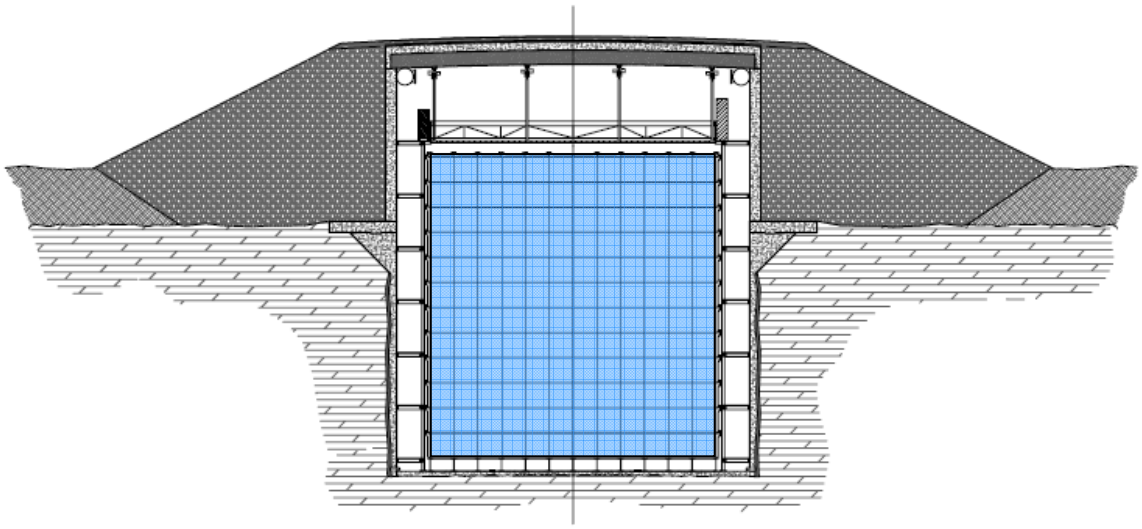

Figure 3.13: Cross section through the Far Detector building as seen by the neutrino beam from Fermilab. The detector is shaded blue. The excavated granite is bermed against the sides of the enclosure. Solid granite remains surrounding the bottom 40 feet of the detector.

The roof of the building would be composed of material designed to reduce the cosmic ray event rate in the NOvA detector. Approximately 2.0 feet of concrete plus 1.5 feet of barite (barium sulfate) would sufficiently reduce the cosmic background rate. Barite is an extremely stable rock with no known environmental effects. The sides of the above ground portion of the building would be shielded with granite spoils from the excavation.

The floor and walls of the assembly area and detector enclosure would be treated with a sealant (e.g., epoxy based paint) and accommodate a steel "pallet" used as the base of the detector. These pallets would separate the PVC modules from the concrete floor and serve as the "witness zone" for the space beneath the detector, a component of the secondary containment system. The sealant and separation would prevent liquid scintillator from being forced into the porous concrete surface due to the 19 psi hydrostatic pressure head from the 53 foot high scintillator columns (see section 3.2.2). Any scintillator that escapes the primary containment of the detector would be at atmospheric pressure in the secondary containment. This low pressure witness zone feature would reduce the effect of any small cracks in the sealant surface , though special

attention would have to be paid to expansion and construction joints. The floor of the detector enclosure and assembly area would allow for the collection of any scintillator that may find its way beneath the detector. The floor would be sloped to allow any spilled scintillator to be routed to a scintillator sump.

All groundwater would be collected between the solid granite bathtub and the concrete liner. The groundwater sumps would be isolated from the scintillator sumps, would be exterior to the bathtub, and would be monitored for fluid levels.

The sides of the detector in Figure 3.13 would be accessible by seven catwalks. The top of the detector would be accessible by a rolling bridge hung from the ceiling.

The new area requires an appropriate fire protection system for areas in which the scintillator is handled, stored or used. A water mist (fog) system, water foam system, or inert gas system (with breathable levels of oxygen) would be used. Support spaces including a loading dock, shop, storage and related functions would be housed in an above ground structure adjacent to the Detector Enclosure and Assembly Area as shown in the plan view of the building in Figure 3.14.

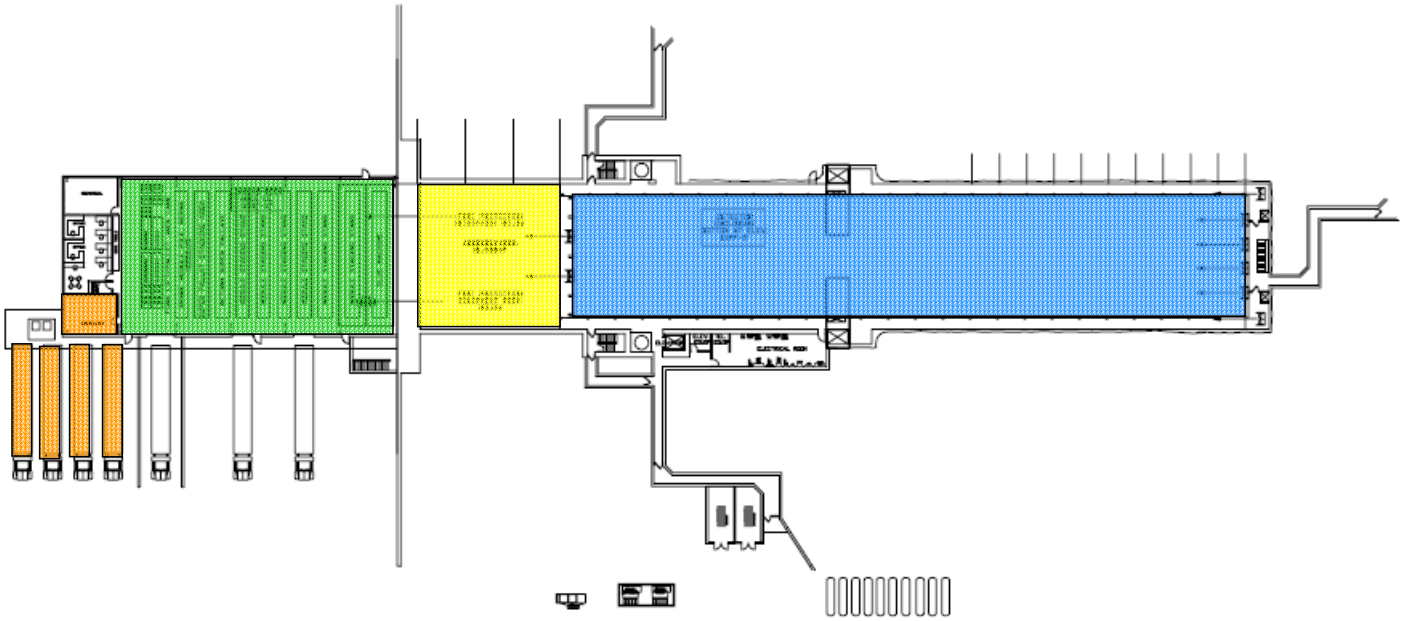

Figure 3.14: A plan view of the NOvA building showing the dector area (blue) with an assembly area (yellow) to the left of the detector and a loading dock area (green) with recessed and drive-in truck bays to the left of the assembly area. The scintillator handling area is in orange with adjacent four tanker truck bays.

An outside parking area would be built for four trucks delivering liquid scintillator (see Figure 3.14). This area would be equipped with a sump and a spill-control berm that is sufficient to contain 100% of the liquid from four tankers. Because of the remote location the truck turning area next to the loading bays would have a designated helicopter landing area for use in an emergency.

Construction of the proposed detector building and service building would include grading, rock and soil excavation, potential de-watering, concrete formwork, structural steel, metal siding and roofing as well as the associated mechanical and electrical infrastructure to support the detector assembly and operation. Possible equipment to be used includes standard construction machinery such as trucks, backhoes, graders, compactors, skid-steers, cranes, loaders, compressors and possibly de-watering pumps.

Construction of a facility the size of the Far Detector Building requires significant contractor staging and segregated stockpiling areas. The stockpiled material would be segregated into topsoil, clay and rock areas. Each stockpile would require sediment and erosion control devices as well as adequate access. Figure 3.15 shows the local area around the building and the proposed stockpile areas.

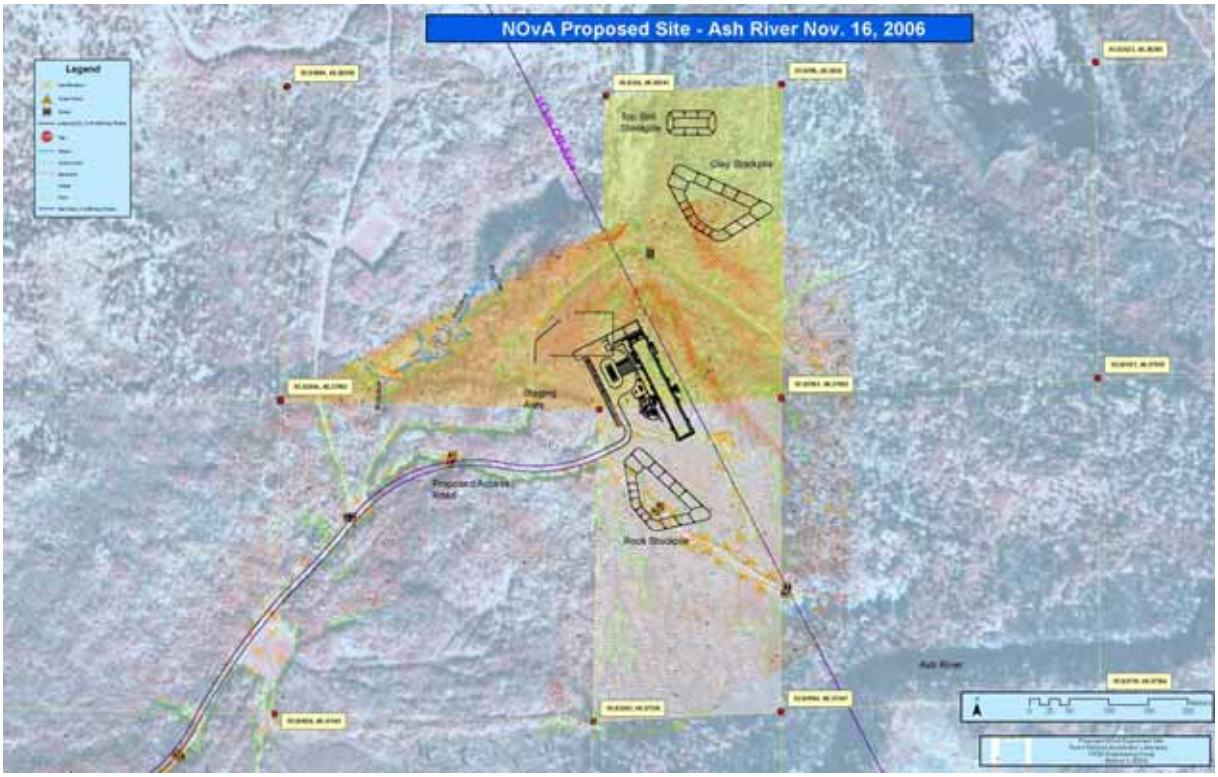

Figure 3.15: The NOvA site and Far Detector building showing stockpile areas for topsoil and clay to the north of the building and a stockpile area for excavated granite rock to the south of the building. The scale in the bottom right corner is 200 meters long.

3.2.2 Installation / Assembly

NOvA proposes to assemble a 20 kiloton tracking calorimeter, 15.7 m by 15.7 m by 90 m long, with alternating horizontal and vertical rectangular cells of liquid scintillator contained in PVC extrusion modules like those pictured in Figure 3.9. One plane of the detector would be constructed from 12 extrusion modules as shown in Figure 3.9 except that for the NOvA Far Detector, each module is 15.7 m long. Figure 3.16 illustrates the size of the complete detector.

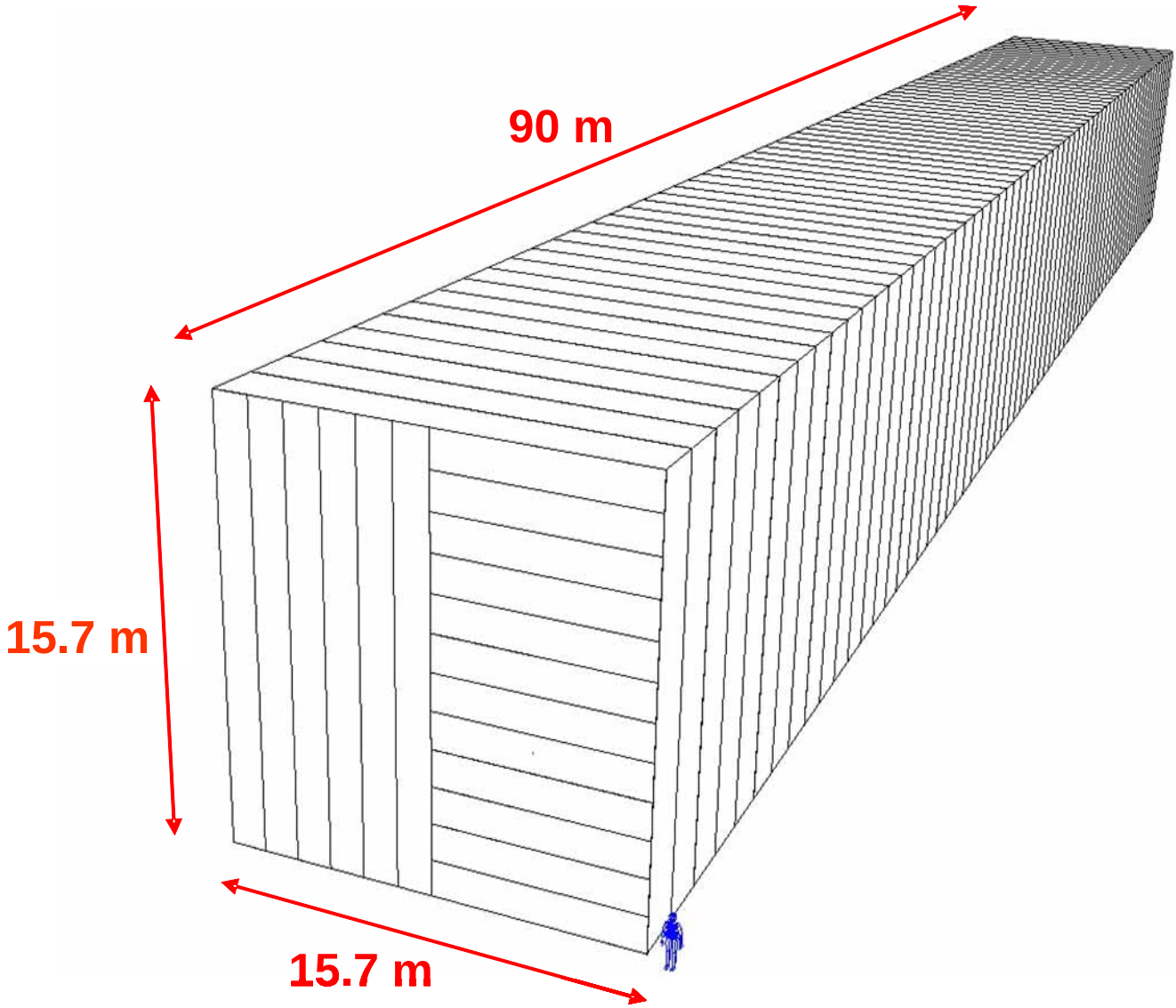

Figure 3.16: Overview of the NOvA Far Detector Structure. The figure shows one-half of the first vertical plane cut away to view the second horizontal plane of extrusion modules. The detector has a total of 1302 planes, each with 12 extrusion modules. Note the person in the lower right corner for scale.

20kT Detector Summary	Quantity	Units
Number of Planes of PVC Extrusions	1,302	planes
Number of 32 Cell Extrusion modules	15,624	extrusions
Weight of all Filled PVC Extrusions	19,853,835 (43,770,222)	kg (lbs)
Weight of all empty PVC Extrusions	5,939,028 (13,093,318)	kg (lbs)
Weight of all Liquid Scintillator	13,914,806 (30,676,902)	kg (lbs)
Volume of all Liquid Scintillator	16,314,699 (4,309,888)	Liters (gallons)
Volume of Liquid Scintillator in one of the primary containment PVC modules	1045 (276)	Liters (gallons)

Table 3.5: Summary of Far Detector parameters.

3.2.2.1 Detector Assembly at Ash River.

PVC extrusion modules would be assembled elsewhere by NOvA collaborators, and trucked to the Far Detector site in approximately 650 separate truck loads. Since these PVC modules serve as primary containment vessels for the liquid scintillator, each module is leak tested after initial assembly and again at Ash River after the truck journey. Each primary containment PVC module holds 276 gallons of liquid scintillator.

The modules are then assembled into blocks of 31 alternating horizontal and vertical planes with 12 modules per plane. Each plane is attached to the previous plane with Devcon-60 Plastic welder, a methyl methacrylate (MMA) based adhesive which requires appropriate ventilation of MMA vapors. The chemical components of Devcon-60 are listed in Table 3.2 on page 16.

Approximately 168 tons (42,000 gallons) of Devcon-60 Plastic Welder would be used at Ash River spread over an assembly period of several years. This amount of MMA requires careful attention to ventilation details, so a specially ventilated "adhesive booth" on the loading dock in Figure 3.14 would contain the machine which applies 2.7 gallons (~ 22 pounds) of adhesive to each module during a 10 minute period. Filtering of outgoing air may also be done adjacent to the building.

The 31 plane blocks are assembled horizontally on a table in the Assembly area shown in Figure 3.14. The Assembly area also has a separate special ventilation system for MMA

vapors which persist during a 30 minute cure period. A device known as the "block pivoter" conveys the assembled block through the Detector Area shown in Figure 3.14 and then rotates the horizontal table and its 31 plane block into the vertical position so that the block can be attached to the previous blocks. The block pivoter looks like a giant fork-lift.

3.2.2.2 Filling the Detector with Liquid Scintillator.

The Far Detector would be filled with 4,310,000 gallons of liquid scintillator as the last step of the assembly process. As construction of blocks proceeds, blocks are filled while additional blocks are being assembled.

The liquid would be delivered to the Ash River site in 7,000 gallon tanker trucks. Approximately 615 separate tanker truck loads (about 15 tankers per 31 plane block) are required over a period of several years. The liquid scintillator distribution system would be designed to accept liquid scintillator from inbound tankers at a rate of one tanker per day. The delivery system would include components that ensure that filling of the PVC Modules is done at a precisely controlled flow rate. During fill, a large volume of vapor would be displaced from the extrusions and would be returned from the modules back to the tankers. Spill control plans, counter measure materials, PPE and working procedures would be developed for each process that involves work with the blended liquid scintillator.

3.2.3 Operations at Ash River

Operations at the proposed Far Detector site would be under the oversight of the University of Minnesota as part of a D.O.E. Cooperative Agreement and comply with the safety requirements of the University of Minnesota. The University of Minnesota is strongly committed to insuring the safety and health of the NOvA Far Detector Laboratory for its staff, visiting scientists and students and members of the general public. The University would identify and mitigate all issues associated with the site and building. The site would have a designated Safety Officer who would be trained and prepared to deal with ES&H issues. Special training would be available for local first responders, including local fire and ambulance crews, as well as possible mutual aid agreements with the Minnesota Department of Natural Resources and the National Park Service.

Propane would be the fuel source for heating the building and powering backup generators in the event of the loss of electricity at the proposed site.

3.2.4 Decommissioning / Disposal at Ash River

The operations of the facility at the proposed NOvA Far Detector, as part of the Fermilab Neutrino experimental program, would cease with the decommissioning of the NOvA experiment. It is possible that this facility would continue to be used for other experiments not associated with the operation of the Fermilab accelerators.

When the proposed NOvA facility at Ash River is decommissioned, the experimental apparatus would be disassembled. The components would be reused, shipped to other laboratories for use, or made available as surplus equipment according to standard procedures for disposition of United States Government properties. The PVC modules would be drained and disposed of as normal waste. The liquid scintillator could be used as an alternative fuel for incineration plants. Information necessary for eventual decommissioning of the NOvA experiments would be collected, documented, and retained for future reference. This information would include the details of the design, the history of operation, and records of environmental monitoring.

At the end of the NOvA detector decommissioning, the building at Ash River would continue to be the property of the University of Minnesota under the terms of the Cooperative Agreement.

3.3 Alternatives Considered

3.3.1 Fermilab Sites

3.3.1.1 Near Detector Sites

Locating the proposed NOvA Near Detector at location 2.5 km from the NuMI target was considered. At a 2.5 km site, NOvA would be sited within the Fermilab boundaries along the NuMI beamline but at a much greater depth then in the existing NuMI. A Near Detector at 2.5 km from the NuMI target has a slightly different mass requirement. Since the neutrino flux falls roughly as the inverse of the distance squared, the volume of the detector would need to be 2.5 times as large to get the same number of events as a 212 ton detector at 1 km. This means the volume at 2.5 km would be 700 tons and cost 2.5 times as much.

This alternative would require substantial additional investigation, and the potential environmental effects would be greater because of the additional construction required for a new experimental hall more than 450 feet underground and other key infrastructure services. The potential environmental hazards would also be larger due to the larger volume of liquid scintillator required. The cost of building this new site with proper containment would be prohibitively high.

Because of the construction cost and the possible environmental effects the alternative site is not considered reasonable, and therefore dismissed from further analysis.

3.3.1.2 Blending Facility

NOvA management is seriously investigating the feasibility of using an offsite vendor for the blending of the Liquid Scintillator. Such "Toll Blenders" exist and are used to blending crude oil products but typically do not blend other additives like the NOvA waveshifters.

This alternative would offer an apparent advantage for environmental effects since Toll Blenders are already cognizant of containment issues and typically have their entire operations within a huge containment area. Toll Blenders in the Chicago area are being investigated so that the crucial Quality Assurance issues in this blending can be addressed by Fermilab personnel just like they would be if the blending were on the Fermilab site.

3.3.1.3 PVC Module Assembly at Fermilab

Different adhesives are still being considered for attaching two 16 cell extrusions together to form a 32 cell extrusion. The MMA vapors associated with the Devcon-60 Plastic Welder product drive this investigation. The adhesive used in this particular application for NOvA is not related to the integrity of the final structure at Ash River and need only withstand forces seen in handling and transportation. A less volatile two part epoxy like 3M-2216 or DP-190 might be sufficient for this task, however these adhesives are much weaker than Devcon-60 in peel strength and peel is the critical parameter dealing with handling forces.

3.3.2 Ash River Sites

The scientific performance requirements dictate a long baseline between Fermilab and the Far Detector site, so sites from Lake Superior into Canada were considered. Figure 3.17 shows the area of possible sites explored along the existing NuMI beamline.

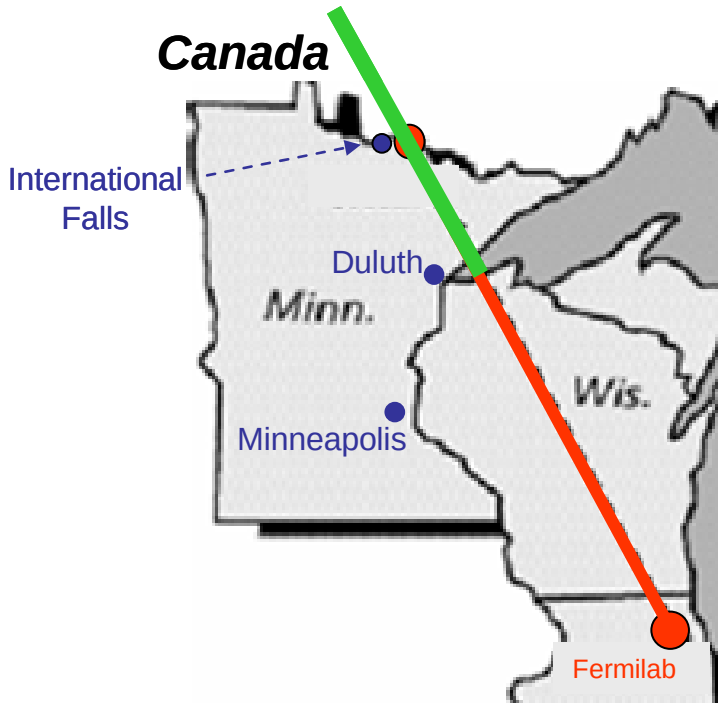

Figure 3.17: Map of the central United States and Canada showing Fermilab, the NuMI beam, and the area of sites considered for the Far Detector in green.

The criteria used to judge possible sites included:

a) The ability to have the detector as far away from Fermilab as possible;
b) The ability to have a detector ~ 12 km off-axis from the central NuMI neutrino beam;
c) Access to the site by existing roads. Available sites in the green area of Figure 3.17 are limited because there are relatively few east-west all-weather roads in the area;
d) Ability to do construction in all seasons on the experimental hall and on the detector;
e) Access to power, telephone lines, and fiber optic data connections;
f) The availability of a relatively flat area for construction;
g) The availability of high ground well above the water table with no wetlands; and
h) The absence of features likely to provoke controversy or litigation. Examples are nearby high population density, nearby national or state parks, and on-site cultural resources like burial mounds or historical site and artifacts.

There are only a handful of choices with all weather roads in this part of the world. The intersections of appropriate all weather roads and the 12 km off-axis line are shown in

Figure 3.18. Seven possible sites were considered: on Lake Superior, at an inactive surface mine at Cliffs-Erie in Minnesota, near the MINOS underground detector at Peyla, Minnesota, at a site along the Orr- Buyck Road in Minnesota, at Ash River, at a site along Trans-Canada 11 and Ontario 502 in Ontario, Canada, and at a site near Vermilion Bay on Trans-Canada 17. In some cases equivalent sites are available on the east side of the NuMI beamline at 12 km off-axis.

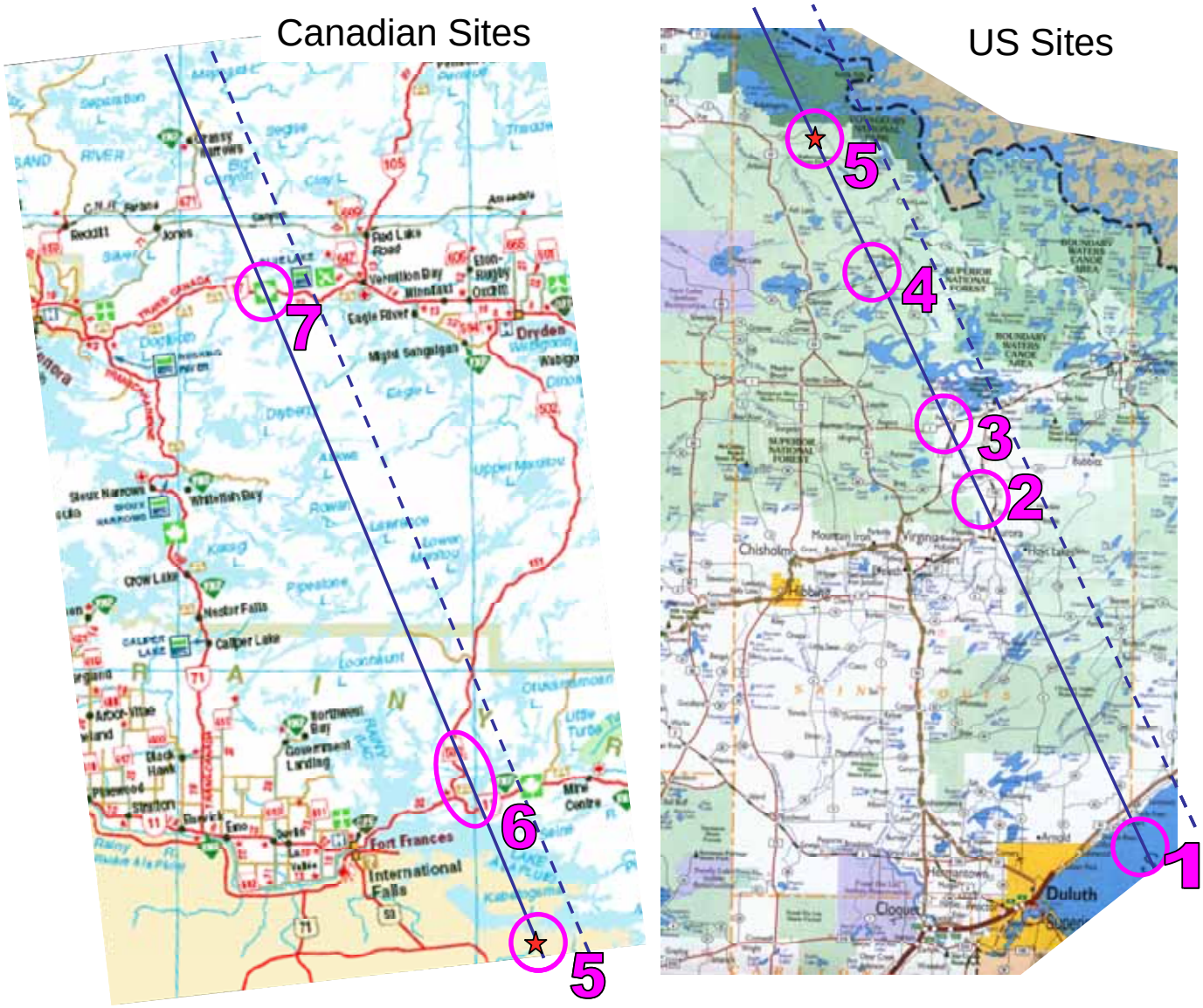

Figure 3.18: Maps showing alternate Far Detector sites in Canada (left) and the United States (right). From south to north, the US sites are 1) Lake Superior, 2) Cliffs-Erie, 3) Peyla, 4) Orr-Buyck, and 5) Ash River, with all sites in Minnesota. From south to north, the Canadian sites are 6) Fort Frances-Mine Center, Ontario and 7) Vermilion Bay, Ontario. The NuMI beam centerline is shown as the dashed blue line and the 12 km Off-axis line is the solid blue line. The Ash River site is marked with a red star on both maps.

A discussion of the various sites from north to south follows since the longest distance from Fermilab is the predominant scientific consideration. Site 7 at Vermilion Bay is ruled out because the NuMI beam at that site is 15.6 km in the air and thus the second

requirement to be 12 km off-axis cannot be satisfied. Site 6 at Fort Francis / Mine Center is ruled out because of the lack of Canadian participation in the project. Managing a U.S. project in Canada would be politically complicated without involved Canadian scientific personnel. Site 5 is the selected site at Ash River and is unique because it is at the farthest distance from Fermilab while still inside the United States.

Site 4 at Orr-Buyck was seriously considered by NOvA and three separate spots in that area were investigated in detail. In the final analysis, Ash River is superior to Orr-Buyck since a detector at Orr-Buyck would require 40% more mass than a detector at Ash River to accomplish the same science. At a cost per kiloton of ~ $ 7.5 million, the Orr-Buyck site would cost ~ $ 60 million more than a scientifically equivalent detector at Ash River. The Orr-Buyck site does not have any superior environmental characteristics over Ash River, so the increased cost cannot be justified on environmental grounds. In addition the environmental impacts of a 40% larger detector at any site would be larger for any impacts that scale with mass.

Site 3 at Peyla and Site 2 at Cliffs-Erie also have shorter distances from Fermilab and are even more inferior to Ash River than the Orr-Buyck site. Sites 3 and 2 have no particular environmental advantages over Ash River and would require much larger detectors with a larger potential for environmental impacts. Site 1 in Lake Superior was only investigated for an alternate detector technology that could be underwater. In addition to having the shortest distance of all from Fermilab, any underwater activity in Lake Superior would be environmentally risky.

3.3.3 Alternate Far and Near Detector Technologies.

The scientific performance requirements demand a robust and efficient detector for electron neutrino interactions at 2 GeV. Other detector technologies including Water Cherenkovs, Low Z (atomic number) sampling Calorimeters with a variety of active elements and passive absorbers, and Liquid Argon Time Projection Chambers (TPC) have been considered. This section reviews the alternates from an environmental point of view and discusses the reasons these alternates were not chosen for NOvA. Additional information regarding alternatives based on scientific performance is available in the NOvA Conceptual Design Report [1].

3.3.3.1 Water Cherenkov Detectors

The NOvA Letter of Intent [4] discussed this technology. The concept uses a large water volume viewed by an array of large phototubes looking inward from the surface of the volume. This technology depends on seeing rings of Cherenkov light from each track produced in a neutrino interaction. One disadvantage of a single water volume is that a single cosmic ray lights up a fair fraction of the photodetector array on the surface of the volume, making operations of such a detector without a robust cosmic ray shield problematic. A very deep excavation of order 1000 feet would be required. This has environmental concerns in addition to cost implications.

3.3.3.2 Low Z Sampling Calorimeters

The NOvA collaboration considered a wide variety of Low Z sampling Calorimeter alternatives for NOvA [1,6,7]. Sampling calorimeters are similar to the proposed NOvA tracking calorimeter design except that a large fraction of the active scintillator mass is replaced by an inert absorber. The smaller number of active samples reduces the particle tracking information and reduces the energy information available from the calorimeter. Such detectors have an inferior performance relative to the chosen NOvA design and do not eliminate the environment concerns arising from liquid scintillator. Alternate active media such as gas-filled resistive plate chambers were considered. These use a gas mixture of 8% isobutene, 61% tetrafluoroethane and 31% argon and have different environmental concerns in addition to inferior performance.

3.3.3.3 Liquid Argon TPC

Liquid Argon Time Projection Chambers (TPCs) have fine resolution for charged tracks in three dimensions. This resolution promises enormous potential for use in neutrino physics and Liquid Argon TPCs appear to have the greatest efficiency for identifying electron neutrino interactions. However, the largest detector operated to date has only about 500 tons of imaging mass and would need to be scaled up by about a factor of fifteen to be useful in the NuMI beam intensities projected for NOvA. The NOvA collaboration judged this cryogenic technology to require additional R&D beyond the envisioned time scale and this technology was eliminated from consideration. Cryogenic detectors with Liquid Argon would also have additional Occupational Health and Safety concerns than the chosen room temperature liquid scintillator detector design.

3.3.4. Alternate Site and Building Designs at Ash River

Alternate building designs were considered by NOvA. Buildings on the surface are cheaper to construct but do not offer the same ease in achieving 100% secondary containment. Alternate access roads from the north avoid the wetland area on the existing logging road off St. Louis County Road 129, but at the expense of being extremely visible from Voyageurs National Park.

Alternate Building designs like the one shown in Figures 3.19 and 3.20 were considered. Compare Figures 3.19 and 3.20 to Figure 3.13. The alternate versions would use more or less granite as the cosmic shield and Figure 3.20 uses a steel truss system to support a granite overburden. Additional granite would require a deeper excavation would have additional safety considerations. Less granite would leave a granite spoils area upon completion and leave an exposed concrete building above grade.

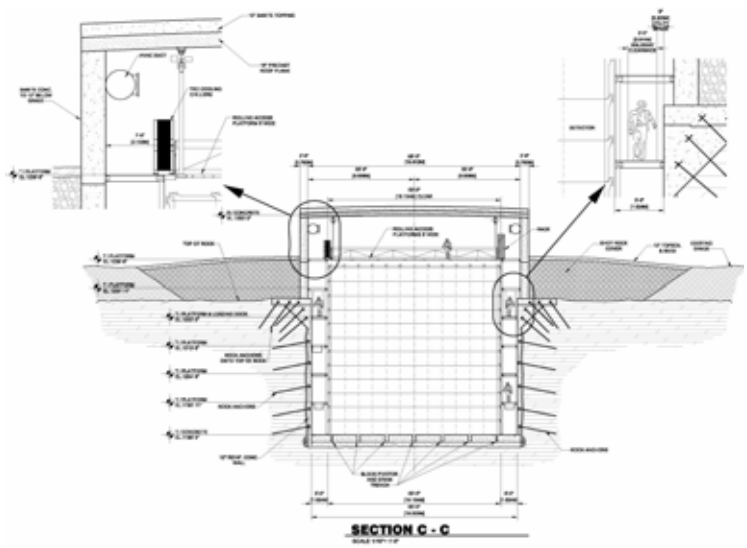

Figure 3.19: An alternate version of the building with a cosmic ray shield constructed of barite loaded concrete walls above grade. This version uses less of the granite spoils.

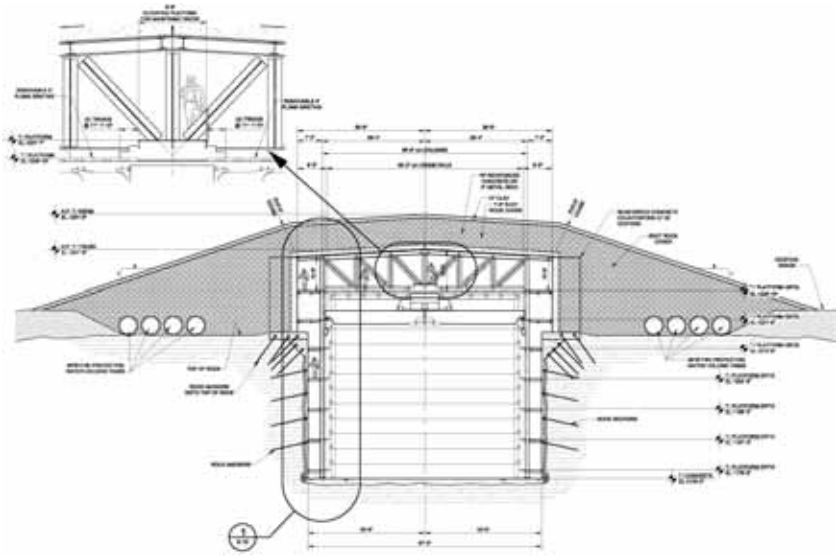

Figure 3.20: Another alternate version of the building with a steel truss roof support and cosmic ray shield constructed of excavated granite spoils.

In contrast, the NOvA design in Figure 3.13 uses the excavated granite to best effect for science and the environment. Granite on the sloped sides makes good use of all the material and still keeps the roof low without deep steel truss supports. Such a design comes closest to restoring the site to its original condition with granite outcroppings. The excavated soil from the building area can be placed back on the sloped sides and allow vegetation restoration as well.

3.3.5 Alternate Adhesive for the Detector Construction at Ash River

The NOvA Project has considered alternate adhesives to Devcon-60 Plastic Welder to avoid the concerns with MMA vapors. Unfortunately all alternative adhesives are weaker than Devcon-60 Plastic Welder in shear strength and in peel strength. NOvA proposes to build a rather unique structure from PVC, a structure that is equivalent to a five story building. Such a unique structure demands a large safety factor in its design and extensive finite element calculations verified by small model tests indicate that alternate two-part epoxies like 3M-2216 are not sufficiently strong. This is a case of weighing one safety concern (MMA vapor) against another (stability of the huge PVC structure). The structure concerns are with the detector for its full lifetime, while the MMA vapor problem is a short-lived one during construction and can be solved with appropriate ventilation.

3.4 No Action Alternative

Under the no action alternative, the scientific goals for the studies of neutrino oscillations would not be achieved in the U.S. in the near future. There is no other known method by which all the topics of particle physics addressed by this experiment can be explored.
There would be no environmental impacts from implementing the no action alternative. This alternative would leave the environment at the Minnesota location essentially unchanged as no other uses for the site are envisioned at this time.

The NOvA scientific goals cannot be met without the Far Detector at Ash River and the Near Detector at Fermilab. However, one no action alternative considered was to forego building the Integration Prototype Near Detector (IPND). This alternative would not provide NOvA with the opportunity to study structural properties, to test mitigation techniques for environmental impacts at a small scale, to improve assembly procedures, and to perform time and motion studies. Consequently, the alternative not to build a prototype has been rejected.

4. Affected Environment

4.1 Fermilab Site

The Fermilab site is located 38 miles (61 kilometers) west of downtown Chicago, Illinois. Its 6800 acres (2750 hectares) straddle the boundary between eastern Kane and western DuPage counties in an area of mixed residential, commercial, and agricultural land use. Immediately to the east is the town of Warrenville (13,363 population), to the west is Batavia (23,866 population), to the north is West Chicago (23,469 population), and to the south is Aurora (142,990 population). Figure 4.1 shows the location of Fermilab and the surrounding communities.

Figure 4.1: Fermilab and the surrounding communities.

Since the spring of 2005, the NuMI facility at Fermilab has been in operation for the MINOS experiment. An environmental assessment [8] performed for the NuMI facility led to a DOE Finding of No Significant Impact (FONSI) [9] for NuMI operations up to 400 kilowatts (kW) of beam power delivered on target. This section of document gives an assessment of the Fermilab environment including the effects of current operations with the NuMI beamline for the MINOS experiment at a beam power of approximately 300 kW. This includes an assessment of the air, surface water, groundwater, and occupational safety conditions.

4.1.1 Air Quality at Fermilab

The climate of the area is continental, with cold winters and hot humid summers. There are frequent short period fluctuations in temperature, humidity, and wind speed and direction. The predominant wind direction is generally westerly with the wind direction from the southwest quadrant occurring with a frequency of almost 50 per cent. The average wind velocity is typically 3 meters per second (6.7 miles per hour). The average annual precipitation at Fermilab ranges from 76 to 89 centimeters (30 to 35 inches), with roughly two-thirds of the total falling in the period from April 1 to September 30, often in the form of heavy showers and thunderstorms. The relatively flat topography does not significantly affect air flow over or near the site. The Fermilab site is within an ozone-nonattainment area where there are lower thresholds for air emissions of volatile organic compounds and nitrogen oxides. Fermilab has an Air Pollution Permit that regulates these and other emissions from onsite fuel combustion sources, vapor degreasing operations, and a fuel dispensing facility, in addition to radionuclide emissions from beamline ventilation stacks and a magnet debonding oven.

Tritium and other short lived radionuclides are also produced as a normal by-product of NuMI operations. The airborne radionuclides produced in the NuMI facility are released into the atmosphere through vent stacks to the surface of the Fermilab site. Environmental emissions are limited by minimizing the ventilation of the tunnels during beam operations. Ventilation is maximized for personnel access; however, by allowing sufficient time for decay after beam shutdown, and before accessing, air emissions are still limited. Air from the ventilation stacks is monitored for radionuclide emissions.

The total activity of typical releases from Fermilab (sitewide) in recent history and the estimated maximum dose rate at the site boundary from these releases is summarized in Table 4.1. This dose rate at the site boundary is assessed for a hypothetical member of the public who would spend the entire year at the location of maximum exposure at the Fermilab site boundary. Total releases are reported annually to the IEPA and the U.S. Environmental Protection Agency (EPA) in accordance with conditions of the relevant NESHAP permit [2].

The operations of the NuMI facility for the MINOS experiment have not caused Fermilab to approach the regulatory limits for total activity releases or for the dose limit at the site boundary.

Source of Radionuclide Air Emissions	Annual Release of Radionuclides	Estimated Maximum Dose at Site Boundary
Fermilab Accelerators (Excluding NuMI)	30 Curies/year	0.02 mrem/year
NuMI Air Ventilation (Short Lived Radionuclides †)	20 Curies/year	0.01 mrem/year
NuMI Tritiated Water Vapor	10 Curies/year	0.0002 mrem/year
Fermilab Site Wide Total	**60 Curies/year**	**0.03 mrem/year**
Regulatory Limits	**2,000 Curies/year (NESHAP Permit [2])**	**10 mrem/year (40 CFR 61 [10])**

† The principal radionuclides typically measured to be present include carbon-11, oxygen-15, nitrogen-13, and argon-41 (half-lives from 2 minutes to 1.8 hours).

Table 4.1: Estimated maximum release of radionuclide air emissions and estimated maximum dose at the Fermilab site boundary during operations of NuMI at 400 kW of beam power for the MINOS experiment.

4.1.2 Ground Water at Fermilab

Groundwater flow in the glacial deposits is generally downward and slow and the water table fluctuates seasonally between 1.5 - 4.6 m (5 and 15 feet) below the ground surface. Water moving through the glacial deposits recharges the underlying Silurian Dolomite aquifer which the Illinois Environmental Protection Agency (IEPA) has classified as a Class I groundwater aquifer.

Below the Silurian Bedrock is the Ordovician-age Maquoketa Shale Group which serves as a low permeability aquitard that confines deeper aquifers. This barrier isolates the groundwater in the vicinity of the NuMI tunnel from the deeper aquifers.

The hydrogeology of the Fermilab site along with the NuMI tunnel construction ensures that groundwater in the vicinity of the NuMI facility would continuously flow into the NuMI tunnel. This is illustrated in Figure 4.2. Therefore, any radionuclides that would be produced in the water in the immediate vicinity of the NuMI tunnel would not flow away from the tunnel. The groundwater that would flow into the tunnel would be collected and continuously pumped to the surface where it would be considered surface water. This water would not be used as a drinking water supply.

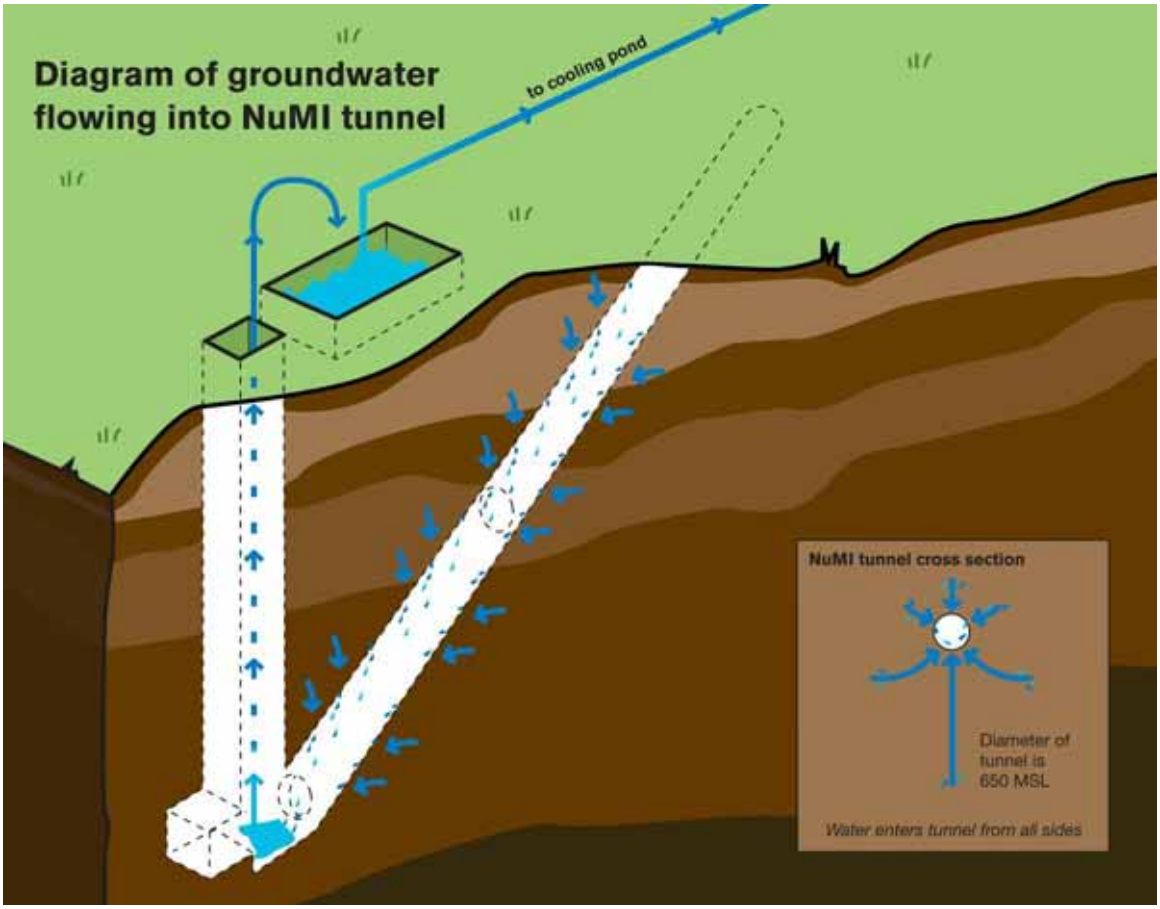

Figure 4.2: Diagram of Groundwater Flowing into the NuMI Tunnel. The NuMI tunnel is 650 feet below mean sea level (MSL)

4.1.3 Surface Water at Fermilab

There are three watersheds that collect water on site. Surface water on the Fermilab site is retained in ponds and is moved across watersheds for use in the industrial cooling water (ICW) system. Surface water runoff in the southeast is into Ferry Creek. The northern part of the site drains to Kress Creek. These two creeks drain to the West Branch of the DuPage River. Surface drainage in the west and southwest is to Indian Creek and the Fox River.

There is an inward flow of water toward the NuMI tunnel from the surrounding dolomite of about 170 gallons (650 liters) per minute. The water flowing into the tunnel is collected in a drainage system and pumped continuously to the surface where it is introduced into the ICW system. The water pumped from the NuMI tunnel can be radioactive with the radionuclides of primary concern being tritium and sodium-22.

The water in the NuMI tunnel and the water in the ICW ponds are subject to DOE standards for surface water as documented in the FRCM [4]. The hazard associated with the surface waters is ranked by comparing the concentration with the Derived

Concentration Guide's (DCG) values as shown in Table 4.2 and Table 4.3. To meet the requirements for surface water the sum of the fractions of radionuclide concentrations, relative to the standards, must remain below 1.

Since the initiation of experiments in the NuMI facility, several steps have been taken to reduce the amount of tritium in the water discharged from the NuMI tunnel. These mitigation steps resulted in a reduction of the tritium levels in the water pumped from the NuMI tunnel by a factor of about 7. All of the measured concentrations are well below the regulatory limit for surface water.

	Tritium Levels (NuMI Discharge Water)	**Tritium Levels (ICW Pond Water)**
NuMI/MINOS Present operations	5-8 pCi/ml †	1 pCi/ml
DOE Regulatory Limits for Surface Water (DCGs)	2,000 pCi/ml	2,000 pCi/ml

† Due to daily fluctuations in the NuMI operating conditions, the tritium concentration in the NuMI discharge water ranges from 5 to 8 pCi/ml.

Table 4.2: Measured concentrations of tritium in the NuMI discharge water and Fermilab ICW ponds during NuMI operations for the MINOS experiment and the DOE regulatory limits.

	Sodium-22 Levels (NuMI Discharge Water)	**Sodium-22 Levels (ICW Pond Water)**
NuMI/MINOS Present operations	< 0.03 pCi/ml *	< 0.01 pCi/ ml *
DOE Regulatory Limits for Surface Water (DCGs)	10 pCi/ml	10 pCi/ml

- No sodium-22 was measured in the NuMI discharge water at the detectable limit of 0.03 pCi/ml. Therefore the sodium-22 concentrations are upper limits.

Table 4.3: Measured concentrations of sodium-22 in the NuMI discharge water and Fermilab ICW ponds during NuMI operations for the MINOS experiment and the DOE regulatory limits.

4.1.4 Biological Overview of Fermilab

Most of the land that Fermilab now occupies was actively farmed prior to the existence of Fermilab. Approximately 1600 acres has remained in crop production, primarily corn. About 1000 acres has, to date, been planted in native prairie vegetation.

The biotic communities within Fermilab include upland forests, oak savannas, prairie remnant, reconstructed prairie, non-native grasslands, old fields, pastures, turfgrass lawns, fence rows, row-crop fields, and various types of wetlands. A mesic upland forest, about 69 acres in size, has bur oak as the dominant canopy tree with other common species including red oak, sugar maple, white ash, swamp white oak, hop hornbeam, basswood, hawthorn, black cherry, bitternut hickory, and box elder. Wetlands include persistent emergent palustrine wetlands, palustrine forested wetlands along the flood plain of Indian Creek, and small palustrine scrub-shrub wetlands.

The mixture of vegetation communities, open fields, deciduous forests, restored prairie, wetlands, and mowed areas, coupled with a large degree of protection from human intrusion, makes the Fermilab site a desirable refuge for many species of animals. It attracts many birds and mammals that are characteristically found in open fields, forests, and forest-edge communities. In addition, many bird species use the site as a stopover during spring and fall migration. The U. S. Fish and Wildlife Service has been consulted to determine if the potential exists for the presence of Federal endangered or threatened species within the NOvA experimental area on the Fermilab site. The Illinois Department of Natural resources has also been consulted to determine if the potential exists for the presence of State endangered or threatened species within the NOvA experimental area. The conclusion of this process was that there are no endangered or threatened species in the area of the NOvA experiment at Fermilab.

Various types of wetland communities also exist around the Fermilab site. The wetland types at Fermilab include primarily palustrine emergent, forested, scrub-shrub and unconsolidated bottom varieties, lacustrine limnetic and littoral wetlands and riverine intermittent wetlands. The wetlands exist along the creek banks and in the area surrounded by the Main Ring ponds.

4.1.5 Cultural and Historical Overview of Fermilab

Fermilab has conducted comprehensive surveys for prehistoric and historic sites within its boundaries (Lurie, 1990, Bird, 1991, Schaffer, 1993). No archaeological or historical resources were found in the areas that would be disturbed during construction activities.

4.1.6 Socioeconomics / Demographics at Fermilab

Fermilab lies in western DuPage county and eastern Kane County, the western most of the six collar counties around Chicago. The populations of DuPage and Kane Counties are growing rapidly. DuPage County is largely urbanized, although considerable development is still occurring in the western part. DuPage population, currently about 930,000, is expected to be about 985,000 by the year 2010. The eastern part of Kane county is the rapidly developing edge of urbanization which is moving out from the Chicago metropolitan area. The central and western parts of Kane County are mostly agricultural with a few cities, housing developments, and villages dotting the country side. Kane County population, now about 480,000, is expected to increase more than 20% by the year 2010.

The Fermilab site has approximately 2000 employees, and 1400 experimenters from all over the world who use the facilities. Most of the employees are located in a large office building, Wilson Hall, approximately 1.6 km (1 mile) east of the proposed NOvA site. Approximately one hundred experimenters would work on the proposed NOvA experiment, principally at Wilson Hall on the Fermilab site. The overall number of scientists who conduct research at Fermilab is not anticipated to change significantly from present levels. On an annual basis, the Laboratory typically has approximately 50,000 day visitors who visit Wilson Hall to attend cultural activities, to take self-guided tours, to participate in activities at Fermilab's science education center, and to conduct business with the Laboratory. The closest residences to the proposed NOvA experiment are approximately one km from the proposed site.

Operation of the Fermilab Accelerators and associated beamlines produce ionizing radiation such as muons. Beamlines and experiments are designed so that most of the muons remain under the ground surface; however some remain above the surface and present a small potential for radiation dose. Annual doses to members of the public are limited to 100 microSieverts (10 mrem/year) due to Fermilab operations.

4.1.7 Occupational Health and Safety at Fermilab

Over a 5-year period from 2001 to 2005, the total recordable cases of injuries and illnesses at FNAL averaged 1.5 cases per 200,000 worker hours (DOE 2006). This rate is lower than the average incidence rate for DOE sites (1.9 cases per 200,000 worker hours). For comparative purposes, the DOE average incidence rates were well below the Bureau of Labor Statistics rates for U.S. private industry of 5.4 cases per 200,000 worker hours during the 5-year period from 2000 to 2004 (most recent data available) (DOE 2006).

The DOE Office of Environment, Safety and Health reports occupational radiation exposure data for monitored DOE and contractor employees. In 2005, approximately 1600 Fermilab workers were monitored for occupational radiation exposure. Of that number, 426 workers had measurable dose equivalents. The average measurable dose equivalent was 38 mrem, and the maximum dose received by any worker was 280 mrem. The Fermilab Total Effective Dose Equivalent (TEDE), which is an indicator of the overall workforce radiation exposure, was about 16 person-rem. For perspective, the 426 individuals with measurable does equivalents would have received about 153 person-rem from background radiation sources during 2005.

4.1.8 Geological Resources at Fermilab

The Fermilab NuMI tunnel resides within three major geologic units: Quaternary (Glacial Till), Silurian, and Upper Ordovician. The subsurface characteristics in the vicinity of the NuMI tunnel on the Fermilab site have been documented in a number of reports [11, 12, 13, 14, 15]. Figure 4.3 shows a view of the major geological layers beneath the Fermilab surface.

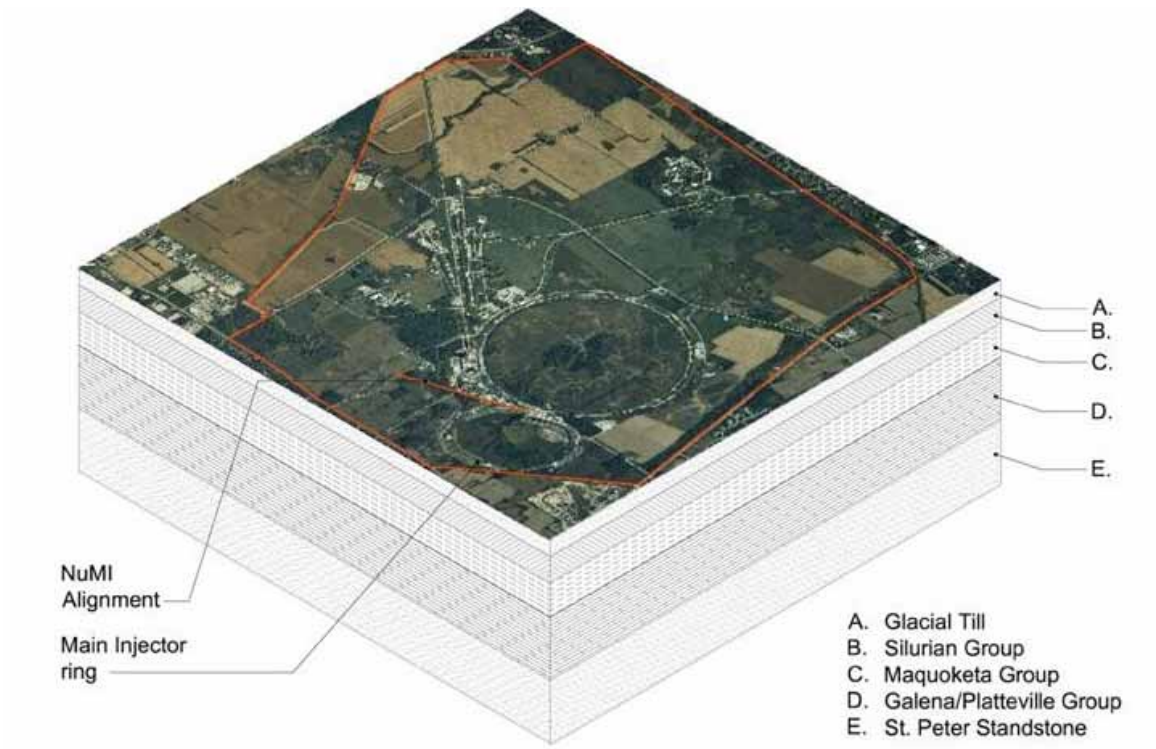

Figure 4.3: View of the Fermilab site showing the underlying geological layers. The NuMI tunnel exists in the Glacial Till, Silurian Group, and Maquoketa Group, but does not extend into the Galena/Platteville Group or the St. Peter Sandstone.

The upper geology at Fermilab consists of glacial deposits (Glacial Till) from the Wisconsin Episode of glaciation overlying bedrock of Silurian-age dolomite. Glacial Till starts at ground level, approximately 740 ft mean sea level (MSL), and goes to approximately 660 ft MSL. The glacial deposits are predominantly subglacial and ice-marginal deposits, mainly fine to medium grained, massive, and are composed of a silty clay matrix with varied amounts of non- to poorly- sorted, coarse gravel.

Below the Glacial Till is the Silurian Group consisting of Silurian-age dolomite which extends between about 615 ft MSL and 400 ft feet MSL. The Silurian Group is divided into the Joliet, Kankakee, Elwood, and Wilhelmi formations. The fractured rock in this region consists of dolostones (dolomite and limestone) with some shale. The fractures allow rapid water transport into unlined tunnels or wells. The interface region between the Glacial Till and Dolomitic Rock is an extremely variable region. This region is not considered stable for tunnel construction so the portion of the NuMI tunnel in this region is lined.

The Upper Ordovician System underlies the Silurian Group and contains the Maquoketa Group (shale), the Galena/Platteville Group (Dolomite) and the St. Peter Sandstone. Regional references indicate that the Maquoketa Group shale, in combination with the upper Galena-Platteville dolomite, functions as a confining layer for the underlying Cambrian-Ordovician sandstone aquifer. The NuMI tunnel exists in the Glacial Till,

Silurian Group, and Maquoketa Group. The tunnel does not extend into the Galena/Platteville Group or the St. Peter Sandstone except for an approximately 18 ft deep sump pit in the Galena/Platteville group near the bottom of the NuMI tunnel.

4.2 Ash River Site

4.2.1 Air Quality at Ash River

The air quality in the Ash River area is rated as good. Measurements of the air quality index in the area listed 257 days with ratings less than a 50, which is categorized as good. The air quality index ranges from 0 to 500. [16] The higher the air quality index value, the greater the level of air pollution and the greater the health concerns. St. Louis County in Minnesota continues to meet all federal ambient air quality standards.

4.2.2 Ground Water at Ash River

Groundwater elevations were found to be approximately 2.5 feet below the surface. Given the lack of weathering in the bedrock at the site, it is possible that water infiltrating through the upper soil deposits perches on top of the bedrock. The direction of groundwater movement likely follows the slope of the bedrock at the site.

Additional information applicable to ground water can be found the Minnesota EAW Sections 13, 18 and 19.

4.2.3 Surface Water at Ash River

The Ash River site is currently undeveloped and surface water would follow the natural contours of the lands to the south. The surface water conditions at the proposed Ash River site are described in the Minnesota EWA Sections 12, 14 and 17.

4.2.4 Biological Overview of Ash River

The proposed Ash River site is undeveloped woodland that has been previously used for logging. The Minnesota EWA describes the area in Section 9, the types of cover in section 10, and wildlife and ecological conditions in Section 11.

4.2.5 Cultural and Historical Overview of Ash River

The proposed Ash River site contains no cultural or historic sites. This is further explained in Section 25 of the Minnesota EAW.

4.2.6 Socioeconomics / Demographics at Ash River

The proposed Ash River site is in remote area of Northeastern Minnesota. The population density is 1 person per square mile. [17] Approximately 35 workers would be needed at the site during construction and only eight people would be needed for operations.

4.2.7 Occupational Health and Safety at Ash River

The proposed site is undeveloped. Therefore, there is no affected occupation health and safety environment to describe.

4.2.8 Geological Resources at Ash River

This area of northern Minnesota is characterized by thin glacial deposits overlying PreCambrian shield rocks. The PreCambrian shield rock is known as the Canadian Shield and is the exposed surface rock of the North American Craton . The elastic thickness of this rock is many kilometers [18]. The area is geological extremely stable and is ranked as an earthquake zone zero. Figure 4.4 shows the bedrock geology of Minnesota.

Most glacial deposits in this area of northern Minnesota originated from glacial lake deposits and are comprised of silts and clays. Other glacial deposits occur in the area and consist of till deposits originating from glacial end moraines or stagnation moraines, forming pitted to hilly land surfaces. These till deposits of variable thickness are admixtures of sand, silt, clay, gravel and boulders.

Two borings have been made at the proposed Ash River building site to a depth of 60 feet and found 7 – 10 ft of glacial till over solid hard granite to full depth. A packer test was done at one boring and found the granite exhibits no significant fracturing at these depths. In the wetland portion of the proposed access road to NOvA just off St. Louis County 129, the glacial till is much thicker with one boring not reaching bedrock even at 40 ft in depth.. A detailed geotechnical engineering report of the Ash River site is available [19]. Section 19 of the Minnesota EAW discusses the geological environment at the proposed Ash River site.

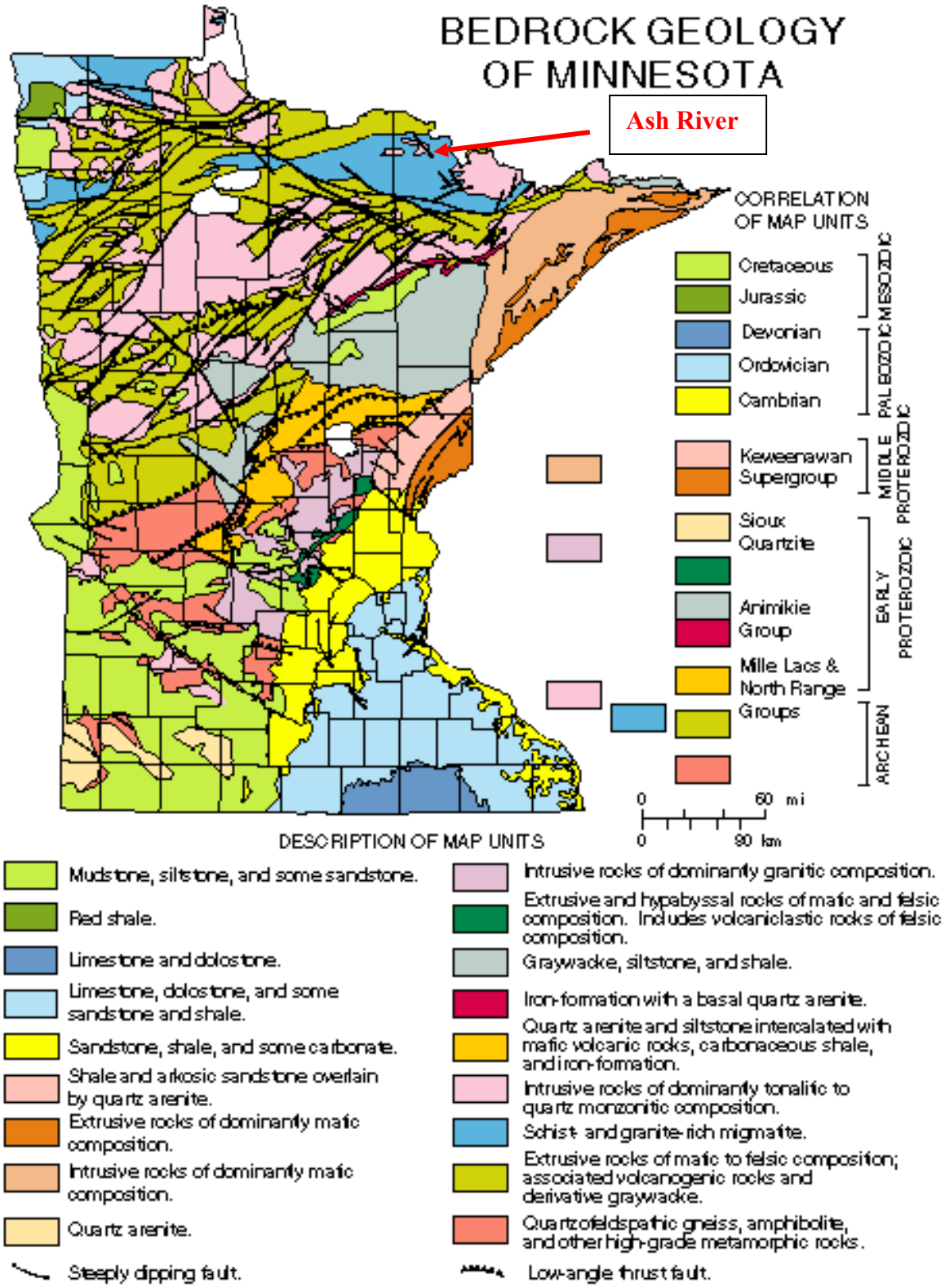

Figure 4.4: Bedrock Geology of Minnesota

5. Potential Environmental Impacts of the Proposed Action

This section describes the anticipated environmental consequences of the four elements of the proposed action: civil construction, assembly, operation, and decommissioning of the proposed action.

The region between Fermilab and the NOvA Far Detector would be unaffected by the civil construction and decommissioning since no excavation connected to the Nova experiment is required in that region.

Because Neutrinos rarely interact with material, they do not activate the material they pass through. Therefore there are no Radiological affects associated with the Ash River, Minnesota site, and the earth in between the near and far detectors.

5.1 Fermilab Site

5.1.1 Construction / Excavation at Fermilab

The areas where construction would take place on the Fermilab site are currently in use or have been previously used for other purposes. The main environmental issues associated with civil construction would be the transportation/traffic associated with moving the rock spoils. The rock spoils created would be moved by truck to an existing Fermilab stockpile. The truck traffic associated with moving the spoils to stockpile(s) would be less than 50 trucks per day. This would not have a significant effect on the environment.

5.1.1.1 Air Quality

During construction there would be minor, short-term, localized impacts on air quality from vehicular traffic and earth-moving operations. To the maximum extent practical, dust would be controlled by established engineering practices, chiefly by water sprinkling of all distributed earth surfaces and earth stockpiles. The technique is one successfully employed in the Chicago area to control dust created during similar operations. Exhaust fumes from construction traffic and internal combustion equipment used at the construction site, should be rapidly dispersed.

The impact of the proposed action would have no significant effect on the environment.

5.1.1.2 Ground Water

The proposed NOvA project would have no impact on ground water at the Fermilab site. No civil construction is planned that would effect ground water levels.

5.1.1.3 Surface Water

The proposed actions would create minimum potential for erosion during construction of the liquid scintillator blending facility. No major impacts to the environment are expected.

5.1.1.4 Occupational / Human Health and Safety

Fermilab employees, visitors and experimenters, and members of the public would not be impacted by the construction or operation of the NOvA experiment.

5.1.2 Fermilab Installation and Assembly

5.1.2.1 Air Quality

The greatest potential impact to air quality is the possible release of pure pseudocumene vapors, which represents 5% of the liquid scintillator that NOvA proposes to blend at Fermilab. The pseudocumene is noxious to inhale, an irritant for the eyes and skin, and may cause irritation if ingested. This impact is being mitigated by providing closed loop blending system including tanker trucks to minimizing the release of fugitive fumes. This along with specific training and minimizing open containers would mitigate the release of vapors into the atmosphere. The other chemicals used in the liquid scintillator (Table 3.2) have the potential for affecting air quality if the vapors exceed the permissible limits specified on the material safety data sheets. The proposed engineering and administrative controls would minimize the impact.

The method for combining the PVC extrusions could impact air quality. The adhesive chosen, Devcon-60, contains Methyl Methacrylate and has the potential for affecting air quality if the vapors exceed the permissible limits specified on the material safety data sheet. The adhesive would be used, maintained, and wastes disposed of in accordance with manufacturer recommendations and requirements.

The impact of the proposed action at Fermilab is anticipated to approach or even exceed the permitted limitations. An updated permit would be required.

5.1.2.2 Ground Water

Ground water would not be affected by the installation and assembly of the NOvA Near Detector. The Near Detector would have 100 % secondary containment.

5.1.2.3 Surface Water

The greatest potential of affecting the water resources at Fermilab during installation would be a spill of pure pseudocumene or the blended liquid scintillator. These chemicals could have a negative impact on aquatic life. Because of the engineering controls, limiting the quantities of liquids handled and the decision that there would be 100 % secondary containment at all work sites the environmental impact to surface water would be minimal.

5.1.2.4 Occupational Health and Safety

The greatest potential of affecting occupational health and safety during installation and assembly would be the injury to workers or damage to equipment. Based on the proposed actions the impacts would be minor.

Methyl Methacrylate (MMA) Monomer and other Devcon-60 components can cause moderate eye irritation, can cause skin irritation and sensitization, and is a respiratory

tract irritant. Ingestion causes irritation, a burning sensation, and abdominal pain. The proposed ventilation controls for the project would keep the MMA exposures below the American Conference of Governmental Industioal Hygienists (ACGIH) time-weighted average (TWA) threshold limit value (TLV) of 50 parts per million (ppm) and also below the short-term exposure limit (STEL) of 100 ppm. Based on the proposed actions the impacts would be minor.

5.1.3 Fermilab Operations

A detailed Fermilab Technical Memo analyzing the radiological releases for operating the NuMI facility during MINOS and NOvA Operations has been written. The titled "An Assessment of Radiological Releases from the NuMI Facility during MINOS and NOvA Operations" [20].

5.1.3.1 Air Quality

Operating the NuMI beamline under NOvA operating conditions would increase the level of radionuclide emissions to the atmosphere. Some of the radionuclide emissions produced by NuMI would become airborne in the form of tritiated water vapor and would continue to enter the atmosphere through three mechanisms: 1) ventilation of air from the NuMI facility, 2) evaporation of tritiated water from the Central Utility Building (CUB), and 3) evaporation from the Fermilab ponds. At the maximum beam intensity with which the NOvA experiment would operate, 1.5 MW of beam power, the total radionuclide air emissions that would be released into the atmosphere through vent stacks to the surface of the Fermilab site is shown in Table 5.1.

	MINOS Present	NOvA 1.5 MW design
Source of Radionuclide Air Emissions	Maximum Release (Curies/yr)	Maximum Release (Curies/yr)
Fermilab Site Wide Total	**60**	**260**
Regulatory Limits (NESHAP Permit [2])	**2,000 Curies/year**	**2,000 Curies/year**

Table 5.1: Maximum release of radionuclide air emissions during the running of NuMI facility under present operating conditions and operating conditions for the NOvA experiments at 1.5 MW of beam power.

The estimated maximum radiation dose rate at the site boundary that would result from these releases is summarized in Table 5.2. This dose rate at the site boundary is assessed for a hypothetical member of the public who would spend the entire year at the location of maximum exposure at the Fermilab site boundary. This would not cause Fermilab to approach either the NESHAP limits [2] for the release of airborne radionuclide or the 40 CFR 61 requirements limiting the dose at the site boundary.

	NOvA 1.5 MW design
Source of Radionuclide Air Emissions	Maximum Dose at Site Boundary (mrem/yr)
Fermilab Site Wide Total	**0.08**
Regulatory Limits (40 CFR 61 [8])	**10**

Table 5.2: Maximum estimated dose rate at the Fermilab site boundary during the operating conditions for the NOvA experiments at 1.5 MW of beam power.

In summary, the effects of radionuclide emissions on workers or members of the public would be minor.

5.1.3.2 Ground Water

Activation levels of ground water from beamline operations would remain below applicable regulatory limits. The result in Table 5.3 indicates that immediately outside the NuMI tunnel the concentrations of radionuclides would be negligible, yet still well within the minimum capture zone of the groundwater flow into the NuMI tunnel.

Type of Operations	Estimated Maximum Tritium Level	Estimated Maximum Sodium-22 Level
NuMI/NOvA 1.5 MW	7 pCi/ml	0.7 pCi/ml
Groundwater Regulatory Limits	**20 pCi/ml**	**0.4 pCi/ml**

Table 5.3: Estimated radionuclide concentrations in the water immediately outside of the NuMI tunnel that would be expected during the running of the NuMI facility under NOvA operating conditions at 1.5 MW of beam power.

Spills of NOvA scintillator from the Near Detector in the MINOS tunnel that might enter the ground water system are controlled by primary and secondary containment systems as described in section 3.1.2.2.

5.1.3.3 Surface Water

The design of the NuMI tunnel ensures that groundwater in its vicinity continuously flows into the tunnel, where it is collected and continuously pumped to the surface cooling ponds. The cooling ponds are underlain with naturally occurring clay, therefore

preventing direct contact of radionuclides such as tritium or sodium-22 produced during the MINOS and NOvA experiments with surface water.

The estimates for the pond water concentration would be conservative because they assume drought conditions. In drought conditions the volume of water in the Fermilab pond system would be reduced resulting in a higher concentration of radionuclides.

Estimates of the tritium and sodium-22 concentration that would result from running NuMI under the NOvA operating conditions are summarized in Tables 5.4 and 5.5. All of these concentrations would be below the regulatory limit for surface water.

Phase	**Tritium Levels (NuMI Sump Water)**	**Tritium Levels (Pond Water)**
NuMI/NOvA	100 - 200 pCi/ml	25 - 50 pCi/ml
DOE Surface Water Regulatory Limits	**2,000 pCi/ml**	**2,000 pCi/ml**

Table 5.4: Estimated concentrations of tritium in the NuMI sump and Fermilab ponds during NuMI operations for the MINOS experiment and for the NOvA experiment at 1.5 MW of beam power.

Phase	**Sodium-22 Levels (NuMI Sump Water)**	**Sodium-22 Levels (Pond Water)**
NuMI/NOvA	< 1.2 pCi/ml	< 0.3 pCi/ml
DOE Surface Water Regulatory Limits	**10 pCi/ml**	**10 pCi/ml**

Table 5.5: Estimated concentrations of sodium-22 in the NuMI sump and Fermilab ponds during present NuMI operations and the estimated maximum concentration levels during NuMI operations for the MINOS experiment and for the NOvA experiment at 1.5 MW of beam power.

Spills of NOvA scintillator from the Integration Prototype Near Detector in the MINOS Service Building that might enter the ground water system are controlled by primary and secondary containment systems as described in sections 3.1.2.2 and 3.1.1.1.

5.1.3.4 Occupational Health and Safety

Occupational health and safety addresses the broad range of workplace hazards from accident prevention to the more insidious hazards including toxic fumes, dust, noise, heat, cold, ergonomic issues and other hazards.

All of the existing NuMI safety features used for the MINOS experiment to create a safe environment for employees, contractors and visitors would be in effect for the NOvA experiment.

The impact on Operational Safety and Health for the NOvA experiment would be minimal.

5.1.4 Other Potential Impacts at Fermilab

5.1.4.1 Socioeconomic Issues

The number of personnel engaged in the NOvA experiment would not alter Fermilab's staffing level beyond the numbers of normal routine fluctuations. The proposed NOvA experiment does not pose any adverse impacts to the general public or surrounding area.

5.1.4.2 Waste Generation and Disposal

Fermilab presently generates approximately 75 cubic meters of regulated chemical waste annually. Approximately 9,000 cubic meters (315,000 cubic feet) of solid wastes, other than regulated chemical wastes are generated annually and disposed of in local sanitary landfills. These wastes are typical of light industrial operations and are disposed of in accordance with DOE, federal, and state regulations. Fermilab has implemented a program to minimize the generation of theses wastes in accordance with the Resource, Conservation, and Recovery Act and the Fermilab Environmental Management System (EMS).

Operation of existing accelerators at Fermilab results in the generation of approximately 70 cubic meters of low level radioactive wastes annually (excluding tritiated water from the NuMI facility.) Operation of the NuMI facility generates approximately 20,000 gallons of tritiated water annually. The tritiated water is solidified in 55 gallon drums and disposed of by shipping off site or is evaporated in accordance with the permissions of the NESHAP permit [2]. Fermilab disposes of the radioactive wastes at a permitted disposal facility outside of the State of Illinois. No waste is disposed on the Fermilab site. All wastes leaving the site for disposal are packaged in accordance with Department of Transportation (DOT) regulations.

The liquid scintillator oil from NOvA would be reused or recycled as an alternative fuel for incineration.

Although the NOvA experiment represents additional activity at Fermilab, the level of new waste generated would not significantly add to the normal waste volume.

5.1.4.3 Utilities at the Fermilab Site

The increase in the Fermilab utility requirements as a result of assembly and operation of the NOvA experiment would not impact the ability of public utilities to supply their other customers. Because NOvA would be reusing magnets and power supplies that are in service now for use in the upgraded beamline no increase in power consumption is

planed. Utilities, including sanitary sewers, natural gas, and drinking water needed for this facility would be provided by the services already present at Fermilab.

The electrical power utilized by NOvA would be similar in magnitude to that presently used in the operation of the Fermilab research program and would not represent a significant additional power requirement.

5.1.4.4 Sensitive Resources

The proposed project would have no impact on any 100 year floodplain as determined by reference to information provided by the Federal Emergency Management Agency (FEMA, 1982).

The impact NuMI beamline on jurisdictional wetlands was analyzed by qualified experts (CTE, 1997). The pathway for the proposed NOvA project beam is identical to NuMI and adds no additional environmental concerns.

No impacts on sensitive resources including floodplains, wetlands, archeological and historic resources, or threatened or endangered species that would result from the proposed NOvA project.

5.1.4.5 Cumulative Impacts at Fermilab

Based on the results of the previous sections the cumulative NOvA impacts at the Fermilab site are projected to be minimal. The potential radiological impacts on the environment and human health and safety present the greatest interest to the public. The proposed actions include mitigations that would ensure that no regulatory limits are exceeded. The Fermilab goal is to go beyond merely satisfying regulatory limits and reduce environmental impacts to as low as reasonably achievable.

5.2 Environmental Impacts at the Ash River Site

5.2.1 Construction / Excavation at Ash River

5.2.1.1 Air Quality

The environmental impacts to air quality at the proposed Ash River Site during construction would be minor, localized and short term. No traffic congestion is anticipated as a result of construction or operation. The proposed action would not generate emissions from boilers or exhaust stacks during its construction. The impacts to air quality at the Ash River site are discussed in Sections 21, 22 and 24 of the Minnesota EAW.

5.2.1.2 Ground Water

The environmental impacts to ground water at the proposed Ash River Site during construction would have minor impacts. The impacts to the ground water are discussed in Sections 13, 19 and 31 of the Minnesota EAW.

5.3.1.3 Surface Water

The environmental impacts to surface water at the proposed Ash River Site during construction would be minor. The impacts to the surface water are discussed in Sections 11, 16, 17 and 31 of the Minnesota EAW.

5.2.1.4 Occupational / Human Health and Safety

There would be no Occupational / Human Health and Safety impacts to the public. There are no near-by facilities to be impacted by construction. Occupational / Human Health and Safety impacts would be limited to the proposed site. Impacts would be minor and only related to those associated with the proposed construction activities. Emergency response at the remote location is discussed in section 3.2.1.2.

5.2.2 Ash River Installation and Assembly

5.2.2.1 Air Quality

Based on the proposed actions there would be no impact on air quality at the Ash River site during installation and assembly. Issues that could impact air quality are discussed in Sections 20, 21, 22, 23 and 24 of the Minnesota EAW.

Note in this DRAFT version: We need to get our EAW consultant S E H to look at the effects of MMA vapors from the projected use of 42,000 pounds of Devcon-60 outlined in section 3.2.2.1 on page 28. Our peak use rate is to coat one extrusion every 10 minutes – this is 16 pounds of adhesive per hour. As of this writing, we believe Devson-60 outgases 2.7% of the weight of applied adhesive during a 30 minute cure period. It is worth noting that the "trade secret" ingredients listed in Table 3.2 contain additives designed to quickly create a skin on any glue surface to limit the MMA vapor. A quick reading of the Minnesota Pollution Control Agency's Hazardous Air Pollutants (HAPs)

page indicates up to 10 tons per year of HAPs can be released without permits. S E H has been asked to confirm these facts and update the EAW. This highlighted section would be removed from this EA assuming the EAW covered the material sufficiently. The adhesive would be used, maintained, and wastes disposed of in accordance with manufacturer recommendations and requirements.

5.2.2.2 Ground Water

The highest probability of affecting the ground water would be from a spill of the liquid scintillator. Based on the proposed actions with 100% secondary containment of all liquid in every stage of the installation, there would be little or no impact to ground water at the Ash River site during installation and assembly.

5.2.2.3 Surface Water

The highest probability of affecting the surface water would be from a spill of the liquid scintillator. Based on the proposed actions with 100% secondary containment of all liquid in every stage of the installation, there would be little or no impact to surface water at the Ash River site during installation and assembly.

The State of Minnesota Pollution Control Agency has given NOvA a written determination that the liquid scintillator to be used in the detector is not considered a hazardous material. [21]

5.2.2.4 Occupational Health and Safety

During installation and assembly the highest probability of impact would be from an injury to an employee or damage of equipment.

Methyl Methacrylate Monomer can cause moderate eye irritation, can cause skin irritation and sensitization, and is a respiratory tract irritant. Ingestion causes irritation, a burning sensation, and abdominal pain. The proposed ventilation controls for the project would keep the exposures below the American Conference of Governmental Industioal Hygienists (ACGIH) time-weighted average (TWA) threshold limit value (TLV) of 50 parts per million (ppm) and also below the short-term exposure limit (STEL) of 100 ppm. Presumably an updated version of the EAW would allow removal of this section.

The proposed action addresses the issue that the project is in a remote location in section 3.2.1.2. There would be low impact to the environment.

Section 20 of the Minnesota EAW addresses waste issues impacting occupational health and safety.

5.2.3 Ash River Operations

5.2.3.1 Air Quality

Based on the proposed actions there would be no impact on air quality at the Ash River site during operation. Sections 21, 22, 23 and 24 of the Minnesota EAW address air quality issues related to operations.

5.2.3.2 Ground Water

Based on the proposed actions there would be no impact on ground water at the Ash River site during operations. Sections 16 and 18 of the Minnesota EAW address ground water issues related to operations.

5.2.3.3 Surface Water

Based on the proposed actions there would be no impact on surface water at the Ash River site during operation. Sections 16 and 18 of the Minnesota EAW address surface water issues related to operations.

5.2.3.4 Occupational Health and Safety

Based on the proposed actions there would be low impact on Occupational Health and Safety at the Ash River site during operations. Section 20 of the Minnesota EAW addresses waste issues impacting occupational health and safety.

5.2.4 Other Potential Impacts at Ash River

5.2.4.1 Socioeconomic Issues

The proposed action would have no negative socioeconomic impacts to the general public or surrounding area at the Ash River site. The site is in a very remote area and has a very low population density.

5.2.4.2 Waste Generation and Disposal

Based on the proposed actions there would be no impact caused by waste generation and disposal at the Ash River site. Section 20 of the Minnesota EAW addresses waste generation and disposal.

5.2.4.3 Utilities at the Ash River Site

There would be no impact on utilities at the Ash River site caused by the proposed actions. Section 28 of the Minnesota EAW addresses utility issues.

5.2.4.4 Sensitive Resources

Based on the proposed actions there would be no impact on the sensitive resources at the Ash River site. Sections 25, 26 and 27 of the Minnesota EAW address sensitive resources.

5.2.4.5 Cumulative Impacts

Noise generated by construction would be cumulative with noise from aircraft, local road traffic in the vicinity of the sites. Together this noise may be a temporary annoyance to

the general population in the area. This is further discussed in Section 24 of the Minnesota EAW.

Potential impacts to land use and visual resources, cultural resources, infrastructure, human health, waste generation, ecological, habitat and socioeconomics when combined with those effects of other actions do not result in cumulatively significant impacts. This is further discussed in Section 29of the Minnesota EAW.

5.3 Cumulative Impacts of the Proposed Actions Considering Both Sites Together

5.3.1 Environmental Justice

The proposed actions are constrained by the nature of the science to have impacts at Fermilab and at Ash River since the two sites are connected by the required NuMI neutrino beam. The proposed actions would not have a disproportionately high or adverse environmental effect on minority and low-income populations. Off property impacts would be minimal and limited to the immediate areas surrounding the sites.

6. Accident Analysis

It is the intent that the technical and scientific goals of the NOvA experiment be achieved in a safe and environmentally sound manner. NOvA management has completed a hazard analysis for the entire proposed action [21]. This document summarizes a variety of potential ES&H hazards and accident scenarios that might be encountered in the construction, installation and operation of the NOvA experiment at both the Ash River and at Fermilab locations. The conclusion is that all major hazards have been identified and can be addressed by the means discussed in the document. A NOvA Safety Assessment Document (SAD) would document the actual procedures and actions taken to achieve the construction, installation and operation of NOvA in compliance with applicable regulations and with Fermilab policy before project construction begins.

6.1 Potential Leaks or Spills

Given the large volume of liquid scintillator in NOvA, its use at Fermilab and Ash River, and the need to transport it from Fermilab to Ash River, this section analyzes scintillator leaks or spills as the highest credible accidents.

NOvA would blend, ship and use approximately 4.3 million gallons of liquid scintillator. The liquid scintillator contains 5% pseudocumene, 95% mineral oil and 1000 ppm of wavelength-shifting fluor. The liquid components for the liquid scintillator would be shipped via tanker trucks holding approximately 7,000 gallons each. The handling of all the tanks containing components and or liquid scintillator has the potential for the occurrence of leaks or spills. These conditions could result in producing environmental hazards, damage to equipment or injury to personnel. The basic precautions taken to prevent such accidents are described below.

1) The <u>passive</u> mitigating measures that would be taken at the Far Detector and Near Detector to limit environmental impacts of a leak or spill are:
   a) All PVC extrusions would be assembled into planes with manifolds and bottom plates. These assemblies would be pressure tested for leaks prior to being assembled into the 31 plane blocks and prior to being filled with scintillator.
   b) Primary containment of liquid scintillator is performed by the PVC extrusions. Subdivision of the detector into parts containing at most 275 gallons of scintillator minimizes the potential for large leaks.
   c) All piping systems for filling the NOvA detectors would be in accordance with NFPA 30, Chapter 5.
   d) 100% Secondary containment would be provided for all areas where liquid scintillator is located.
   e) Smoking or open flames would be prohibited in scintillator areas.

2) The <u>active</u> mitigating measures that would be taken at the Far Detector and Near Detector sites to limit environmental impacts are:
   a) Flow sensors would be built into all filling machines.
   b) Emergency stop buttons would be provided on automated transfer systems.

c) Leak detection and alarms would be provided to monitoring leaks.
d) Material and equipment for management of spills would available at the work site to minimize the volume of any leaks and spills.
e) Sumps and collection systems would be provided as part of secondary containment. At the Fermilab blending site this would address the worst-case scenario by including the volume of 24-hour rainfall as determined by a 25-year storm.
f) Only trained personnel would be permitted to conduct blending and filling operations. A minimum of two full time technicians wouldl participate in blending and filling operations for each shift, each operation, and each location. Under no condition would a technician work alone.
g) Advance scheduling of the liquid scintillator shipments would ensure that shipments arrive only when technicians are present to handle delivery.
h) Administrative procedures and checklists would be developed and used for all scintillator handling operations.
i) Fermilab areas would have independent reviews and subsequently recommendations for permits to perform filling and blending procedures by a Fermilab appointed safety review subcommittee reporting to Fermilab line managment.

The mitigating measures that would be taken for transporting the liquid scintillator between the Near and Far Detector sites to limit environmental impacts are:

a) A transportation company would be chosen that provides proof of having a good safety record.
b) All equipment used to transport the liquid scintillator would be required to meet State and Federal Department of Transportation (DOT) certification requirements.
c) All shipping would be in 7,000-gallon top fill tanker trucks that are DOT approved and meet design code ASME VIII Division 1.
d) The transporter of the mixture would comply with all DOT regulations of placards and labeling, and have all necessary shipping papers.
e) A documentation package would be supplied with each shipment tendered into commerce and would have a DOE "Bill of Lading", MSDS attached, and State Emergency Response Team phone numbers.
f) Each truck would be required to have a satellite phone or equivalent with it during transit.
g) The shipper would be instructed to call 911 or State Emergency Response phone number and have the local jurisdiction take charge in case of an accident.
h) On-scene first responders would secure the bill of lading in the event of any emergency and call 630.840.3414, -24 hours; Fermilab personal would be able to provide First Responders with the information for this particular shipment.

With considerations of the above measures, the hazard classification for both the Fermilab and Ash River areas would be reduced to one of very low risk as the potential for a large leak or spill of liquid scintillator or pseudocumene has been made an unlikely occurrence.

6.2 Credible Accidents

Credible accident scenarios involve a potential leak or spill of liquid scintillator at the Ash River Minnesota Site (Far Detector) or at the Fermilab National Accelerator Sites (Near Detector) or in transit. It is believed that most detector leaks would be small or would be distributed over a long time period. The materials used to absorb liquid scintillator would need to be disposed of as special waste in all cases.

6.2.1 Far Detector

The most probable accident at the Far Detector would involve one full plane of 12 PVC modules. The most probable cause would be from someone dropping a power supply or electronics crate and having it puncture all 12 fiber manifolds (see Figure 3.9) in a plane. This would allow 3,300 gallons of liquid scintillator to leak out. The response to such an accident would be to follow the local spill plan procedure. That plan would instruct people to evacuate the area and call for the emergency response team and wait for further instructions. The 3300 gallons of liquid scintillator would be pumped from the secondary containment sump into a tanker truck. The tanker truck would be stored until a decision is made about final disposition. The damaged PVC plane would be taken out of service and not repaired.

6.2.2 Near Detector

The most probable accident at the Near Detector would involve one PVC plane. The most probable cause would be from someone dropping a power supply or electronics crate and having it puncture a plane of PVC modules. This would allow 150 gallons of liquid scintillator to leak out into the secondary containment. The response to such an accident would be to follow the local spill plan procedure. That plan would instruct people to evacuate the area and call for the emergency response team and wait for further instructions. The 150 gallons of liquid scintillator would be pumped from the secondary containment tank into 55 gallon drums. The drums would be stored until a decision is made about final disposition. The damaged PVC plane would be taken out of service and not repaired.

6.2.3 Blending

The most probable accident at the blending facility would be a small spill caused by a failure of a hose or connector during transfer. The handling of all the tanks containing components and or liquid scintillator has the potential for the occurrence of leaks or spills. Any small leaks would be absorbed by rags or other absorbent materials and disposed of properly. Larger spills would be collected from the secondary containment vessel and stored until a decision is made about final disposition.

6.2.4 Transporting

The most probable accident during transportation would be that a tanker truck had a traffic accident and leaked its entire 7000 gallon load of liquid scintillator into the environment. Approximately 620 tanker trucks would be shipped the 600 miles from Fermilab to Ash River, Minnesota for a total of 372,000 miles. 97% of this transport route is on federal interstate or U.S. highways. The accident rate for shipping non-

hazardous materials by truck is 0.73 accidents per million miles [22]. The statistical expectation of a truck carrying NOvA liquid scintillator being involved in an accident is therefore approximately 0.3 accidents for the entire shipping process.

Should an accident occur, the response plan would include the following steps:

a) The shipper would be instructed to call 911 or State Emergency Response phone number and have the local jurisdiction take charge in case of an accident.
b) On-scene first responders would secure the bill of lading in the event of any emergency and call 630.840.3414, -24 hours; Fermilab personal would be able to provide First Responders with the information for this particular shipment.

6.3 Highest Consequence Credible Accidents

The highest consequence credible accident scenarios involve larger potential leaks or spills of liquid scintillator at the Ash River Minnesota Site (Far Detector) or at the Fermilab National Accelerator Sites (Near Detector) or in transit. Such scenarios are much less likely to occur than the scenarios described in Section 6.2.

6.3.1 Far Detector Highest Consequence Credible Accident and Response

At Ash River 4.3 million gallons of liquid scintillator are held in the Far Detector for a period of years. A leak might occur due to aging failure of the adhesive holding the end manifolds on the PVC extrusions. Extensive aging tests would have been done on these components, so such a failure is unanticipated.

Such a leak would probably happen slowly over a period of 6 to12 months since the failing modules would have been constructed during a similar period. Problems from the earliest assemblies would be expected to occur first, and the original assembly time is expected to take about 3 years. The PVC extrusions at the Far Detector act as 15,624 separate individual primary containment objects, so a failure of about one-third of these modules would release about 1.4 million gallons of scintillator into the secondary containment volume (the building below grade, see Section 3.2.1.2).

The response plan would include the following steps:

a) Call the local emergency response phone number. That would get subject matter experts notified of the problem and local spill plan actions would start as well as appropriate reporting would occur.
b) Power down the Far Detector.
c) The 1.4 million gallons of leaked liquid scintillator held in the secondary containment vessel would need to be transferred to tanker trucks as soon as possible. This would require 200 tanker truck loads with each tanker truck capable of holding 7000 gallons . At a rate of two tankers per day the cleanup operation would last approximately 5 months. The local spill plan would have the names and phone number of tanker truck vendors to call.
d) The tankers would be moved from the Ash River site to a railroad siding in Minnesota and the liquid would be transferred to railcars. A total of about 50 railcars would be needed to hold the liquid scintillator. The local spill plan for

would have the names and phone numbers of railcar vendors to call. The railcars could be stored almost anywhere until a decision is made to reuse or dispose of the scintillator.

e) Any absorbent materials used would be disposed of as special waste.

6.3.2 Near Detector Highest Consequence Credible Accident and Response

At Fermilab approximately 30,000 gallons of liquid scintillator are held in the Near Detector. A leak might occur due to an accident involving rock falling from the ceiling of the tunnel or from other users in the tunnel area damaging the detector (e.g. forklift accident damage). Such leak could happen instantaneously. Since the PVC extrusions at the Near Detector act as 500 primary containment objects, it is difficult for falling rock or errant fork lifts to destroy the entire detector and perhaps one third of the scintillator (10,000 gallons) might leak into the secondary containment volume. If the secondary containment were also breached during the same accident, there is a danger that liquid scintillator could get into the NuMI tunnel sump and be introduced into the Fermilab ICW system.

The response plan would include the following steps:

a) Call the Fermilab emergency response phone number (3131). This would get subject matter experts notified of the problem and local spill plan procedures would be implemented.
b) Power down the Near Detector.
c) Examine the secondary containment vessel to make sure there are no leaks. Emergency materials would be on hand to shore up the containment if required.
d) The 10,000 gallons of leaked liquid scintillator would be transferred from the secondary containment vessel into 200 fifty-five gallon drums as soon as possible. Fermilab has a small supply of these barrels on hand and the rest would need to be ordered. The local spill plan would have the names and phone numbers of barrel vendors to call.
e) The barrels would be removed from the underground area and moved to a storage facility until a decision is made to reuse or dispose of the scintillator. The storage facility would most likely be at an offsite location.
f) Any absorbent materials used would be disposed of as special waste.

6.3.3 Blending Highest Consequence Credible Accident and Response

At the Fermilab blending facility a full tanker of liquid pseudocumene could develop a leak and spill its entire 7000 gallons into the secondary containment vessel before detection. If the secondary containment was compromised at the same time as the tanker leak, some of the pseudocumene could get into nearby aquatic environments.

Personnel near the effected area could be exposed to aspiration hazards and fumes. The Computer-Aided Management of Emergency Operations (CAMEO) modeling program [23] would be used in advance of any possible accident to determine the Emergency

Response Planning Guidelines at Fermilab. Use of CAMEO simply requires that the location of liquid component handling site be finalized.

The response plan would include the following steps:

a) Evacuate the area and assemble in a safe location 100 yards upwind of the leak.
b) Call the Fermilab emergency response phone number. (840-3131) This would get subject matter experts notified of the problem and local spill plan procedures would be implemented.
c) The Fermilab Fire Department, wearing adequate personal protective equipment, would examine the secondary containment vessel to make sure there are no leaks.
d) The Fermilab Fire Department, wearing adequate personal protective equipment, would take measures to stop the leak.
e) The 7000 gallons of leaked liquid would be transferred to barrels as soon as possible. Each barrel would be capable of holding 55 gallons. Fermilab has a small supply of these barrels on hand and the rest would need to be ordered. The local spill plan would have the names and phone numbers of barrel vendors to call for more barrels.
f) The barrels would be removed from the area and moved to a storage facility until a decision is made to reuse or dispose of the pseudocumene.
g) Any absorbent materials used would be disposed of as special waste.

6.3.4 Highest Consequence Credible Accident and Response during Transporting

The highest consequence creditable accident during transportation would be that at tanker truck had a traffic accident and leaked its entire 7000 gallons load of liquid scintillator into the environment along the 3.5 mile access road into the Ash River site or along St. Louis County Road 129.

Both of these roads are in a remote location and response time from the County or the State of Minnesota could lead to environmental impacts. Since wetlands are prevalent in this area, the worst consequence would be the introduction of liquid scintillator into an aquatic environment.

The total transportation route from Fermilab to Ash River includes about 15 miles along these remote roads. The 0.73 per million miles [22] accident rate for shipping non-hazardous materials by truck leads to a statistical expectation of 0.007 such accidents during the entire NOvA assembly process. This is one-fortieth or 2.5% of the probability calculated in section 6.2.4.

Should an accident happen on one of these roads the response would include the following steps:

a) The driver would have instructions to call the Far Detector site first if an accident happened on one of these roads. The Far Detector site would have spill control materials on hand and the crews would be trained and serve as first responders.

Since every tanker delivery is arranged in advance, a crew would always be on hand to respond.

b) Personnel at the Far Detector site would notify Fermilab and others named on the emergency response procedure call list.
c) The driver would then call the State of Minnesota Emergency Response phone number.
d) The first responders would control the spill and begin cleanup.
e) The accident scene would be turned over to State or local authorities when they arrive.

7. List of Permits

List of Fermilab Permits

Name	Expires	
Nuisance Wildlife Control Permit Type: Class C (Governmental)	1/31/2008	
Open Burn - Land Management	9/14/2007	
Resource Conservation Recovery Act - RCRA - Federal	6/30/2016	
Resource Conservation Recovery Act - RCRA - Illinois	8/4/2016	
National Polluant Discharge Elimination Systems - NPDES - Illinois	Renewal pending	
Illinois Department of Resources - IDNR - Class III Dam	Open	
National Pollution Discharge Elimination System - NPDES Pretreatment - Illinois	7/31/2010	
Lifetime Operating Permit – NESHAP (National Emission Standards for Hazardous Air Pollutants) - revised	Evergreen	
Open Burn - Fire Fighter Training	Reapplication pending	
Canada Goose Depredation Permit	6/30/207	
Fox River Water Withdrawal	12/31/2009	
United States Corps of Engineers- USCOE - NuMI Wetland Permit	Open	

List of Ash River Permits

No permits exist for the proposed access road or Far Detector site at this time. The necessary permits that would be needed have been identified and are listed in the state of Minnesota EAW Section 8.

8. Glossary

Acronyms and Abbreviations of the NOvA Environmental Assessment	
ACGIH	American Congress of Governmental Industrial Hygienists
AET	American Engineering Testing
ALARA	As Low as Reasonably Achievable
APD	Avalanche photodiodes
Argon-41	Argon-41 radionuclide
bis-MSB	1,4-di-(2-methylstyryl)-benzene
Bq	Becquerel
CAMEO	Computer-Aided Management of Emergency Operations
Carbon-11	Carbon-11 radionuclide
CDR	Conceptual Design Report
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Ci	Curies
COSMOS	Cosmologically Significant Mass Oscillations
CP	Charge Parity
CY	Calendar year
DCG	Derived Concentration Guide
DEHS	Department of Environmental Health & Safety
DOE	Department of Energy
DOT	Department of Transportation
EA	Environmental Assessment
EAW	Environmental Assessment Worksheet
EPA	(U.S.) Environmental Protection Agency
ES&H	Environment, Safety, and Health
FESHM	Fermilab Environmental, Safety, & Health Manual
FMI	Fermi Main Injector
FNAL	Fermi National Accelerator Laboratory
FONSI	Finding of No Significant Impact
FRCM	Fermi Radiation Control Manual
FY	Fiscal Year, Federal (October 1 through September 30)
GeV	giga-electron volts
GWPMP	Ground Water Protection Management & Plan
HEPAP	High Energy Physics Advisory Panel
Hydrogen-3	Hydrogen-3 radionuclide, also known as tritium
ICARUS	Imaging Cosmic And Rare Underground Signals

ICRP	International Commission on Radiological Protection
ICW	Industrial Cooling Water
IEPA	Illinois Environmental Protection Agency
ISO	International Standards Organization
kW	kilo Watts
LTF	Latent cancer facility
LTV	LTV Steel Company
μCi	micro-Curies, one-millionth of a Curie
MINOS	Main Injector Neutrino Oscillation Search
MNDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
mrem	millirem
MOU	Memorandum of Understanding
NCRP	National Council on Radiation Protection & Measurements
νe	Electron neutrino
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
Nitrogen-13	Nitrogen-13 radionuclide
NOvA	NuMI Off-axis Ve Appearance
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
NSF	National Safety Foundation
NuMI	Neutrinos at the Main Injector
Oxygen-15	Oxygen-15 radionuclide
pCi	Pico Curie
PEL-TWA	Permissible Exposure Limit – Time Weighted Average
PPO	2,5-diphenyloxazole
PSAD	Preliminary Safety Assessment Document
PVC	polyvinyl chloride
RF	Radio Frequency
RPC	resistive plate chambers
RPVC	rigid polyvinyl chloride
SAD	Safety Assessment Document
SEH	Short Elliot Hendrickson
Sodium-22	Sodium-22 radionuclide
SSC	Superconducting Super Collier
SWPPP	Storm Water Pollution Prevention Plan
TEC	Thermoelectric cooling
TEDE	Total Effective Dose Rate

TLV-TWA	Threshold Limit Value-Time Weighted Average
TPC	Time projection chamber
Tritium	Hydrogen-3 radionuclide, also known as tritium
USBM	U.S. Bureau of Mines
WLS	wavelength shifting

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Appendix A: Minnesota Environmental Assessment Worksheet