NORTHERN STATES POWER COMPANY
MONTICELLO NUCLEAR GENERATING PLANT

Control Room Habitability
Toxic Chemical Study

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EXECUTIVE SUMMARY

Due to design changes at the Monticello Nuclear Generating Plant (MNGP), chlorine is no longer stored onsite and regulations requiring early warning of onsite chlorine releases do not apply. NSP recognized that removal of onsite chlorine may eliminate the need for the control room HVAC chlorine detectors. A calculation was prepared in 1986 [Ref. 4.3.27] to determine if the detectors could be removed. The calculation concluded that Interstate 94 truck shipments of chlorine, using conservative deterministic models, posed a significant enough hazard to warrant the continued use of the detectors.

During subsequent Design Bases Document Program activities it was determined that the original chemical survey was incomplete and that the assumed atmospheric condition (Pasquill Category) was non conservative. Follow-on Items (FOIs) were written [Refs. 4.3.28 and 4.3.29] to document these concerns and an initial assessment was prepared to identify any operability impact or unanalyzed condition. No operability impact or reportable condition was identified. The completed assessments of the FOIs recommended the survey be formally revised and deterministic analyses be prepared to assure complete and formal resolution of these concerns (see recommended corrective action 2 of FOI 92-0013 and 1.a of FOI 92-0037). Additionally, a revised analysis would provide a current basis for deciding if the chlorine chemical detectors were still required. The results of this reassessment are contained in this report.

A new toxic chemical survey was performed which identified toxic chemicals in sufficient quantities stored onsite, stored in the vicinity of the site, or shipped near the plant at sufficient frequency to warrant further evaluation. These toxic chemicals were evaluated in accordance with applicable regulatory requirements. It was deterministically concluded that all chemicals stored onsite and transported near the plant, with the exception of chemical shipments by truck, do not pose a significant threat to control room operators. No early detection equipment is required for postulated chemical releases as sufficient time (at least two minutes) is available for the control room (CR) operators to don protective breathing equipment.

For the case of chemicals transported by truck, a probabilistic model was developed which accounts for the frequency of trucking accidents, hazardous material shipments, and various weather conditions to determine the likelihood of a trucking accident which results in a toxic chemical release. Calculated probabilities were compared to the criteria of Standard Review Plan (SRP) Section 2.2.3 [Ref. 4.1.5] and USNRC Regulatory Guide (Reg. Guide) 1.70 [Ref. 4.1.12]. Reg. Guide 1.70, Section 2.2.3.1 states: "Design basis events external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of about 10^{-7} per year or greater and have potential consequences serious enough to affect the safety of the plant to the extent that Part 100 guidelines could be exceeded." The SRP indicates that offsite hazardous releases need not be considered if "a conservative calculation showing that the probability of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines is approximately 10^{-6} per year..." This "is acceptable if when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower." The probability of a toxic chemical release from a trucking accident resulting in control room operator incapacitation to the extent that Part 100 guidelines could be exceeded is less than $3.78X10^{-8}$ per year. This probability was determined with a number of conservatisms in the analysis approach. Therefore, the acceptance criteria of both the Reg. Guide and SRP were demonstrated.

Based on this study, potential hazardous releases from all sources in the survey need not be considered in the design of the MNGP and no special CR HVAC chemical detectors are required.

1.0 INTRODUCTION

Draft Atomic Energy Commission (AEC) 1967 General Design Criterion (GDC) [Ref. 4.1.11] Number 11 requires facilities to provide a "control room from which actions to maintain safe operational status of the plant can be controlled." The criterion also requires that the control room provide adequate radiation protection of personnel during both normal and accident conditions. This criterion is not part of the Monticello Nuclear Generating Plant (MNGP) operating license or design bases as the MNGP design preceded the 1967 draft GDC. However, the MNGP performed a comparative evaluation of the plant design bases with the 1967 draft GDC, and concluded that the MNGP is in conformance with the intent of the draft GDC (see Appendix E of Reference 4.3.21).

Following the Three Mile Island (TMI) accident, the Nuclear Regulatory Commission (NRC) reinforced the requirement of adequate CR operator protection by requiring all plants to perform a Control Room Habitability Study in response to Item III.D.3.4 of NUREG-0737 [Ref. 4.1.2]. This study was to evaluate both the effects of postulated toxic chemical spills and post-accident radiation on CR operators. For toxic chemicals where it could not be demonstrated that adequate time exists for CR operator response, special design features such as early chemical detection and CR HVAC automatic isolation were to be provided.

Bechtel Corporation was contracted by NSP to perform the Control Room Habitability Study (Original Study) in response to NUREG-0737 requirements. The Original Study [Ref. 4.3.1] was completed in 1981 and concluded that four chemicals either shipped on nearby railcars or stored onsite posed a significant enough risk to require detection and automatic CR HVAC isolation. In 1984, Bechtel was again contracted by NSP to re-evaluate the incapacitation effects of the four chemicals using more current modeling techniques [Ref. 4.3.2]. It was concluded that only one of the original four chemicals, chlorine, still required early detection. The principal source of chlorine was onsite as it was used in the water treatment process.

Due to design changes [Ref. 4.3.3] at the MNGP, chlorine is no longer used in water treatment and is no longer stored onsite. Therefore, regulations requiring early warning of potential onsite chlorine releases are no longer applicable. NSP recognized that such a design change may eliminate the need for the chlorine detectors. An additional calculation was prepared by Bechtel in 1986 [Ref. 4.3.27] to determine if the chlorine detectors were still required. It was concluded that truck shipments of chlorine on Interstate 94 posed a significant enough hazard to warrant continued use of the chemical detectors.

During subsequent Design Bases Document Program activities it was determined that the original chemical survey was incomplete and that the assumed atmospheric condition (Pasquill Category) in the toxic chemical spill calculations was non conservative, i.e., Pasquill Category F was used whereas G is more appropriate for Monticello (worst case category that occurs at least 5% of the time). Follow-on Items

(FOIs) were written [Refs. 4.3.28 and 4.3.29] to document these concerns and an initial assessment was prepared to identify any operability impact or unanalyzed condition. No operability impact or reportable condition was identified. The completed assessments of the FOIs recommended the survey be formally revised and deterministic analyses be prepared to assure complete and formal resolution of these concerns (see recommended corrective action 2 of FOI 92-0013 and 1.a of FOI 92-0037). Additionally, a revised analysis would provide a current basis for deciding if the chlorine chemical detectors were still required.

This report presents the results of this reassessment. The implemented approach is in accordance with applicable regulatory requirements as outlined in Section 2.1 below. The remaining parts of Section 2.0 describe the analysis approach and present the survey results. Final incapacitation assessments are presented in Section 3.0. References are itemized in Section 4.0.

2.0 TOXIC CHEMICAL STUDY METHODOLOGY AND SURVEY RESULTS

The toxic chemical study approach consisted of the following steps:

- Define regulatory requirements,
- Perform a survey to identify hazardous materials,
- Develop a toxic chemical spill analysis model,
- Define incapacitation assessment criteria,
- Determine the probability of a release due to trucking accidents, and
- Assess the effects of toxic chemical spills on control room operators.

The first five steps, including the results of the survey, are presented below. The effect of various toxic chemical spills on CR operators are presented in Section 3.0.

2.1 NRC Regulations for Control Room Habitability

The first step of the study was to review current and past regulations on control room habitability and their applicability to the MNGP license. The objective of this review was twofold: 1) to ensure the approach implemented complies with all applicable regulations, and 2) to determine if any recent regulatory changes have occurred which might provide improved criteria upon which to base this study. Results of both objectives are presented below. In summary, the modeling techniques employed have not changed since the Original Study, however, additional tools are now available to model the probabilistic aspect of chemical spills. As shown in Section 3.0, such tools were employed in the evaluation of postulated chemical releases due to trucking accidents in the vicinity of the plant.

NRC regulations on control room habitability are contained in a number of documents including NUREG-0800, Standard Review Plan (SRP) [Ref. 4.1.5], and various regulatory guides (see Table 2-1). These regulations all ultimately refer to 10CFR50 Appendix A General Design Criteria [Ref. 4.1.1] as the basis for implementation. Though MNGP is not a 10CFR50 Appendix A plant (the MNGP design preceded the draft AEC GDC), control room habitability analysis is a requirement as a result of the Three Mile Island (TMI) accident. All plants were required to examine control room habitability for both toxic chemical spills and post design basis accident radiation effects. These requirements are contained in NUREG-0737, Section III.D.3.4 [Ref. 4.1.2].

The effects of toxic chemical vapors on control room operators depend on a number of factors including chemical type, spill distance from the control room, volume of spill, wind speed, etc. The NRC position on many of these factors is contained in two Regulatory Guides (RGs). These are RG 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," June 1974 [Ref. 4.1.3], and RG 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," Revision 1, January 1977 [Ref. 4.1.4]. The accepted NRC model for calculating toxic chemical spill concentrations in the control room is contained in NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release," June 1979 [Ref. 4.1.6]. Additionally, modeling techniques for control room operator incapacitation are contained in NUREG/CR-1741, "Models for the Estimation of Incapacitation Times Following Exposures to Toxic Gases or Vapors," December 1980 [Ref. 4.1.7]. The calculations generated for this study use the criteria of RG 1.78 and the models of NUREG-0570 and NUREG/CR-1741 to select which hazardous materials to model and to assess the potential for CR operator incapacitation.

The probabilistic aspect of the trucking accident calculation used the acceptance criteria of Section 2.2.3 of the Standard Review Plan, "Evaluation of Potential Accidents," July 1981 [Ref. 4.1.5].

Table 2-1 provides an overview of the existing regulatory documents for control room habitability and discusses the specific requirements of these documents. The table identifies which documents are part of the MNGP license as requirements or as guidance used to meet the requirements.

Table 2-1
NRC Regulatory Requirements for Control Room Habitability

Regulatory Document	MNGP Commitment	If not Commitment used as Guidance?	Overview of Requirements
Atomic Energy Commission (AEC) Draft General Design Criteria Criterion 11 - Control Room: The facility shall be provided with a control room from which actions to maintain safe operational status of the plant can be controlled. (Abridged)	No	Yes	Per 10CFR50.34.a.3.i, all nuclear power plants shall be designed and evaluated during the license application against a set of Principal Design Criteria. As MNGP design was nearly complete prior to the issuance of the 1967 draft of 10CFR50, Appendix A, General Design Criteria, these criteria are not part of the plant license as a design requirement. However, the MNGP does conform to the intent of the 1967 draft GDC. Criterion 11 defines requirements for a control room with a safe operating environment. Later regulations, such as RG 1.78 invoke 10CFR50 Appendix A as the basis for their application. Though this implies such regulatory guides are not part of the plant license, the election to invoke such requirements assures the intent of the Draft AEC GDC and later NUREG-0737 requirements are met.

Regulatory Document	MNGP Commitment	If not Commitment used as Guidance?	Overview of Requirements
NUREG-0737 Section III D.3.4. – Control Room Habitability Requirements	Yes	--	This Toxic Chemical Study is an update of the Original Study completed in 1981 to address NUREG-0737 requirements. As a result of TMI, the NRC required all licensees to re-evaluate control room habitability. This review for previously licensed plants, such as MNGP, was to focus on the effects of the accidental release of toxic gases and radioactive materials. The objective was to demonstrate that control room operators are adequately protected in the event of such accidents, and that the plant could be safely operated or shutdown. The NUREG identified RGs 1.78 and 1.95 as acceptable guidance for meeting CR habitability analysis requirements.
RG 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," June 1974	No	Yes	This RG provides the guidelines for performing the toxic chemical analysis. It specifically outlines a position acceptable to the NRC for selecting and analyzing the effects of hazardous chemical spills on CR operators. The RG provides acceptance criteria when, if met, require no special automatic detection or HVAC control equipment installation. Specifically, if there is at least two minutes between the time that the toxic chemical is detected in the control room and the control room operators become incapacitated, no special monitoring or control equipment is required. Two minutes is considered sufficient time for a trained operator to don any necessary protective breathing apparatus.

Regulatory Document	MNGP Commitment	If not Commitment used as Guidance?	Overview of Requirements
RG 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," Revision 1, January 1977.	No	--	This RG was issued to provide guidance on how to design acceptable CR operator protection from postulated onsite chlorine releases. If chlorine is stored onsite, the RG indicates (a) the control room is to be capable of being isolated on a high chlorine level, (b) chlorine detectors shall be installed, (c) the chlorine detectors should meet single failure criteria, be qualified Seismic Category I, and be environmentally qualified "for all expected environments that could clearly lead to or be a result of a chlorine release." In addition, technical specification limits were to be specified. Through part of the original study, this RG no longer applies to the MNGP since chlorine is no longer stored onsite. This is a result of a design change that replaced chlorine as the biocide agent for the cooling water system with a sodium bromide, sodium hypochlorite mixture (see Design Modification 86Z035, Rev. 2, [Ref. 4.3.3]).
RG 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 3, November 1978.	No	Yes	Though the MNGP has no explicit commitment to meet this RG, it does provide acceptance criteria for use when evaluating new plant Final Safety Analysis Reports. The RG indicates a probability of 10^{-7}/year as the cutoff for considering man-made external event hazards in power plant design.

Regulatory Document	MNGP Commitment	If not Commitment used as Guidance?	Overview of Requirements
NUREG-0800, "Standard Review Plan" (SRP), Revision 2, July 1981 Section 2.2.1–2.2.2, "Identification of Potential Hazards in Site Vicinity"	No	Yes	Though the MNGP has no explicit commitment to meet these sections of the SRP, they do outline guidance to be used by the NRC in the review of license applications. Hence, they were reviewed to ensure the intent was being met. This section of the SRP requires that for every site, a review be performed to identify potential hazards. These hazards are to include external hazards or hazardous materials that could present a problem to the plant. This review is to encompass a five-mile radius of the plant.
Section 2.2.3, "Evaluation of Potential Accidents"			This section of the SRP discusses the offsite toxic accidents as an initiating event that could impact control room habitability and potentially result in offsite dose releases to the general public. The intent of this section is to provide guidance to determine what type of potential accidents need to be considered. This determination is based on the expected occurrence rate for the accident. The objective is to show that "the potential for causing onsite accidents leading to the release of significant quantities of radioactive fission products, and thus pose an undue risk of public exposure" is significantly low. Significantly low is defined as an occurrence rate of approximately 10^{-6} per year when combined with reasonable qualitative arguments.
NUREG-0570 "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release," June 1979	No	Yes	This NUREG describes an NRC accepted approach for determining toxic chemical vapor concentrations both outside and inside the control room.

Regulatory Document	MNGP Commitment	If not Commitment used as Guidance?	Overview of Requirements
NUREG/CR-1741 Models for the Estimation of Incapacitation Times Following Exposures to Toxic Gases or Vapors, December 1980	No	Yes	This NUREG provides five modeling techniques for assessing the potential for CR operator incapacitation resulting from toxic chemical exposure. The model selected depends on how the chemical effects a human and how it is ultimately detected. These modeling techniques were used by Bechtel in 1984 [Ref. 4.3.2] to justify the elimination of all CR HVAC toxic chemical monitors except chlorine.
NUREG/CR-2650 "Allowable Shipment Frequencies for the Transport of Toxic Gases Near Nuclear Power Plants," October 1982.	No	Yes	This NUREG provides more realistic (less conservative) criteria for when evaluation of chemicals, based on shipment frequencies, is required. The NUREG concludes that frequencies of 208 per year for railroad traffic and 1820 per year for truck traffic are more realistic criteria than 30 and 10, respectively, as required by Reg. Guide 1.78. Note: The more restrictive frequency requirements of Reg. Guide 1.78 were used in this analysis.
NUREG/CR-5042 "Evaluation of External Hazards to Nuclear Power Plants in the United States," December 1987	No	Yes	This NUREG provides a probabilistic evaluation method to deal with the potential for nuclear power plant accidents initiated by external events, including toxic chemical spills.

2.2 Toxic Chemical Survey

The objective of this survey was to identify all hazardous materials stored at, shipped to, or near the MNGP and to determine which materials from this survey required further evaluation. The steps employed to determine which materials required modeling for comparison evaluation and the resultant list of hazardous materials are presented below.

The first step in performing the survey was to develop a comprehensive list of hazardous materials. The Original Study used RG 1.78, NUREG-0570 and data provided by the Association of American Railroads and the Committee on Safety of Nuclear Installations Organization to develop a list of hazardous materials. In this study both RG 1.78 and NUREG-0570 were used but the list of hazardous materials from Title 29, Code of Federal Regulations, Part 1910 [Ref. 4.1.9] was used in place of railroad data. This list was used as a basis for confirming that the list of hazardous materials provided by different survey contacts included chemicals defined as hazardous.

The next step in the survey was to perform a review of all fixed sites and shipping routes near the MNGP which may store or transport hazardous materials. The guidance of RG 1.78 was applied to define the scope of this review. In accordance with the Reg. Guide, any hazardous chemicals stored or transported beyond a five mile radius of the plant require no evaluation. Therefore, this review was limited to all transportation routes and fixed sites within the five mile radius. Per the MNGP Emergency Plan drawing [Ref. 4.3.6] these are:

- The MNGP (Section 2.2.1)
- Monticello area users of hazardous materials (Section 2.2.2)
- Truck transport near the MNGP (Section 2.2.3)
- The Burlington Northern rail line (Section 2.2.4)

It should be noted that no commercial ship traffic exists on the Mississippi River within five miles of the MNGP [Ref. 4.2.2]. Consequently, commercial shipping and barge traffic were not included in the survey.

The rail company noted above was contacted to obtain information on all hazardous materials transported on routes within five miles of the plant, frequency of shipment, and shipment size. The individual users, local authorities, and state and federal agencies provided hazardous material data for all other transport routes and industry users.

Once the list of chemicals transported and stored was obtained, the remaining criteria of RG 1.78 were applied to determine which chemicals required further evaluation. These criteria include frequency of shipment, stored or shipped quantity and chemical toxicity. The results of this survey are presented below and form the basis for the modeling and comparison evaluations presented in Section 3.0.

2.2.1 Toxic Chemicals Stored Onsite (MNGP)

As required by State and Federal Law, every user of hazardous substances must maintain a list of non-exempt quantities of these substances used at the facility. The "Hazardous Substance Inventory" at the MNGP [Ref. 4.2.7] was used in the survey. This list identifies substances, storage location, maximum storage capacity, average daily amount and if the substance is SARA (Superfund Amendments and Reauthorization Act) reportable. It should be noted that additional chemicals are stored onsite that are not included on the "Hazardous Substance Inventory." A complete listing of chemicals used at the MNGP is contained in the Chemical Materials and Manufacturers List [Ref. 4.2.8]. This list was reviewed to determine if any chemicals not contained in the "Hazardous Substance Inventory" required evaluation. It was concluded that none of these chemicals required evaluation because either: 1) They are stored in quantities below the 100 pound limit specified by RG 1.78, or 2) They are stored in enclosed structures that do not interface with the control room air intake or ventilation system. In these cases it is not considered credible that these materials could pose a risk to the control room operators. During the development of this study it was noted that the SARA Title III Report contains a discrepancy on the size of the propane tank. There is no 1,700 gallon propane tank at Monticello. The actual installed tank is 120 gallons and serves as the pilot light source for the heating boiler. This was confirmed during a plant walkdown. As this discrepancy was identified, the Monticello Chemistry Department performed an independent walkdown of the site to identify all chemicals stored in quantities in excess of Regulatory Guide 1.78 limits. This walkdown was also performed to resolve Corrective Action 1 of FOI 92-0013 [Ref. 4.3.28]. Results of the study [Ref. 4.3.30] do not change the conclusions of this report or in any way modify the chemical list contained in Table 2-2.

With the exception of propane, Table 2-2 lists all chemicals maintained on the "Hazardous Substance Inventory" stored at the MNGP site in excess of SARA limits and that were further evaluated as noted in subsequent sections of this report.

Table 2-2 - Hazardous Chemicals Stored Onsite at the MNGP that Exceed SARA Reportable Limits

Chemical	Maximum Capacity (per container)
1. Diesel Fuel #2	60,000 gallons
2. Sodium Bromide	2,000 gallons
3. Sodium Hypochlorite	6,000 gallons
4. Hydrogen (liquid)	9,000 gallons
5. Nitrogen (liquid & gas)	9,000 gallons
6. Oxygen (liquid)	9,000 gallons
7. Propane (liquid & gas)	120 gallons (see Section 2.2.1)
8. Stoddard Solvent*	110 pounds
9. Turbine Oil	10,000 gallons
10. Gasoline*	500 gallons
11. Lube Oil	10,000 gallons

* Quantity is not SARA reportable. Listed on Hazardous Substance Inventory and included in this table for completeness

2.2.2 Toxic Chemicals Stored Within Five Miles of the MNGP

To obtain information regarding industrial producers or users of hazardous materials near the plant, the "Listing of Facilities and 311 Chemicals" [Refs. 4.2.4 and 4.2.5] was obtained from the Minnesota Department of Public Safety for Wright County and Sherburne County. This listing identifies all facilities that store SARA reportable quantities of hazardous materials. The listing identifies the facility, the location, and the types and quantities of materials stored. It should be noted that the quantities of material given in the listing are shown as an order of magnitude (e.g. 1,000 to 9,999 pounds, 10,000 to 99,999 pounds, etc.); if the maximum quantity of material for a given range could not be shown to be acceptable, the facility was contacted to determine the actual quantity stored.

All facilities shown on the listing within five miles of the plant were evaluated for their potential threat to the MNGP control room operators. The results of the evaluation for each facility are given in Section 3.0.

2.2.3 Toxic Chemicals Transported by Truck Within a Five Mile Radius of the MNGP

Transport of hazardous materials by truck within a five mile radius of the plant is generally limited to two primary highways: Interstate 94 passes approximately one-half mile southwest of the plant and Highway 10 passes approximately two miles northeast of the plant. Other roadways within five miles of the plant are primarily limited to local service and carry vastly less traffic than these two highways. These other roadways were evaluated and determined to have insignificant risk contributions relative to the two primary highways. The evaluation of the risk to the control room operators posed by truck transport of hazardous materials was performed using probabilistic techniques. To perform this evaluation, information was obtained from the Federal Highway Administration, the Minnesota Department of Transportation, and the Minnesota Department of Public Safety, regarding truck traffic, accident rates, hazardous spill frequencies, etc. Additionally, information on the proximity and layout of the various highways relative to the control room intake was obtained from Northern States Power Company site drawings. This information was evaluated in Reference 4.3.11, and the results are summarized in Section 3.0 of this report.

2.2.4 Railroad Traffic Within Five Miles of the MNGP

The Burlington Northern rail line passes within five miles of the MNGP. No other rail lines pass within five miles of the plant. The Burlington Northern line travels past the plant on the opposite side of the Mississippi River with a point of closest approach of two miles. From information provided by the railroad line [Ref. 4.2.3], Table 2-3 was compiled. This table identifies the chemicals that are shipped at frequencies equal to or in excess of the RG 1.78 criterion of 30 times per year. The railroad company considers each individual tanker as a separate shipment. Therefore, the number of shipments shown in Table 2-3 for a particular chemical is conservative as it does not account for the potential of multiple car shipments of a chemical on a single train. Multiple car shipments on a single train would reduce the total number of shipments for RG 1.78 criterion comparisons.

No specific information on the average weight of each shipment could be obtained from the railroad company. However, a tank car manual [Ref. 4.3.4] was obtained that provides information on chemical shipping weights. This information was used in various calculations to provide the basis for chemical shipment weights evaluated.

Table 2-3 - Chemicals Transported by Rail on the Burlington Northern Line that Equal or Exceed 30 Shipments per Year

Chemical	Number of Shipments
1. Anhydrous Ammonia	736
2. Carbon Dioxide, Refrigerated Liquid	34
3. Butadiene, Inhibited	1761
4. Butane	456
5. Isobutane	30
6. Liquefied Petroleum Gas	287
7. Propane	707
8. Propylene	116
9. Vinyl Chloride	327
10. Ethylene Oxide	30
11. Styrene Monomer, Inhibited	82
12. Benzene	100
13. Denatured Alcohol	844
14. Ethyl Alcohol	228
15. Ethylene Dichloride	442
16. Isopropanol	37
17. Methyl Alcohol	620
18. Naphtha & Petroleum Naphtha	524
19. Flammable Liquid, N.O.S.	36
20. Flammable Liquid, N.O.S. (Aromatic Concentrates)	424
21. Diesel Fuel	576
22. Combustible Liquid, N.O.S.	52
23. Sodium, Metal	32
24. Sulfur, Molten	3540
25. Hydrogen Peroxide	84
26. Sodium Chlorate	69
27. Chlorine	71
28. Phenol	67
29. Phosphoric Acid	80
30. Acetic Acid, Glacial	93
31. Titanium Tetrachloride	70
32. Sodium Hydroxide, Solution	285
33. Maleic Anhydride	66
34. Mixed Loads of Hazardous Materials (TOFC/COFC)	4623
35. Hazardous Substance, Liquid, N.O.S.	50
36. Hazardous Substance, Liquid, N.O.S. (Diethyl Phthalate)	69
37. Hazardous Substance, Liquid, N.O.S. (Contains Creosote)	38
38. Hazardous Substance, Solid, N.O.S. (Benzo-A-Pyrene)	75

2.3 Toxic Chemical Spill Models

During the initial stages of the study, it was recognized that many chemicals would require further evaluation beyond the application of RG 1.78 shipment frequency criteria. Two models were developed to determine the buildup rate of a postulated chemical spill in the control room: 1) Model 1 for compressed gases and chemicals whose boiling point is less than ambient temperature and 2) Model

2 for chemicals with boiling points higher than ambient temperature. These models were used, in combination with appropriate incapacitation models, to determine if the two-minute criteria of RG 1.78 could be met. Not all chemicals identified in Section 2.2 were modeled — only those chemicals which could not be eliminated from further consideration using the criteria described in Section 2.4 were modeled.

Both toxic chemical models simulate spill release, atmospheric dispersion and eventual buildup in the control room. These models were developed in accordance with the requirements of NUREG-0570 and are described in detail in TENERA Calculation 1961-2.2-001 [Ref. 4.3.7]. Many conservatisms exist in the models including:

- One complete container of the chemical is assumed immediately released in the accident,
- Wind direction carries the spill directly to the control room intake,
- Worst case 5% atmospheric dispersion conditions are assumed (Pasquill Category G),
- No credit for intervening structures or topology is assumed which would dilute concentration at the control room intake,
- No credit is assumed for an elevated control room intake which reduces the concentration at the intake, and
- No credit is assumed for spill absorption or dilution in surrounding ground or water.

Summary descriptions of both models are provided below. Specific equations and design inputs are contained in the detailed TENERA calculations [Refs. 4.3.7 to 4.3.10].

2.3.1 Model 1: Chemicals Whose Boiling Point is Less Than Ambient

According to NUREG-0570, two release phenomena are assumed for chemical spills when the chemical boiling point temperature is below ambient temperature. These phenomena are instantaneous puff and vaporization. Each spill phenomena acts independently. Therefore, each phenomena is modeled separately and the contributions to control room vapor concentration are summed at corresponding time steps.

An ambient temperature of 70°F was used in the calculations [Refs. 4.3.7 to 4.3.10]. However, a significant change in ambient temperature would not change the model applied as chemical boiling points were typically well below ambient temperature.

Instantaneous Puff:

The percentage of total spill which is instantaneously released depends on the chemical's heat capacity, boiling point, and heat of vaporization. The total amount released is dependent upon the temperature difference between the boiling point and ambient temperature, the above chemical properties, and the total spill mass.

The instantaneous puff assumes the shape of a three dimensional exponential bell curve with the maximum vapor concentration (top of the bell) at the point of spill release. The maximum vapor concentration and puff shape are dependent upon the mass of the instantaneous release, the assumed atmospheric distribution coefficients (Pasquill Category), and the distance to the control room intake. The puff travels in a straight line directly to the control room intake. As no deviation in wind direction is assumed, the problem becomes two-dimensional. The shape of the puff curve is conservatively assumed to remain unchanged during its transport to the control room intake. Therefore, the maximum vapor concentration at the point of release will ultimately reach the control room intake depending on wind speed and distance to CR intake.

Chemical buildup and dissipation in the control room will assume a similar exponential bell shape response over time for an unisolated control room. How quickly control room vapor concentration increases and dissipates depends upon the air exchange rate of the control room, the shape of the outside CR puff at the intake, and the speed at which the puff passes the CR intake.

Vaporization:

The remaining spill is released through vaporization. The rate of vaporization depends upon the spill area rate of change, atmospheric and solar heat fluxes, ambient and chemical boiling point temperature difference, and ground and chemical boiling point temperature difference.

The spill area is assumed to spread uniformly outward in a circular fashion to a maximum spill depth of 1 cm. The spill then remains at this maximum area until completely vaporized. Typically, the spill expands to its maximum area quickly with respect to total time to complete vaporization. This spill area model is conservative as it assumes no credit for surrounding topology which might impede spill growth. As mass release is largely dependent on spill area, any impediments to spill area growth would slow chemical release rate.

Atmospheric dispersion is modeled similar to the instantaneous puff release. The applicable Pasquill Gifford Category is combined with distance to spill to determine the appropriate dispersion coefficients. These coefficients are then combined with the vaporization model, wind speed, spill area model, and remaining spill mass to determine the rate of chemical mass release and its progression to the CR intake. The vaporization cloud assumes the shape of an exponential bell curve in the dimensional plane perpendicular to the direction of propagation. This shape is similar to the instantaneous puff. However, in the direction of propagation, the cloud shape is different due to the interactive effects of the spill area and vaporization models. The cloud assumes a step function shape at the time of spill release. This step function then grows and finally dissipates over time in an exponential manner until the entire spill has vaporized. An end step function then occurs and the mass release rate drops back to zero.

Control room buildup is modeled using the identical equations implemented for the puff release. Buildup and dissipation in the CR is dependent upon the same factors.

As the vaporization cloud is not instantaneously distributed, like the puff release, its contribution to CR chemical buildup will not take effect until the cloud has traveled to the control room at the wind speed rate. By the time it reaches the control room, detection and corrective actions in response to the instantaneous puff may have already occurred. If left unisolated, the CR will experience two separate maximums resulting from each release phenomena's contribution. Typically, the higher maximum is contributed by the puff.

2.3.2 Model 2: Chemicals Whose Boiling Point is Greater than Ambient

A simpler model was developed for chemicals whose boiling point temperature exceeds ambient temperature. For these chemicals, only evaporation exists as the mass release phenomena. The evaporation rate is dependent on the chemical's molecular weight, vapor pressure, Reynolds Number, Schmidt Number, diffusion coefficient, spill area model, and ambient temperature. The spill area model, atmospheric dispersion model, and control room buildup model are all identical to those developed for the vaporization release as described above. The remaining terms are combined into one of two equations for calculating mass release for either turbulent or laminar flow. The selection of laminar or turbulent flow is done conservatively by selecting that equation which results in the highest mass release rate. These equations are described in detail in Reference 4.3.7. For evaporation releases the spill will first reach the control room intake only after it is carried by the wind. Due to much slower release rates than chemicals with below ambient temperature boiling points, these chemicals do not typically pose a threat to CR operators and release over a much longer period.

2.4 Incapacitation Assessment Criteria

The final step in the Toxic Chemical Study was to evaluate the chemicals identified in the survey for potential CR operator incapacitation. A set of incapacitation assessment criteria were developed and applied to each chemical from the final survey described in Section 2.2. These criteria are:

- Is the chemical listed in 29CFR Part 1910 as an air contaminant? Also, does the chemical have a TLV or other limit(s) specified by NIOSH in Reference 4.3.5 or by ACGIH in Reference 4.3.20?
- Based on other locations and quantities of the chemical, can one bounding location be identified such that other locations/quantities can be eliminated?
- Based on known properties of the chemical as compared to spill model results for comparable chemical types, can it be demonstrated that incapacitation will not occur?
- Based on spill model results, will the CR chemical concentration exceed the chemical's Threshold Limit Value (TLV) or the Immediately Dangerous to Life or Health (IDLH) Value?
- Based on spill model results, will the CR chemical concentration result in incapacitation in less than two minutes using the modeling techniques of NUREG/CR-1741?

Each successive criterion was applied until a result of "no incapacitation" could be demonstrated. Only those chemicals transported by truck, due to unknown content, required a probabilistic analysis to determine the likelihood of accidental release.

The acceptance criteria used were in accordance with the regulatory requirements outlined in Section 2.1. Final results for all chemicals are presented in Section 3.0 and a more detailed discussion of each incapacitation assessment criteria is provided below.

2.4.1 29CFR Part 1910, NIOSH or ACGIH Listed

The first step in determining CR operator incapacitation was to review the list of chemicals from the survey against 29CFR Part 1910. An extensive list of hazardous materials is provided in Title 29 and is in accordance with federal standards. Chemicals identified in the survey which are not listed as air contaminants in Title 29 were removed from further consideration provided they also were not contained in the 1990 to 1991 American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Value (TLV) Guidelines [Ref. 4.3.20] or in the Pocket Guide to Chemical Hazards by the National Institute for Occupational Safety and Health (NIOSH) [Ref. 4.3.5]. The ACGIH and NIOSH lists were also used to further substantiate the removal of any chemical from further consideration on the basis of 29CFR Part 1910. However, no instance was found where a chemical from the survey was not listed in Title 29 but was listed in ACGIH or NIOSH.

2.4.2 Comparison to Other Locations/Quantities

The second step in determining potential CR operator incapacitation was to compare each of the surveyed chemicals against other locations where the same chemical was stored or transported. If a bounding location could be determined based on its distance from the plant and the quantity of chemical present, other locations could be eliminated from further consideration.

2.4.3 Chemical Properties Comparison

The third step was to determine if the chemical could be eliminated from further consideration based on its physical properties. This included a review of the chemicals' toxicity and properties which affect mass release. For example, molten sulfur was not evaluated using the toxic spill models as it has an extremely low vapor pressure and an extremely high boiling point. Though shipped in a heated tank car, the chemical's tendency is towards extremely low dispersion and becomes a solid at ambient temperature.

2.4.4 Spill Model Results Comparison to TLV and IDLH

Chemicals which did not meet the first three criteria were modeled and CR concentrations calculated. All calculations were carried out over the first eight hours following the spill. The CR HVAC remained unisolated over the entire period with normal outside air intake rate assumed.

The calculated CR vapor concentration was first compared to its TLV. If it could be shown that for the entire eight-hour period the TLV was not exceeded, incapacitation would not occur and protective breathing equipment would not be required. This acceptance criteria is consistent with RG 1.78. The TLV is defined by the American Conference of Governmental Industrial Hygienist (ACGIH) as that time weighted average chemical concentration that a worker could be exposed to with no long-term health effects. TLVs published by the ACGIH and NIOSH were used.

For those cases where the TLV was exceeded, a comparison to IDLH values was made. The IDLH is defined by the NIOSH as that concentration to which a worker may be exposed for 30 minutes without any escape-impairing symptoms or any irreversible health effects. If it could be demonstrated that two minutes subsequent to CR operator detection the IDLH has not been exceeded, it was concluded that incapacitation would not occur. The total time interval of concern was from the point the TLV is first exceeded to two minutes subsequent to detection. This total time span could be more or less than a total time of two minutes, as the TLV could be greater or lower than the concentration at which detection would occur. This comparison was extremely conservative as constant exposure at the IDLH value is allowed. In most cases the IDLH was never approached and the total time was well within 30 minutes.

2.4.5 Incapacitation Assessment Using NUREG/CR-1741 Models

If TLV or IDLH values were exceeded or could not be found, a comparison using appropriate NUREG/CR-1741 incapacitation models was performed.

NUREG/CR-1741 presents five separate models for determining chemical incapacitation. The selection of which model to implement depends on the properties of the chemical and the biological mechanisms of incapacitation, i.e., concentration or accumulated dose dependent. If it could be demonstrated through the use of the appropriate model that incapacitation in two minutes subsequent to detection would not occur, the chemical was eliminated from further consideration. Specific incapacitation models and desigu inputs used are included in the various calculations. These models are identical to those used in the Bechtel reanalysis of incapacitation effects performed in 1984 [Ref. 4.3.2].

2.5 Probabilistic Assessment of Chemical Releases from Trucking Accidents

As discussed in Section 3.0, due to a lack of information regarding the types and quantities of hazardous materials transported by truck, a probabilistic study was performed to assess the likelihood of a spill event and the likelihood that the spill would result in control room operator incapacitation. This study conservatively assumed that all hazardous chemicals transported by truck could potentially incapacitate the CR operators. Wind conditions were weighted by their frequency of occurrence using historical meteorological data for the site [Ref. 4.3.16]. This was then combined with state and national data on frequency of trucking accidents and probability of chemical release in an accident [Refs. 4.3.12 and 4.3.13] to determine overall probability of an external event and likelihood of incapacitation.

It was further assumed that if CR operator incapacitation occurred, the probability of exceeding 10CFR100 limits is 0.158 per year, consistent with Reference 4.3.15. Such an assumption gives no credit for operator response prior to incapacitation or response by others. The following formula was developed for determining probability:

Probability of a Release Exceeding 10CFR100 Limits = Truck Accident Rate per Mile X Highway Miles of Risk

X Number of Trucks per Year X Fraction of Trucks Carrying Hazardous Material X Fraction of Hazmat Accidents Resulting in Release

X Fraction of Releases Severe Enough to Cause CR Operator Incapacitation X Probability of Exceeding 10CFR100/Operator Incapacitation

The acceptance criteria of Standard Review Plan Section 2.2.3 [Ref. 4.1.5] and Reg. Guide 1.70 [Ref. 4.1.12] were used to determine if the likelihood of a spill resulting from a trucking accident warranted any special control room design features for operator protection. If it could be shown that the probability of an accident where 10CFR100 limits are exceeded, resulting from a trucking accident, is less than 10^{-7} per year or 10^{-6} per year with conservative assumptions, special design features are not required.

3.0 FINAL RESULTS

The Toxic Chemical Survey identified a number of chemicals that exceeded the screening requirements of RG 1.78. These chemicals were evaluated using the assessment criteria of Section 2.4. With the exception of truck shipments, the results are summarized in Table 3-1 and presented below in chemical groupings by locale or transport mechanism similar to Section 2.2. Table 3-1 includes each chemical, identifies the applicable elimination criteria, and summarizes the final analytical results. Each chemical is discussed in more detail below based on the most limiting, conservative, calculation. Many of the chemicals listed below were evaluated in the Original Study and no special detectors were required. The additional bases used in this study further substantiates the conclusion that special detectors for the same chemicals are still not required. However, credit for results of the Original Study was not taken and reanalysis provides added assurance that early detection is not required.

3.1 Toxic Chemicals Stored Onsite

The survey identified a total of eleven chemicals stored onsite that are identified in the MNGP "Hazardous Substance Inventory" [Ref. 4.2.7]. Five of these chemicals (sodium bromide, sodium hypochlorite, liquid oxygen, turbine oil, and lube oil) were eliminated from further consideration as they are not identified in 29CFR 1910 or by the ACGIH [Ref. 4.3.20] or NIOSH [Ref. 4.3.5] as toxic and, due to their physical properties, due not pose a risk to operators. The remaining six chemicals are discussed individually below. It should be noted that additional chemicals are stored onsite that are not included on the "Hazardous Substance Inventory." A complete listing of chemicals used at the MNGP is contained in the Chemical Materials and Manufacturers List [Ref. 4.2.8]. This list was reviewed to determine if any chemicals not contained in the "Hazardous Substance Inventory" required evaluation. It was concluded that none of these chemicals required evaluation because either: 1) They are stored in quantities below the 100 pound limit specified by RG 1.78, or 2) Their individual storage quantity is not significantly greater than 100 pounds and they are stored in enclosed structures that do not interface with the control room air intake or ventilation system. In these cases it is not considered credible that these materials could pose a risk to the control room operators.

During the development of this study it was noted that the SARA Title III Report contains a discrepancy on the size of the propane tank. There is no 1,700 gallon propane tank at Monticello. The actual installed tank is 120 gallons and serves as the pilot light source for the heating boiler. This was confirmed during a plant walkdown. As this discrepancy was identified, the Monticello Chemistry Department performed an independent walkdown of the site to identify all chemicals stored in quantities in excess of Regulatory Guide 1.78 limits. This walkdown was also performed to resolve Corrective Action 1 of FOI 92-0013 [Ref. 4.3.28]. Results of the study [Ref. 4.3.30] do not change the conclusions of this report or in any way modify the chemical list contained in Table 2-2.

Diesel Fuel:

Diesel fuel is not specifically identified in 29CFR 1910 or by the ACGIH or NIOSH as toxic. The vast majority of the diesel fuel stored onsite is stored in underground tanks. A rupture of the underground tanks would result in ground seepage and not vapor release. That portion stored above ground is stored in tanks of approximately 500 gallon and 1,500 gallon capacity. The 1,500 gallon tanks are located indoors which would delay and reduce the release rate to the atmosphere. One 500 gallon tank is located outdoors; however, due to its location behind Warehouse #4 and due to the low evaporation rate and low toxicity of diesel fuel, it is considered to pose no threat to the control room operators. Consequently, diesel fuel was eliminated from further consideration.

Liquid Nitrogen:

Nitrogen is not listed as a toxic material, however, it can act as an asphyxiant by displacing oxygen. It should also be noted that no direct means of nitrogen detection is feasible due to its normal concentration in air. As noted in Reference 4.3.10, conservative modeling methods result in a brief peak CR nitrogen concentration (contribution from the storage tank) of 90,500 ppm. Reference 4.3.25 notes that workplace oxygen levels should equal or exceed 18% (or a 3% reduction in oxygen concentration). A 3% reduction in oxygen concentration due to nitrogen displacement would correspond to an additional nitrogen concentration of 143,000 ppm. Since the peak nitrogen concentration is well below this value, early detection of nitrogen is not required.

Liquid Hydrogen:

Hydrogen is not listed as a toxic material. It acts as an asphyxiant in a manner similar to nitrogen. As the hydrogen stored onsite is stored in an above ground tank of the same size as the above ground nitrogen storage tank, and since the hydrogen storage tank is located approximately 0.2 miles further from the control room intake than the nitrogen tank, the conclusions reached for nitrogen are considered to bound hydrogen releases.

Propane:

Propane was modeled in Reference 4.3.10. The concentration rises rapidly past the detection level (5,000 ppm) at 14 seconds, past the IDLH level (20,000 ppm) at 16 seconds, reaches 143,000 ppm at 94 seconds, and peaks at 178,000 ppm at 256 seconds. At two minutes subsequent to detection, the concentration is 162,000 ppm. As noted in Reference 4.3.10, propane acts as a simple asphyxiant. Although the maximum workplace concentration for asphyxiants of 143,000 ppm (see nitrogen discussion above) is slightly exceeded, the additional oxygen depletion is minor (3.4% at two minutes versus 3% at 143,000 ppm). Also, if the time-weighted-average (TWA) IDLH is considered and conservatively compared to the peak concentration for two minutes, the result is still below the TWA IDLH of $3.6X10^7$ ppm·sec. These results are considered acceptable since it must be noted that the analysis of Reference 4.3.10 assumed a very conservative, worst case scenario where no credit was taken for dilution caused by building wake effects or elevation effects. Also, an appreciable amount (one minute and twenty seconds) of the two minute response time has passed from the time of detection to the time when 143,000 ppm is exceeded. Based on the analysis conclusions and the conservatisms built into this worst-case analysis, the onsite propane tank does not pose an incapacitation threat to the CR operators. Therefore, early detection of propane is not required.

Stoddard Solvent:

Stoddard Solvent is stored in a maximum quantity of 110 pounds in a tank in warehouse #5. This quantity is not reportable under SARA Title III requirements. Due to the quantity stored (which only slightly exceeds the RG 1.78 cutoff criterion of 100 pounds), the storage location, its low vapor pressure (approximately 2 mm Hg), and its relatively high TLV of 500 ppm and IDLH level of 5,000 ppm, stoddard solvent does not pose a risk to CR operators and does not require early detection.

Gasoline:

Gasoline was modeled in Reference 4.3.10. As noted in Reference 4.3.10, the modeling analysis used conservative enveloping values for various components of gasoline to develop the incapacitation analysis. The 30 minute IDLH of the most limiting component is exceeded, however, the CR concentration is still below the IDLH values for the other representative components. If the concentration of the limiting component (without taking credit for dilution in the gasoline mixture) two minutes subsequent to recognition is conservatively assumed to have existed throughout the entire time between exceeding the TLV and two minutes subsequent to recognition (131 seconds), the total dose is $4.11X10^5$ ppm·sec. This is far below the TWA IDLH of the limiting component of $3.6X10^6$ ppm·sec. Operators will have had sufficient time to don protective breathing apparatus before the TWA IDLH is reached. Therefore, early detection of gasoline is not required.

3.2 Toxic Chemicals Stored Within Five Miles of the MNGP

As noted in Section 2.2, the survey obtained listings of hazardous chemicals and their quantities for facilities within five miles of the MNGP. Table 3-1 provides a summary of the chemicals and quantities stored at each facility. Table 3-1 also indicates whether each chemical is listed in 29CFR 1910, ACGIH, or NIOSH, whether each chemical can be eliminated based on other bounding locations and quantities, whether each chemical can be eliminated based on its chemical properties, whether the TLV or IDLH levels are exceeded, and whether greater than two minutes are available to the operators. Not all of the above evaluations are performed for each chemical; only those evaluations that are necessary to demonstrate that early detection is not required for the specific chemical are performed.

Details of the evaluations for each facility are provided below.

Facility: Sherburne County Generating Plant (Sherco)

Chemical: Anhydrous Ammonia:

Eliminated based on bounding case rail shipment.

Ammonia (Hydroxide):

Eliminated based on its not being listed in 29CFR 1910, ACGIH, or NIOSH (hereinafter this will simply be stated as "Not listed"). Also bounded by rail shipment of anhydrous ammonia.

Chlorine:

Eliminated based on bounding case rail shipment.

Sulfuric Acid:

Sulfuric acid was modeled in Reference 4.3.10. The maximum concentration of sulfuric acid in the CR is 0.001807 ppm. This is significantly below the TLV of 0.25 ppm. Therefore, early detection of sulfuric acid as a result of a spill at the Sherco plant is not required.

Hydrazine (35%):

Approximately 3.5 miles from the Monticello site hydrazine is stored inside a building in a maximum quantity of 690 gallons at 35% solution (approximately equivalent to 240 gallons of pure hydrazine). Hydrazine has an IDLH of 80 ppm [Ref. 4.3.5] which equates to approximately 106 mg/m^3. Based on comparison to the exclusion criteria of Table C-2 of Reg. Guide 1.78 [Ref. 4.1.3], it is concluded that analysis of hydrazine is not required. The result of the analysis for a Type C control room (unisolated with no chemical detectors) is presented below:

Pasquill G versus F:	Decrease maximum storage amount to 40%
106 mg/m^3 toxicity limit:	Increase storage amount by 106/50 = 2.12
CR air exchange rate:	1.2 chgs/hr / 16.5 chgs/hr [Ref. 4.3.7] = 0.073
Type C CR 3 to 4 miles: (From Table C-2)	33,000 lbs or less allowable storage

Using the above inputs, the maximum storage amount becomes:

33,000 lbs x 0.4 x 2.12 x 0.073 = 2,043 lbs

As the liquid density of hydrazine is almost exactly that of water, 240 gallons is equivalent to 2,047 lbs of hydrazine. In conclusion, further analysis of hydrazine is not required as hydrazine at the maximum storage quantity is approximately that of Table C-2 of Reg. Guide 1.78, the storage location (3.5 miles) exceeds the minimum allowable distance of 3 miles that the above analysis can be applied to, and the material is stored inside a building which further limits and impedes its release should the container fail.

Sodium Hydroxide (50% solution):

Eliminated based on the location 3.5 miles away and the non-volatile properties of NaOH solutions and the consequent lack of significant toxic vapor releases.

Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Lime:

Eliminated based on chemical properties. Lime is a solid material with essentially zero vapor pressure. Consequently, no significant toxic vapor releases are postulated.

Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Propane:

Eliminated based on bounding case rail shipment.

Carbon Dioxide:

Eliminated based on bounding case rail shipment.

Fly/Bottom Ash:

Eliminated based on chemical properties. Ash is a solid material with essentially zero vapor pressure. Consequently, no significant toxic vapor releases are postulated.

Ethylene Glycol (50% solution):

Eliminated based on chemical properties. Liquid ethylene glycol is not listed. Only ethylene glycol vapor is listed. Further, ethylene glycol has a vapor pressure of 0.06 mm Hg. Consequently, any vapor releases from an ethylene glycol solution at a 3.5 mile distance would be insignificant.

Lube Oil:

Eliminated based on chemical properties. Lubricating oils are not listed and due to their physical properties (e.g. low volatility) they do not present a risk to the CR operators.

EHC Fluid:

Eliminated based on the argument given above for lube oils.

Betz Foamtrol & Flowpro:

These substances are used for material handling treatment. They are stored indoors in small quantities (under 400 gallons), are not listed, and are exempt from SARA reporting requirements. Consequently, they can be eliminated.

Betz Powerline:

The following three Powerline products are stored in SARA reportable quantities: Powerline 2105, Powerline 2107, and Powerline 2151. All are used as material handling treatments or dust suppressants. Powerline 2105 is based on a proprietary formula; however, according to its Material Safety Data Sheet

(MSDS) [Ref. 4.2.10], it has no established TLV, has a low vapor pressure (18 mm Hg), and can cause slight skin irritation and moderate eye irritation. It is stored indoors in a maximum capacity of 8,400 gallons. Due to its low toxicity, its low volatility, its storage location and quantity, and its large distance from the MNGP, the effects of a spill of Powerline 2105 will be bounded by releases of larger quantities of more volatile and toxic materials from the BN railroad line. Consequently, Powerline 2105 can be eliminated.

Powerline 2107 is made up of sodium olefin sulfonate and ethyl alcohol per its MSDS [Ref. 4.2.10]. It is stored indoors in a maximum capacity of 12,800 gallons. Sodium olefin sulfonate has no established TLV. Ethyl alcohol releases are bounded by releases from the BN railroad line which is much closer to the MNGP and which transports larger quantities. For these reasons and the reasons given above for Powerline 2105, Powerline 2107 can be eliminated.

Powerline 2151 is made up of heavy naphthenic distillates. It has a TLV of 5 mg/m^3 (oil mist) and a vapor pressure of 10 mm Hg. It is stored indoors in a maximum capacity of 11,000 gallons. According to its MSDS [Ref. 4.2.10] it is slightly irritating to the skin and eyes. Due to its oil-like physical properties, it has a very low volatility. For these reasons and the reasons given above for Powerline 2105, Powerline 2151 can be eliminated.

Paints:

Paints are not listed and due to the small quantities (5 gallon containers) can be eliminated.

Painter Solvents:

Eliminated based on bounding case rail shipments of various volatile materials in much larger quantities at much smaller distances.

Facility: Becker Tom Thumb

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Fuel Oil:

Due to similar properties as diesel fuel oil, fuel oil is eliminated for the same reasons.

Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Facility: Anderson-Gilyard

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Fuel Oil:

Due to similar properties as diesel fuel oil, fuel oil is eliminated for the same reasons.

Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Propane:

Eliminated based on bounding case rail shipment.

Facility: Becker Schools

Chemical: Antifreeze:

Antifreeze is typically based on ethylene glycol. Antifreeze is eliminated based on the bounding case arguments presented above for ethylene glycol stored at the Sherburne County Generating Plant.

Chlorine:

Eliminated based on bounding case rail shipment.

Fuel Oil:

Due to similar physical properties as diesel fuel oil, fuel oil is eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Lube Oil:

Eliminated based on chemical properties. Lubricating oils are not listed and due to their physical properties (e.g. low volatility) they do not present a risk to the CR operators.

Facility: Howe Co.

Chemical: Aldicarb, Carbofuran, Endosulfan, Phorate, and Terbufos

Eliminated based on physical properties, location, and quantities stored. All of the chemicals listed are insecticides and are stored in dry form in containers no larger than 40 gallons per Reference 4.2.11. They are not volatile and due to their distance from the MNGP (approximately 4-5 miles) they pose no threat to the CR operators.

Paraquat:

Eliminated based on physical properties, toxicity, location, and quantities stored. Paraquat is stored in liquid form in containers no larger than 40 gallons. According to the ACGIH, paraquat causes mild irritation of the eyes, nose and throat. It should be noted that paraquat does cause cumulative lung damage and is a suspected teratogen, however, these are long term effects. Due to the small quantity stored, the distance from the MNGP, and the mild acute symptoms resulting from exposure, early detection of paraquat is not required.

Facility: Tom Thumb #239

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Facility: Sand Plains Soil Service

Chemical: Anhydrous Ammonia:

Eliminated based on bounding case rail shipment.

Facility: Barton Sand & Gravel

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Facility: Bondhus Corp.

Chemical: Nitrogen (liquid):

Eliminated based on the large distance (greater than 4 miles) and the non-toxic nature of nitrogen which only poses a risk as an asphyxiant. Also, nitrogen stored at the MNGP much closer to the control room intake poses no asphyxiant hazard.

Selenious Acid:

Greater than 4 miles from the Monticello site selenious acid is stored in a quantity less than 1,000 lbs. Selenium compounds have an IDLH of 100 mg/m^3 [Ref. 4.3.5]. Based on comparison to the exclusion criteria of Table C-2 of Reg. Guide 1.78 [Ref. 4.1.3], it is concluded that analysis of selenious acid is not required. The result of the analysis for a Type C control room (unisolated with no chemical detectors) is presented below:

Pasquill G versus F:	Decrease maximum storage amount to 40%
100 mg/m^3 toxicity limit:	Increase storage amount by 100/50 = 2
CR air exchange rate:	1.2 chgs/hr / 16.5 chgs/hr [Ref. 4.3.7] = 0.073
Type C CR 4 to 5 miles:	60,000 lbs or less allowable storage

Using the above inputs, the maximum storage amount becomes:

60,000 lbs x 0.4 x 2 x 0.073 = 3504 lbs

In conclusion, further analysis of selenious acid is not required as the stored quantity is less than that allowed by the Reg. Guide.

Facility: Sunny Fresh Foods

Chemical: Anhydrous Ammonia:

Eliminated based on bounding case rail shipment.

Carbon Dioxide (liquid):

As discussed in Section 3.5 of this report, carbon dioxide shipments on the rail line do not require analysis as they meet the exclusion criteria of Reg. Guide 1.78 [Ref. 4.1.3] for the amount shipped and the distance to the site. If the results of that analysis are applied to the Sunny Fresh Foods facility which is farther from the site (3.2 miles versus 2 miles for the rail line) the allowable storage quantity can be increased (per Reg. Guide 1.78 Table C-2) by approximately 2.5 (33,000 lbs/13,000 lbs) and still meet the exclusion criteria. The resulting allowable storage quantity exceeds both the maximum amount normally stored and the maximum amount allowed to be stored at this facility (see Table 3-1).

Facility: Pump-N-Munch

Chemical: Gasoline:

Gasoline is stored in underground tanks of up to 8,000 gallon capacity per Reference 4.2.12. Due to the underground location of the tanks, any leakage or rupture would result primarily in ground seepage with minimal vapor release. Further, due to the large distance (approximately 3 miles) and the relatively low toxicity of gasoline, no impact on the MNGP is postulated. Additionally, gasoline stored onsite was deterministically modeled and demonstrated not to result in incapacitation. Consequently, gasoline at this location can be eliminated.

Facility: Monticello Waste Treatment Plant

Chemical: Chlorine:

Eliminated based on bounding case rail shipment.

Facility: Minnesota Dept. of Transportation

Chemical: Asphalt:

Eliminated based on the low toxicity and low volatility of asphalt and due to the inability to produce an atmospheric "release" of asphalt due to its physical properties.

Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Fuel Oil:

Due to similar physical properties as diesel fuel oil, fuel oil is eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Facility: Monticello Middle School

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Fuel Oil:

Due to similar physical properties as diesel fuel oil, fuel oil is eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Facility: Pinewood Elementary School

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Facility: Bridgewater Telephone Co.

Chemical: Sulfuric Acid:

Eliminated based on bounding case quantities/location at Sherburne County Generating Plant.

Facility: Monticello High School

Chemical: Chlorine:

Eliminated based on bounding case rail shipment.

Fuel Oil:

Due to similar physical properties as diesel fuel oil, fuel oil is eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Facility: JM Oil Co.

Chemical: Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Fuel Oil:

Due to similar physical properties as diesel fuel oil, fuel oil is eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Kerosene:

Kerosene is not listed and is not particularly volatile. Due to the large distance (3 miles), the quantity stored (less than 10,000 pounds), and its low toxicity and volatility, kerosene can be eliminated from consideration.

Facility: AT&T

Chemical: Sulfuric Acid:

Eliminated based on bounding case of sulfuric acid storage at the Sherco plant.

Facility: Amoco Oil SS 7399

Chemical: Gasoline:

Eliminated based on bounding case of gasoline storage at the Pump-N-Munch in Monticello.

Facility: Vision Energy MN

Chemical: Propane:

Eliminated based on bounding case rail shipment.

3.3 Toxic Chemicals Transported by Truck

Toxic chemicals transported by truck were evaluated based on probabilistic techniques as documented in Reference 4.3.11. In regard to truck transport of toxic materials, there are two principal highways of concern in the vicinity of the MNGP: Interstate 94 passes approximately one-half mile to the southwest of the site, and Highway 10 passes approximately two miles northeast of the site. As documented in Reference 4.3.11, the probability of a radioactive release from the MNGP in excess of 10 CFR 100 guidelines due to operator incapacitation resulting from a trucking accident on the above mentioned highways is less than 3.78×10^{-8} per year. This value is well below the acceptance criterion of approximately 10^{-6} per year stated in Reference 4.1.5. The actual probability of this event is lower than the value calculated due to conservatisms used throughout the analysis of Reference 4.3.11. Consequently, no actions are required to protect the control room operators from hazardous materials transported by truck.

3.4 Toxic Chemicals Transported by Barge

There is no commercial barge traffic on the Mississippi River within a five mile radius of the MNGP [Ref. 4.2.2]. Consequently, no barge shipments were evaluated.

3.5 Toxic Chemicals Transported by Rail

The Burlington Northern (BN) rail line constitutes a major source of toxic chemicals transported by the plant. No other active rail lines pass within five miles of the MNGP. The survey results indicate that 38 chemicals carried by the Burlington Northern Railroad past the plant exceed the shipping frequencies of 30 per year defined in RG 1.78. These chemicals are listed in Tables 2-3 and 3-1 and are discussed individually below.

Anhydrous Ammonia:

Anhydrous ammonia was modeled in Reference 4.3.8. The time between detection and incapacitation is 3 minutes 12 seconds. Since this exceeds the 2 minute limit established in RG 1.78, no automatic detection is required.

Carbon Dioxide:

Carbon dioxide is transported in 20,000 gallon containers by rail approximately 2 miles from the Monticello site. "Carbon dioxide when inhaled in elevated concentrations may act to produce mild narcotic effects" [Ref. 4.3.26] and as such, it has a high IDLH (50,000 ppm). Based on comparison to the exclusion criteria of Table C-2 of Reg. Guide 1.78 [Ref. 4.1.3], it is concluded that analysis of carbon dioxide is not required. The result of the analysis for a Type C control room (unisolated with no chemical detectors) is presented below:

Pasquill G versus F:	Decrease maximum storage amount to 40%
91,462 mg/m^3 toxicity limit: (based on a 50,000 ppm IDLH and molecular weight of 44 g/mole)	Increase storage amount by 91,462/50 = 1829
CR air exchange rate:	1.2 chgs/hr / 16.5 chgs/hr [Ref. 4.3.7] = 0.073
Type C CR 2 miles:	13,000 lbs or less allowable storage

Using the above inputs, the maximum storage amount becomes:

13,000 lbs x 0.4 x 1829 x 0.073 = 694,000 lbs

In conclusion, further analysis of carbon dioxide rail shipments is not required as the shipped quantity is less than that allowed by the Reg. Guide.

Butadiene:

Butadiene was modeled in Reference 4.3.8. Two minutes subsequent to recognition, the concentration is 170.7 ppm which is well below the TLV of 1,000 ppm. Consequently, early detection is not required.

Butane:

Butane was modeled in Reference 4.3.8. Two minutes subsequent to detection, the CR concentration is 406.4 ppm. This is well below the TLV of 800 ppm. Therefore, early detection is not required.

Isobutane:

Isobutane was modeled by analyzing butane releases from the BN line. As noted in the modeling results for butane, significantly greater than two minutes are available prior to operator incapacitation. Therefore, early detection of isobutane is not required.

Liquified Petroleum Gas (LPG):

LPG is primarily a combination of butane and propane. Reference 4.3.8 demonstrates that for butane and propane CR operators have greater than two minutes until incapacitation subsequent to detection. This analysis conservatively assumes detection at a propane concentration of 5,000 ppm. This is much higher than the detection threshold for butane. Also, a foul smelling odorant is typically added to LPG to aid in its detection. Consequently, early detection of LPG is not required.

Propane:

Propane was modeled in Reference 4.3.8. The TLV (1,000 ppm) is first exceeded at 3118 seconds following the release. Two minutes subsequent to detection, the CR concentration is 8377 ppm. At this point, the concentration is decreasing with a peak of 8505 ppm occurring 20 seconds earlier.

The time-weighted-average (TWA) of the IDLH is $3.6X10^7$ ppm·sec. If the peak concentration is conservatively assumed present over the entire period from when the TLV is first exceeded, the TWA for propane is $1.75X10^6$ ppm·sec. This value is well below the IDLH TWA and well below an asphyxiant level. Therefore, early detection of propane is not required.

Propylene:

Propylene was modeled in Reference 4.3.10. Propylene is a simple asphyxiant and consequently must displace a significant quantity of oxygen to pose a threat to the CR operators. Two minutes subsequent to recognition, the concentration is 2,876 ppm. This is far below the TLV of 143,000 ppm for simple asphyxiants. Consequently, early detection of propylene is not required.

Vinyl Chloride:

Vinyl chloride was modeled in Reference 4.3.8. Vinyl chloride can be first detected at 20 ppm. Two minutes subsequent to detection the CR concentration has climbed to 853 ppm. Model D of Reference 4.1.7 integrates the curve chemical concentration versus time to determine the incapacitating dose, which for vinyl chloride is $4.5X10^6$ ppm·sec. The lower limit is the time at which the concentration equals the value C_o, at which significant and immediate physiological effects are evident. The upper limit is the time at which incapacitation occurs. In this case, the sum within the time interval between reaching a concentration C_o and two minutes subsequent is approximately $2.1X10^5$ ppm·sec which is significantly below the incapacitating dose. Therefore, early detection for vinyl chloride is not required.

Ethylene Oxide:

Ethylene oxide was modeled in Reference 4.3.8. The TLV (1 ppm) is first exceeded at time = 2986 seconds. Recognition occurs (concentration at 490 ppm) at time = 3170 seconds. Two minutes subsequent to recognition, the CR concentration has risen to 1352 ppm. The average concentration over the time period beginning at the TLV being exceeded and ending at two minutes subsequent to recognition (about five minutes) is under 700 ppm. Both the average concentration and total time are less than the IDLH of 800 ppm. Consequently, early detection of ethylene oxide is not required.

Styrene Monomer:

Styrene monomer was modeled in Reference 4.3.9. The peak CR concentration is 10.63 ppm. This is well below the TLV of 100 ppm. Therefore, early detection of styrene monomer is not required.

Benzene:

Benzene was modeled in Reference 4.3.9. The CR concentration two minutes subsequent to recognition is 142.9 ppm. The 30 minute IDLH for benzene is 2,000 ppm. Consequently, the CR operators have sufficient time to don protective breathing gear and early detection of benzene is not required.

Denatured Alcohol:

Denatured alcohol is not listed as a toxic vapor in 29CFR 1910, nor does it have an established TLV in the ACGIH or NIOSH references. Also, the modeling results for other alcohols show acceptable results; it can therefore be concluded that although potentially harmful, denatured alcohol poses no incapacitation threat. Therefore, early detection is not required.

Ethyl Alcohol:

Ethyl alcohol was modeled in Reference 4.3.7. The peak CR concentration is 175 ppm. This is far below the TLV of 1,000 ppm, indicating that CR operator incapacitation will not occur. Therefore, early detection is not required.

Ethylene Dichloride:

Ethylene dichloride was modeled in Reference 4.3.9. The results indicate a TWA of 61,716.6 ppm·sec which is significantly below the IDLH TWA of $1.8X10^6$ ppm·sec. Consequently, early detection of Ethylene dichloride is not required.

Isopropanol:

Isopropanol is transported in identical quantities to ethyl alcohol. Isopropanol has a higher boiling point and a lower vapor pressure than ethyl alcohol. Consequently, the concentrations obtained from modeling ethyl alcohol can be assumed to be bounding for isopropanol. Isopropanol has a TLV of 400 ppm which is significantly greater than the peak CR concentration of 175 ppm obtained for ethyl alcohol. Therefore, isopropanol does not pose an incapacitation threat and early detection is not required.

Methyl Alcohol:

Methyl alcohol was modeled in Reference 4.3.9. The peak concentration of 478.6 ppm occurs at approximately 5300 seconds (1.5 hours) following the release. The detection and recognition thresholds for Methyl alcohol are 160 ppm and 690 ppm respectively. Therefore, although recognition will not occur, detection will prompt operator actions. Also, the time required for the peak to be reached should allow notification to the CR operators that a release has occurred. Finally, the IDLH of 25,000 ppm is never approached for Methyl alcohol. Consequently, early detection is not required.

(Petroleum) Naphtha:

Petroleum naphtha was modeled in Reference 4.3.9. The peak CR concentration is 201.1 ppm. This is well below the TLV of 500 ppm. Therefore, early detection is not required.

Diesel Fuel:

Eliminated based on the arguments presented above for diesel fuel stored at the MNGP.

Metallic Sodium:

This material is a solid at ambient temperature and has an extremely low mass release rate due to a low vapor pressure. Therefore, early detection is not required.

Molten Sulfur:

Molten sulfur is not listed in NIOSH or ACGIH. Due to the physical nature of sulfur, it is a solid at room temperature and is shipped in a liquid state in heated tank cars. According to Reference 4.3.23, sulfur has a vapor pressure of only 1 mm Hg at 184°C. As there is no physical means to keep sulfur heated once it has spilled, it does not pose a threat to the CR operators. Therefore, early detection is not required.

Hydrogen Peroxide:

Hydrogen peroxide was modeled in Reference 4.3.9. The peak CR concentration of 5.861 ppm occurs at 5700 seconds (1.6 hours) following the release. This concentration exceeds the TLV of 1 ppm, however, the 30 minute IDLH is 75 ppm. Consequently, it can be expected that the CR operators will have:

$$(30 \text{ minutes})\cdot(75\text{ppm}/5.861 \text{ ppm}) = 6.4 \text{ hours}$$

without significant ill effects. It is also reasonable to assume detection will occur and protective actions will be taken prior to reaching the peak concentration given the long time periods involved. Consequently, early detection of Hydrogen peroxide is not required.

Sodium Chlorate:

This chemical is a solid at ambient temperature and has an extremely low mass release rate due to a low vapor pressure. Therefore, early detection is not required.

Chlorine:

Chlorine was modeled in Reference 4.3.7. A conservative detection level of 1 ppm is used, even though Reference 4.3.24 cites a value of 0.08 ppm. The concentration in the CR reaches 1 ppm at 2970 seconds following the spill. The incapacitation analysis performed in Reference 4.3.7 indicates that an incapacitating concentration in the CR is reached at 3106 seconds following the spill. The time between detection and incapacitation is 136 seconds (2 minutes and 16 seconds). This exceeds the limit of 2 minutes set in RG 1.78. Because the 2 minute limit is exceeded, early detection for Chlorine is not required.

Phenol:

This chemical is a solid at ambient temperature and has a very low mass release rate due to a very low vapor pressure (0.4 mm Hg at S.T.P.). Therefore, early detection is not required.

Phosphoric Acid:

Phosphoric acid was modeled in Reference 4.3.9. The peak CR concentration is 0.1508 ppm. This is well below the TLV of 0.245 ppm. Consequently, early detection for Phosphoric acid is not required.

Acetic Acid, Glacial

Acetic acid was modeled in Reference 4.3.10. Detection occurs at 0.074 ppm at time = 3222 seconds. The TLV (10 ppm) is exceeded at time = 3298 seconds, one minute and 16 seconds later. Although no recognition value is identified, a conservative estimate of ten times the detection threshold results in 62 seconds before the TLV is exceeded. It should be noted, however, that the TLV is an eight hour exposure limit. When the peak concentration of 55.31 ppm is compared to the IDLH value, which signifies that the operators have 30 minutes when exposed to a concentration of 1000 ppm of Acetic Acid to respond and not incur any escape-impairing symptoms or irreversible health effects, it is evident that operators have sufficient time to don protective masks. Therefore, early detection is not required.

Titanium Tetrachloride:

Titanium Tetrachloride is not listed in 29CFR 1910 as an air contaminant, nor is it listed in NIOSH or ACGIH. According to Reference 4.3.23, titanium tetrachloride is a liquid with a density and boiling point greater than water. It is used commercially to produce smoke screens and, consequently, can be expected to have a low capacity for incapacitation. Therefore, early detection is not required.

Sodium Hydroxide (solution):

Sodium hydroxide solutions are non-volatile (behaving similarly to water) and have insignificant release rates for sodium hydroxide vapors. Consequently, no incapacitation threat is posed to the CR operators and early detection is not required.

Maleic Anhydride:

Maleic anhydride is a non-volatile, solid material at ambient conditions and has an extremely low vapor pressure. As such, there is no potential for significant airborne releases to travel to the CR intake and pose a threat to the CR operators. Therefore, early detection is not required.

Flammable Liquid, Aromatic Concentrates, Combustible Liquid, Mixed Loads of Hazardous Materials, Hazardous Liquid, Hazardous Liquid containing Diethyl Phthalate, Hazardous Liquid containing Creosote, and Hazardous Solid containing Benzo-A-Pyrene:

None of these materials are described in sufficient detail to conclusively identify each of their constituents. Also, they are generally not listed in 29CFR 1910 or ACGIH or NIOSH. However, they can reasonably be expected to be bounded in their effects by other materials that are modeled. For example, the flammable liquid, aromatic concentrates, and combustible liquid are expected to be bounded by results for other flammable or volatile materials such as benzene, alcohols, or propane.

For the reasons given above, it can be concluded that these materials pose no incapacitation risk to the CR operators. Consequently, early detection is not required.

Table 3-1
Final Results for Surveyed Chemicals

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
Toxic Chemicals Stored Onsite:										
1. Diesel Fuel	MNGS 0 miles	94,170/84,100 gallons	60,000 gallons	Yes	No	Yes				
2. Sodium Bromide (Nalco Actibrom)	MNGS 0 miles	2,000/1,500 gallons	2,000 gallons	Yes						
3. Sodium Hypochlorite	MNGS 0 miles	6,000/6,000 gallons	6,000 gallons	Yes						
4. Hydrogen (liquid)	MNGS 0 miles	9,000/9,000 gallons	9,000 gallons	No	Yes (5) (Note 1)					
5. Nitrogen (liquid and gas)	MNGS 0 miles	9,000 gal + 21,544 cf	9,000 gallons	No	No	No	Yes			
6. Oxygen (liquid)	MNGS 0 miles	9,000/9,000 gallons	9,000 gallons	Yes	No	Yes				
7. Propane (liquid and gas)	MNGS 0 miles	120 gal	120 gallons	No	No	No	No	Yes		
8. Stoddard Solvent	MNGS 0 miles	110/110 lbs	110 lbs	No	No	Yes				
9. Turbine Oil	MNGS 0 miles	10,000/10,000 gallons	10,000 gallons	Yes	No	Yes				
10. Gasoline	MNGS 0 miles	1,000/600 gallons	500 gallons	No	No	No	No	Yes		
11. Lube Oil	MNGS 0 miles	10,000/8,600 gallons	10,000 gallons	Yes	No	Yes				
Toxic Chemicals Stored Within Five Miles of Plant:										
12. Anhydrous Ammonia	Sherco 3.5 miles	820/490 gallons	820 gallons	No	Yes (74)					
13. Ammonia (Hydroxide)	Sherco 3.5 miles	600/360 gallons	300 gallons	Yes	Yes (74)					
14. Chlorine	Sherco 3.5 miles	23/14 ton	4 tons (in four 1 ton ganged containers)	No	Yes (100)					
15. Sulfuric Acid	Sherco 3.5 miles	55,100/33,000 gallons	14,800 gallons	No	No	No	Yes			

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
16. Hydrazine (2% & 35% Solution)	Sherco 3.5 miles	1,035/620 gal (35%) 393/236 gal (2%)	690 gal (35%) 282 gal (2%)	No	No	Yes				
17. Sodium Hydroxide (50% Solution)	Sherco 3.5 miles	6,000/3,600 gallons	6,000 gallons	No	No	Yes				
18. Diesel Fuel	Sherco 3.5 miles	434,475/260,000 gallons	400,000 gallons	Yes	No	Yes				
19. Lime	Sherco 3.5 miles	5,000/3,600 ton	5,000 ton	No	No	Yes				
20. Gasoline	Sherco 3.5 miles	2,500/1,500 gallons	2,500 gallons	No	Yes (56)					
21. Propane	Sherco 3.5 miles	10,000/6,600 gallons	10,000 gallons	No	Yes (60)					
22. Carbon Dioxide	Sherco 3.5 miles	24,000/14,400 lbs	12,000 lbs	No	Yes (75)					
23. Fly/Bottom Ash	Sherco 3.5 miles	not given	not given	Yes	No	Yes				
24. Ethylene Glycol (50% Solution)	Sherco 3.5 miles	74,000/60,000 gallons	40,000 gallons	No	No	Yes				
25. Lube Oil	Sherco 3.5 miles	109,248/64,600 gallons	14,450 gallons	Yes	No	Yes				
26. EHC Fluid	Sherco 3.5 miles	1,500/1,600 gallons	600 gallons	Yes	No	Yes				
27. Betz Foamtrol & Flowpro	Sherco 3.5 miles	455/273 gallons	400 gallons	Yes	No	Yes				
28. Betz Powerline (Various)	Sherco 3.5 miles	33,110/19,846 gallons	12,000 gallons	Yes	Yes (Various Rail Shipments)	Yes				
29. Paints	Sherco 3.5 miles	700/592 gallons	5 gallons	Yes	No	Yes				
30. Painter Solvents	Sherco 3.5 miles	500/355 gallons	55 gallons	No	Yes (Various Rail Shipments)					
31. Diesel Fuel	Becker Tom Thumb 4-5 miles	1E5-1E6/1E4-1E5 lbs		Yes	No	Yes				
32. Fuel Oil	Becker Tom Thumb 4-5 miles	1E4-1E6/1E4-1E5 lbs		Yes	No	Yes				
33. Gasoline	Becker Tom Thumb 4-5 miles	1E5-1E6/1E4-1E5 lbs		No	Yes (56)					

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
34. Diesel Fuel	Anderson-Gilyard 4-5 miles	1E5-1E6/1E4-1E5 lbs		Yes	No	Yes				
35. Fuel Oil	Anderson-Gilyard 4-5 miles	1E5-1E6/1E4-1E5 lbs		Yes	No	Yes				
36. Gasoline	Anderson-Gilyard 4-5 miles	1E5-1E6/1E4-1E5 lbs		No	Yes (56)					
37. Propane	Anderson-Gilyard 4-5 miles	1E4-1E5/1E3-1E4 lbs		No	Yes (60)					
38. Antifreeze	Becker Schools 4.4 miles	1E2-1E3/0-1E2 lbs		No	Yes (24)					
39. Chlorine	Becker Schools 4.4 miles	1E2-1E3/0-1E2 lbs		No	Yes (100)					
40. Fuel Oil	Becker Schools 4.4 miles	1E5-1E6/1E4-1E5 lbs		Yes	No	Yes				
41. Lube Oil	Becker Schools 4.4 miles	1E2-1E3/0-1E2 lbs		Yes	No	Yes				
42. Aldicarb	Howe Co. 4-5 miles	1E3-1E4/1E2-1E3 lbs (40 gal max.)		Yes	No	Yes				
43. Carbofuran	Howe Co. 4-5 miles	1E3-1E4/1E2-1E3 lbs (40 gal max.)		No	No	Yes				
44. Endosulfan	Howe Co. 4-5 miles	1E3-1E4/0-1E2 lbs (40 gal max.)		No	No	Yes				
45. Paraquat	Howe Co. 4-5 miles	1E2-1E3/0-1E2 lbs (40 gal max.)		No	No	Yes				
46. Phorate	Howe Co. 4-5 miles	1E3-1E4/1E2-1E3 lbs (40 gal max.)		No	No	Yes				
47. Terbufos	Howe Co. 4-5 miles	1E3-1E4/1E2-1E3 lbs (40 gal max.)		Yes	No	Yes				
48. Diesel Fuel	Tom Thumb #239 4-5 miles	1E3-1E4/1E2-1E3 lbs		Yes	No	Yes				

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
49. Gasoline	Tom Thumb #239 4-5 miles	1E5-1E6/1E4-1E5 lbs		No	Yes (56)					
50. Anhydrous Ammonia	Sand Plains Soil Serv. 3.2 miles	1E5-1E6/1E4-1E5 lbs (30,000 gal max.)		No	Yes (74)					
51. Diesel Fuel	Barton Sand & Gravel 1/2-5 miles	1E4-1E5/1E4-1E5 lbs		Yes	No	Yes				
52. Nitrogen (liquid)	Bondhus Corp. Over 4 miles	1E5-1E6/1E5-1E6 lbs		No	Yes (5)	Yes				
53. Selenious Acid	Bondhus Corp. Over 4 miles	1E2-1E3/0-1E2 lbs		No	No	Yes				
54. Anhydrous Ammonia	Sunny Fresh Foods Approx. 3.2 miles	1E3-1E4/1E3-1E4 lbs		No	Yes (74)					
55. Carbon Dioxide (liquid)	Sunny Fresh Foods Approx. 3.2 miles	1E5-1E6/1E4-1E5 lbs		No	No	Yes				
56. Gasoline	Pump-N-Munch 3.1 miles	1E5-1E6/1E5-1E6 lbs (22,000 gal max.)	8,000 gal	No	Yes (10)	Yes				
57. Chlorine	Monti. Waste Plant 4.3 miles	1E3-1E4/1E3-1E4 lbs		No	Yes (100)					
58. Asphalt	MN/DOT 3.7-5 miles	1E4-1E5/1E4-1E5 lbs		No	No	Yes				
59. Diesel Fuel	MN/DOT 3.7-5 miles	1E3-1E4/1E2-1E3 lbs		Yes	No	Yes				
60. Fuel Oil	MN/DOT 3.7-5 miles	1E4-1E5/1E3-1E4 lbs		Yes	No	Yes				

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
61. Diesel Fuel	Montl. Middle School 4.8 miles	1E2-1E3/1E2-1E3 lbs		Yes	No	Yes				
62. Fuel Oil	Montl. Middle School 4.8 miles	1E4-1E5/1E4-1E5 lbs		Yes	No	Yes				
63. Diesel Fuel	Pinewood El. School Approx. 2.5 miles	1E2-1E3/1E2-1E3 lbs		Yes	No	Yes				
64. Sulfuric Acid	Bridgewater Tel. Co. 3.3 miles	1E2-1E3/0 lbs		No	Yes (15)					
65. Chlorine	Montl. High School 3.8 miles	1E2-1E3/1E2-1E3 lbs		No	Yes (100)					
66. Fuel Dil	Montl. High School 3.8 miles	1E4-1E6/1E4-1E5 lbs		Yes	No	Yes				
67. Diesel Fuel	JM Oil Co. 3 miles	1E3-1E4/1E3-1E4 lbs		Yes	No	Yes				
68. Fuel Dil	JM Oil Co. 3 miles	1E3-1E4/1E3-1E4 lbs		Yes	No	Yes				
69. Gasoline	JM Oil Co. 3 miles	1E3-1E4/1E3-1E4 lbs		No	Yes (56)					
70. Kerosene	JM Oil Co. 3 miles	1E3-1E4/1E3-1E4 lbs		Yes	No	Yes				
71. Sulfuric Acid	AT&T Approx. 5 miles	1E2-1E3/1E2-1E3 lbs		No	Yes (15)					
72. Gasoline	Amoco Oil SS 7399 3.5 miles	1E5-1E5/1E5-1E6 lbs		No	Yes (56)					

Chemical	Facility/ Distance	Total Quantity Stored Max/Ave	Max Quantity in Largest Storage Container	Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
73. Propane	Vision Energy MN Greater than 3.2 miles	1E4-1E5/1E2-1E3 lbs		No	Yes (80)					
Chemical	Facility/ Distance	Max Quantity Shipped per Container		Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
Toxic Chemicals Shipped by Truck										
See Section 3.3										Yes
Toxic Chemicals Shipped by Barge										
None (See Section 3.4)										
Toxic Chemicals Shipped by Rail	2 miles per Ref. 4.3.6									
74. Anhydrous Ammonia		33,500 gal		No	No	No	No	No	Yes	
75. Carbon Dioxide		20,000 gal		No	No	Yes				
76. Butadiene		33,500 gal		No	No	No	Yes			
77. Butane		33,500 gal		No	No	No	Yes			
78. Isobutane		33,500 gal		No	No	No	Yes			
79. Liquefied Petroleum Gas		33,500 gal		No	No	No	No	Yes		
80. Propane		33,500 gal		No	No	No	No	Yes		
81. Propylene		33,500 gal		No	No	No	Yes			
82. Vinyl Chloride		24,750 gal		No	No	No	No	No	Yes	

Chemical	Facility/ Distance	Max Quantity Shipped per Container		Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
83. Ethylene Oxide		33,500 gal		No	No	No	No	Yes		
84. Styrene Monomer		20,000 gal		No	No	No	Yes			
85. Benzene		20,000 gal		No	No	No	No	Yes		
86. Denatured Alcohol		29,200 gal		Yes	No	Yes				
87. Ethyl Alcohol		29,200 gal		No	No	No	Yes			
88. Ethylene Dichloride		20,000 gal		No	No	No	No	Yes		
89. Isopropanol		29,200 gal		No	No	No	Yes			
90. Methyl Alcohol		29,200 gal		No	No	No	No	Yes		
91. Naphtha		20,000 gal		No	No	No	Yes			
92. Flammable Liquid		20,000 gal		Yes	No	Yes				
93. Aromatic Concentrates		20,000 gal		Yes	No	Yes				
94. Diesel Fuel		20,000 gal		Yes	No	Yes				
95. Combustible Liquid		20,000 gal		Yes	No	Yes				
96. Metallic Sodium				Yes	No	Yes				
97. Molten Sulfur		13,550 gal		Yes	No	Yes				
98. Hydrogen Peroxide		20,000 gal		No	No	No	No	Yes		
99. Sodium Chlorate		20,000 gal		Yes	No	Yes				
100. Chlorine		90 ton		No	No	No	No	No	Yes	
101. Phenol		20,000 gal		No	No	Yes				

Chemical	Facility/ Distance	Max Quantity Shipped per Container		Not Listed in ACGIH, NIOSH or 29CFR 1910?	Eliminated Based on Other Bounding Locations/Quantities?	Eliminated Based on Chemical Properties?	TLV Not Exceeded?	IDLH Not Exceeded?	Greater Than 2 Minutes Using NUREG/CR-1741	Probability of Not Exceeding 10CFR 100 Limits
102. Phosphoric Acid		20,000 gal		No	No	No	Yes			
103. Acetic Acid, Glacial		20,000 gal		No	No	No	No	Yes		
104. Titanium Tetrachloride		20,000 gal		Yes	No	Yes				
105. Sodium Hydroxide (Solution)		20,000 gal		No	No	Yes				
106. Maleic Anhydride		20,000 gal		No	No	Yes				
107. Mixed Loads of HazMat		20,000 gal		Yes	No	Yes				
108. Hazardous Liquid		20,000 gal		Yes	No	Yes				
109. Hazardous Liquid (Diethyl Phthalate)		20,000 gal		No	No	Yes				
110. Hazardous Liquid (Contains Creosote)		20,000 gal		Yes	No	Yes				
111. Hazardous Solid (Benzo-A-Pyrene)		20,000 gal		No	No	Yes				

Notes:

1. Number shown in parentheses represents the number corresponding to the bounding chemical location/quantity.

4.0 REFERENCES

4.1 NRC Regulations and Other Regulatory Requirements

4.1.1 10 CFR 50 Appendix A — General Design Criteria for Nuclear Power Plants.

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