REMEDIAL DESIGN/REMEDIAL ACTION (RD/RA) WORK PLAN

Wausau Water Supply NPL Site
Wausau, Wisconsin

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CONESTOGA-ROVERS & ASSOCIATES

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1.0 INTRODUCTION

The City of Wausau is located in Central Wisconsin along the Wisconsin River in Marathon County. Since 1985 numerous studies have been performed characterizing subsurface soils and groundwater conditions within the east and west (in relation to the Wisconsin River) public water supply well fields. Analyses of samples from the public water supply wells had shown contamination by volatile organic compounds (VOCs) and the Wausau Water Supply Site (site) was listed on the National Priorities List in December 1985.

In July 1987, the U.S. Environmental Protection Agency (EPA) contracted with Warzyn Engineering to conduct the Remedial Investigation/Feasibility Study (RI/FS) of the Wausau Water Supply NPL site. Groundwater contamination was identified in both the east and west water supply well fields consisting primarily of VOCs. Two locations were identified as the primary sources of the VOC contamination impacting the east side wells and two locations were similarly identified as the primary sources of the VOC contamination impacting the west side wells.

In the course of the RI/FS, an interim operable unit was identified and, following a Phased Feasibility Study, an interim Record of Decision was issued on December 23, 1988. The interim remedy consisted of the design and installation of a groundwater extraction well to be installed on the west side of the Wisconsin River to capture, treat and discharge contaminated groundwater.

Upon completion of the RI/FS, EPA issued a Record of Decision (ROD) which was signed on September 29, 1990. The final remedy selected in the ROD includes the following actions:

- Installation of soil vapor extraction (SVE) systems to remove Volatile Organic Compounds (VOCs) in soils at each of the three identified source areas;
- Treatment of off-gases from the SVE operation using vapor phase carbon units which shall be regenerated at an off-site RCRA approved site;
- Implementation of Monitoring Program;
- Groundwater remediation utilizing specified pumping rates of the municipal supply wells in order to expedite removal of the groundwater contaminant plumes affecting these wells;
- Groundwater remediation utilizing a specified pumping rate of the operable unit extraction well, with provisions for the addition of a second operable unit extraction well, if necessary; and
- Treatment of groundwater utilizing existing City air strippers and operable unit extraction well treatment system.

Following issuance of the ROD by the EPA, Wausau Chemical Corporation, Marathon Electric Manufacturing Corporation and the City of Wausau (the PRP Group) negotiated a Consent Decree and accompanying scope of work with EPA and the Wisconsin Department of Natural Resources (WDNR), for the PRP Group to design and implement the final remedy. Conestoga-Rovers & Associates (CRA) and Hydro Geo Chem have been retained by the PRP Group to prepare the Remedial Design/Remedial Action Work Plan (RD/RA Work Plan) and perform all associated activities.

As specified in the SOW attached to the consent decree, the final RD/RA Work Plan will include the Project Plans and address the performance of the work outlined below:

Task 1: Project Plans

1. Description and Qualifications of Personnel
2. Health and Safety Plan
3. Quality Assurance Project Plan
4. Monitoring Program Plan, addressing:
    a. SVE
    b. Municipal Wells
    c. Operable Unit Well(s)
5. Project Schedule for Completion of Tasks

Task II: Remedial Design

1. Design Plans and Specifications
2. Operation and Maintenance Plan
3. Cost Estimate
4. Construction Schedule
5. Construction Quality Assurance Plan

6. Community Relations

Task III: Final Remedy Construction

1. Construction Quality Assurance (CQA) Program Plan:
    a. Responsibility and Authority
    b. Construction Quality Assurance Personnel
    c. Inspection Activities
    d. Documentation
2. Implementation of CQA Program Plan

Task IV: Reports

1. Progress
2. Draft
3. Final
4. SVE Completion Report

This report presents the RD/RA Work Plan for the Wausau Water Supply Site and includes each of the required elements as outlined above.

The RD/RA Work Plan is organized into major sections and supporting appendices. Section 2.0 provides a detailed site description, including site location, site history, environmental setting and source areas for contaminants of concern. Section 3.0 provides a discussion of the project management team and Appendix A presents qualifications of project personnel. Section 4.0 discusses the required RD/RA project plans including predesign Quality Assurance Project Plan (QAPP), Compliance Monitoring

Plan and Compliance Monitoring Health and Safety Plan. The Predesign QAPP, Compliance Monitoring Plan and Compliance Monitoring Health and Safety Plan are enclosed in Appendices B, E and F, respectively. Section 5.0 details predesign and design activities. Predesign activities include collection and analyses of site specific data and performing soil vapor extraction (SVE) pilot tests at each source area. Appendix B presents the SVE Predesign Work Plan which includes a Predesign QAPP and Health and Safety Plan. The SVE Predesign Work Plan emphasizes the SVE predesign tasks, pilot study, design considerations and SVE operation and monitoring. The design activities include a discussion on the design process for the SVE system, mass flux calculations and groundwater extraction rates. Section 6.0 discusses performance of the Remedial Action activities including remedial construction, operation and maintenance, monitoring and testing and decommissioning the SVE system. Section 7.0 summarizes reports and documentation required to be prepared and submitted during the RD/RA.

The specific project plans contained in this RD/RA Work Plan are considered working documents subject to EPA and WDNR final approval. The implementation of the RD/RA will commence upon final approval of the RD/RA Work Plan.

1.1 REMEDIAL ACTION OBJECTIVES

The objectives of the final remedy are:

1) reduction of long-term exposure to low levels of VOCs from ingestion of drinking water;

2) protection from potential future use of private wells in contaminated groundwater; and

3) protection from emissions of contaminants from proposed water treatment systems that release VOCs to the atmosphere.

These objectives will be accomplished by the installation of soil vapor extraction (SVE) systems in major source areas east and west of the Wisconsin River; the Marathon Electric/former City of Wausau landfill, on the west side of the river; and the Wausau Chemical Corporation property east of the river. This RD/RA Work Plan includes each of these required elements as specified by the Consent Decree. This section describes the SVE elements of the final remedy.

As mandated by the SOW, the SVE systems will include a network of wells completed just below the water table and screened in the unsaturated zone at each of the identified source areas (Wausau Chemical and the City Landfill/Marathon Electric area). The exact locations of the SVE system wells will be determined on the basis of the SVE predesign investigation. The SVE systems will be operated to meet the Performance Standards and SVE Cleanup Standards specified in the Consent Decree.

One of the performance specifications includes the requirement that the SVE systems be designed to meet Soil Cleanup

Standards within three years of system startup. The SVE systems will be designed to meet soil cleanup goals within three years of system startup, as specified in the Consent Decree. Based on Hydro Geo Chem's experience with SVE systems in soils similar to those described in the site RI reports (Warzyn, 1988, 1989), a cleanup goal of 12 months is feasible and the additional two years will only be necessary if previously unidentified sources of contamination or unexpectedly low unsaturated zone air permeabilities are encountered. All soil vapors extracted by the SVE systems will be treated by vapor-phase activated carbon units.

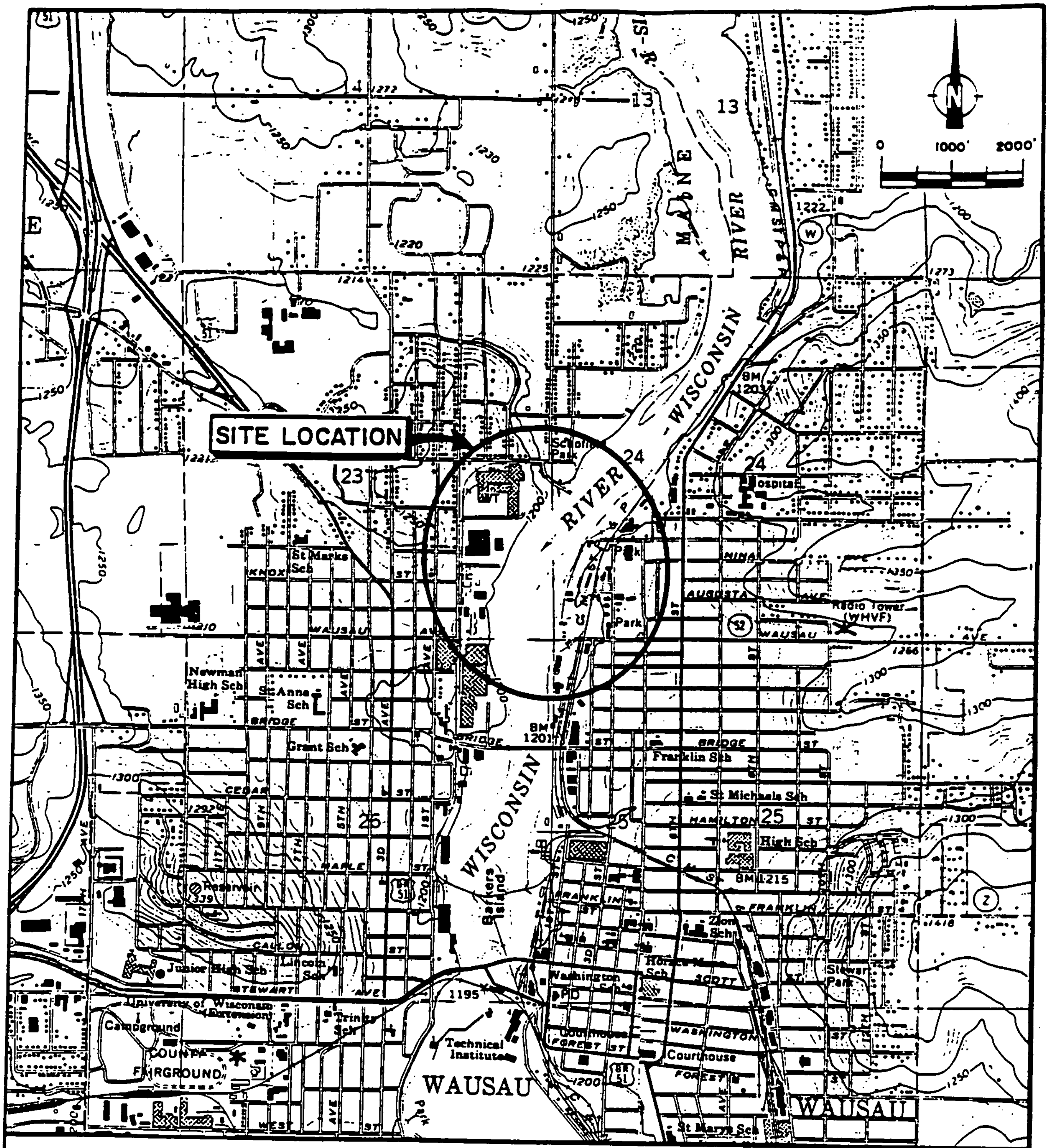
The groundwater remediation objective will be met by operating the operable unit extraction well(s) and municipal wells at pumping rates specified in the Consent Decree or as modified in accordance with the Consent Decree.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

The Wausau Superfund Site (site) is located within the City of Wausau which is located in north-central Wisconsin along the Wisconsin River, Marathon County, Wisconsin. Figure 2.1 shows the location of the site and Figure 2.2 presents a site plan. The site consists of two areas separated by the Wisconsin River. The property comprising the former City of Wausau landfill is presently owned by Marathon Electric Company and is located on the west side of the Wisconsin River. The east side location is owned by the Wausau Chemical Corporation. Plan 1 is a 1990 aerial photograph showing the site and property boundaries of the source areas. These two locations are considered source areas for contaminants in the aquifer which is the source of drinking water for the City of Wausau.

The City presently operates seven production wells, six of which are located on the north side of the City. The seventh well, CW-8, is located adjacent to the Wausau Municipal Airport on the south side of the City. Plan 1 shows the location of City water supply wells within the site. Production wells CW-6, CW-7, CW-9 and CW-10 are located west of the Wisconsin River and are collectively referred to as the west well field. Production wells CW-3 and CW-4 are located on the east side of the Wisconsin River and are referred to as the east well field. Presently, the water from CW-8 has a high concentration of iron and is used only during peak demand periods. The water from CW-4 is also used only during peak demand periods.



SOURCE U.S.G.S. WAUSAU WEST QUADRANGLE MAP.

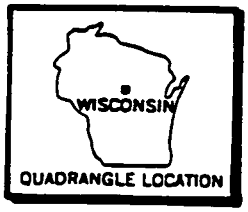


figure 2.1
SITE LOCATION
Wausau Superfund Site

CRA

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SOURCE: RMT INC. FIGURE 1, 5/14/87.

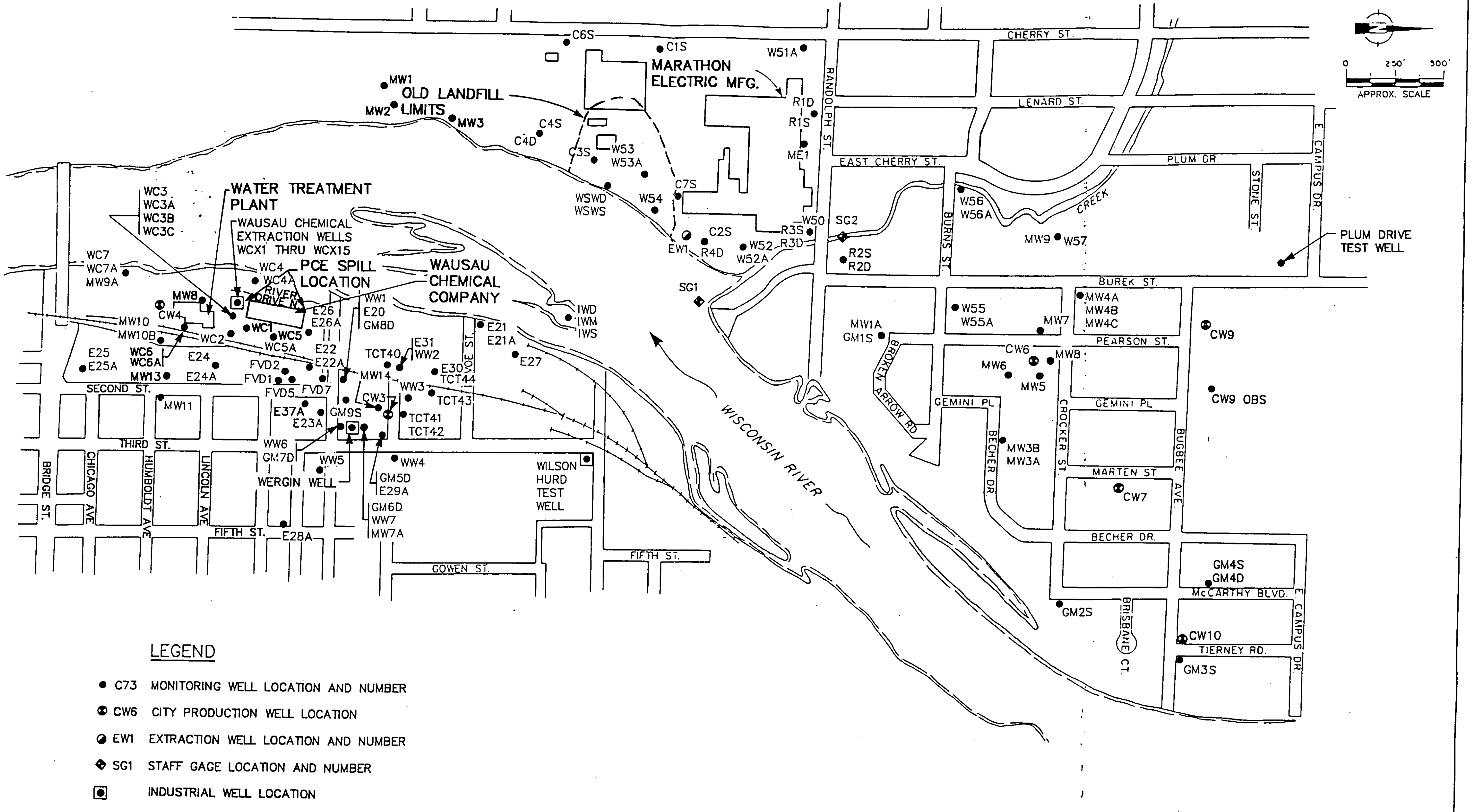

figure 2.2

SITE PLAN

Wausau Superfund Site

The west well field is located in a predominantly residential area. Wausau Chemical Corporation is located between production wells CW-3 and CW-4. The east well field is located in a predominantly industrial section of the City. The former City of Wausau landfill is located on the south side of the Marathon Electric property, south of the City of Wausau's west well field. Plan 2 is a 1990 aerial photograph of the Wausau Chemical property and Plan 3 is a 1990 aerial photograph of the Marathon Electric property. Also shown on Plan 3 are the approximate limits of the former landfill as determined from a 1942 aerial photograph.

2.2 SITE HISTORY

The City of Wausau discovered in early 1982, that its production wells CW-3, CW-4 and CW-6 were contaminated with volatile organic compounds (VOCs). Tetrachloroethylene (PCE), trichloroethylene (TCE) and 1,2-dichloroethene (DCE) were the predominant contaminants found. TCE was the primary VOC detected at CW-6, however, PCE and DCE have also been reported (Weston, 1984). Since TCE was first detected, the concentrations at CW-6 have ranged from 26 to over 200 micrograms per liter (μg/L). Sample results from the east well field (CW-4 and CW-3) indicate PCE, TCE and DCE contamination. CW-4 has generally shown a steady decrease in concentrations of these three constituents since 1984. CW-3 has shown decreases in PCE and DCE since they were discovered. TCE concentrations, however, have remained relatively constant at concentrations ranging between 80 and 210 μg/L. Toluene, ethylbenzene and xylene were also detected in well CW-4.

The City instituted a blending program whereby uncontaminated water from CW-9 and CW-7 was blended with water from CW-3, CW-4 and CW-6 in order to decrease VOC levels to acceptable drinking water quality prior to distribution. However, the program was largely ineffective due to continuing increases in VOC concentrations and groundwater quality which exceeded regulatory limits at that time.

In the fall of 1983, the EPA awarded the City a federal grant to help fund the design and installation of research units (GAC and Air Strippers) to reduce contaminants and provide sufficient water of acceptable quality to City residents. However, during the interim, the DNR requested assistance from the EPA emergency response team to evaluate possible response to the contaminant levels in the City's drinking water supply. Under emergency response, the EPA installed and operated a temporary granular activated carbon (GAC) treatment system at CW-6 starting in July 1984. As part of the research effort, full-scale packed tower VOC strippers were operational in August 1984 at the City water treatment plant (see water plant location on Plan 2) to treat water from wells CW-3, CW-4 and CW-6. The air stripping towers proved to be very effective for removal of the VOCs from the City's water supply. The temporary GAC system was subsequently removed from service in October 1984.

In December 1985, the site was nominated for inclusion on the National Priorities List (NPL). A remedial investigation/feasibility

(RI/FS) study was conducted for the EPA by Warzyn Engineering, Inc. The RI/FS entailed two phases of field sampling. Phase I of the field work was conducted between August 1987 and January 1988. An Operable Unit Record of Decision (ROD) and Interim Consent Decree to address the west side contamination plume was signed in September 1988. Phase II of the RI/FS field work was conducted between June and September 1988. Results of the Phase II study are summarized in the RI/FS report dated August 1989. The remedial alternative selected is outlined in the ROD issued by the EPA in September 1989. A negotiated Consent Decree incorporating the ROD in the final remedy was negotiated by the settling defendants, EPA and the WDNR in 1990. The Consent Decree was lodged with the United States District Court for the Western District of Wisconsin on November 9, 1990. The Consent Decree establishes a schedule by which settling defendants must design and construct the final remedy.

The remedial design and construction of the operable unit groundwater extraction well on the Marathon Electric Corporation's property north of the former City landfill has been completed. The approximate location of the operable unit extraction well is shown on Figure 2.2 and on Plans 1 and 3. The groundwater extraction well was put into operation on November 14, 1990 and initially extracted groundwater at an approximate flow rate of 1,600 gallons per minute (gpm). In December 1990, CRA submitted a report entitled "Extraction Well No. 1, Well Installation and Pump Testing, Marathon Electric Manufacturing Company, Wausau, Wisconsin", which summarized the installation and pump testing of the extraction well. In January 1991, CRA submitted a report entitled "Evaluation of Pumping Rate in Extraction Well No. 1, Marathon Electric Manufacturing

Company, Wausau, Wisconsin". The report recommended that the pumping rate for the extraction well be reduced to approximately 800 gpm. The EPA provided written approval of the reduction in the pumping rate and on January 31, 1991, the pumping rate for the extraction well was reduced. The extraction well is currently operating at approximately 800 gpm.

2.3 ENVIRONMENTAL SETTING

Marathon County is situated near the margin of the exposed Precambrian Shield. The bedrock in the Wausau area is predominantly Precambrian igneous and metamorphic rocks of Lower and Middle Proterozoic age.

Glacial deposits underlying the site consist of glacial outwash and alluvial sediments which have filled in the preglacial stream valley where the Wisconsin River now follows. The surface topography of the project area is controlled by the underlying Precambrian bedrock topography, glacial deposition and post-glacial erosion.

The seven production wells for the City of Wausau provides drinking water for approximately 33,000 people. These wells are screened in the glacial outwash and alluvial sand and gravel deposits which underlie and are adjacent to the Wisconsin River. This alluvial aquifer ranges from 0 to 160 feet thick and has an irregular base and lateral boundaries. The boundaries of the aquifer are defined by the relatively impermeable bedrock which underlie it and form its lateral boundaries within a preglacial valley.

Groundwater flow within the unconfined glacial aquifer has been drastically changed by the installation and operation of the operable unit extraction well and the City production wells. Under natural conditions, groundwater would flow toward and discharge to the Wisconsin River and its tributary, Bos Creek. Under existing conditions, however, groundwater flows toward the extraction well and production wells during pumping. Prior to operation of the extraction well the natural groundwater flow directions were frequently reversed due to the City well pumping. The pumping of the east well field has appeared to have affected groundwater flow west of the Wisconsin River. Monitoring well nests located at the Marathon Electric property indicated very slight downward gradients adjacent to the Wisconsin River. Pumpage of the east well field induced recharge of surface water into the aquifer and induced groundwater below the river and on the west side of the river to flow toward CW-3. Based on water level data collected since commencing operation of the extraction well, the extraction well has created a cone of influence which extends below the river. The extraction well effectively contains and collects groundwater contamination on the west side of the river south of CW-6.

Tests performed during the RI indicated that the hydraulic conductivity of the aquifer ranges from 9.7×10^{-2} cm/sec to 2.8×10^{-1} cm/sec. Results of pump tests performed at the operable unit extraction well, as summarized in the December 1990 CRA report indicate hydraulic conductivity ranging from 1.9×10^{-2} cm/sec to 1.9×10^{-1} cm /sec.

2.4 SOURCE AREAS FOR CONTAMINANTS OF CONCERN

Previous investigations have identified several potential point sources of VOC contamination surrounding the City of Wausau production well fields. Table 2.1 lists the previous studies which have been conducted and supporting documents. Results of groundwater quality analyses for VOCs conducted during the RI in 1987 and 1988 show a vertical and lateral distribution of total chlorinated ethenes which suggests that a minimum of three sources are affecting the City well field; these are described below.

2.4.1 West Side Source Area

The former City landfill/Marathon Electric property occupies a former sand and gravel pit located on the west bank of the Wisconsin River. The landfill, which consists of approximately 4.5 acres, operated between 1948 and 1955 and accepted the majority of commercial, industrial and residential waste generated within the City of Wausau. The majority of the landfill is currently being used as a parking lot and is covered with a bituminous pavement; the southern portion is vegetated. The approximate limits of the sand and gravel pit and the estimated extent of the former landfill are shown on Figure 2.2 and on Plan 3.

TABLE 2.1

HISTORICAL REPORTS ON WAUSAU, WISCONSIN WATER SUPPLY SITE

Author	*Date*	*Title*
Becher Hoppe Engineers, Inc.	1983	Groundwater Investigation (for the City of Wausau)
STS Consultants, Ltd.	July, 1984	Subsurface Exploration and Testing Program to Evaluate Groundwater Quality at the Wausau Chemical Facilities in Wausau, WI
Joseph L. Gehin	January, 1985	Wausau Water Quality Update and Performance Evaluation of CW-3 and CW-4 Air Strippers
Roy F. Weston, Inc.	September, 1985	Hydrogeological Investigation of Volatile Organic Contamination in Wausau, Wisconsin, Municipal Wells
STS Consultants, Ltd.	December, 1985	Interim Report Groundwater Extraction Program, Wausau Chemical Corp., Wausau, WI
CH_2M Hill	February, 1986	Investigation of Abandoned City of Wausau Landfill
Foth & Van Dyke & Associates	July, 1986	VOC Groundwater Investigation at the former Wausau Energy Facility in Wausau, WI
Twin City Testing Corp.	August, 1986	Existing Conditions Report and Exploration Program, Wausau East Municipal Well Field, Wausau, WI
RMT, Inc./Geraghty & Miller, Inc.	June, 1987	Hydrological Investigation of Alluvial Aquifer Beneath City Well 6, Wausau, WI

TABLE 2.1

HISTORICAL REPORTS ON WAUSAU, WISCONSIN WATER SUPPLY SITE

Author	*Date*	*Title*
Geraghty & Miller, Inc.	March, 1987	Preliminary Data Sheets, East Side Groundwater Quality Investigation, City of Wausau, WI
Warzyn Engineering	July 24, 1989	Remedial Investigation for the US EPA Volumes 1, 2 and 3 for the Wausau NPL Site
US EPA	September 29, 1989	Record of Decision (ROD) Document Explaining Selection of Final Remedy
Conestoga-Rovers & Associates	May, 1990	Interim Remedial Alternative for Operable Unit Extraction Well for Marathon Electric Manufacturing Co.
US EPA	November 8, 1990	Consent Decree Lodged in United States District Court for the Western District of Wisconsin for the United States of America, State of Wisconsin vs City of Wausau, WI, Marathon Electric Mfg. Corp., and Wausau Chemical Co.
Conestoga-Rovers & Associates	December, 1990	Extraction Well No. 1, Well Installation and Pump Testing, Marathon Electric Manufacturing Company, Wausau, Wisconsin
Conestoga-Rovers & Associates	January, 1991	Evaluation of Pumping Rate in Extraction Well No. 1, Marathon Electric Manufacturing Company, Wausau, Wisconsin

2.4.1.1 Source Characterization

The predominant source of contamination to CW-6 and CW-3 appears to be the former City landfill/Marathon Electric property. Elevated concentrations of TCE were detected in groundwater, soil and soil gas samples obtained from the northern portion of the landfill. Soil gas TCE concentrations within the landfill ranged from below detection limits (1.0 µg/L) to approximately 107 µg/L. Soil samples obtained from borings in the vicinity of the landfill contained TCE concentrations of approximately 200 µg/kg. Based on calculations performed during the RI, it is estimated that 270 pounds of VOCs are present in the unsaturated soils and fill at the former City landfill/Marathon Electric property. Groundwater samples obtained from the vicinity of the landfill indicate TCE concentrations range from 16 µg/L to 1900 µg/L. Also detected in the vicinity of the landfill were DCE,1,1,1-trichloroethane (TCA), chloroform and carbon tetrachloride at concentrations below 100 µg/L.

2.4.1.2 Contaminant Migration

West side monitoring wells delineate a deep (greater than 100 feet deep) north-south trending TCE plume. The vertical distribution of TCE throughout the aquifer near the old City landfill also suggests that the source of contamination lies within the northern portion of the landfill. The plume appears to have migrated northward under influence of the pumpage of CW-6 and eastward, under the Wisconsin River, toward CW-3. The highest TCE concentration (4200 µg/L) in the plume was detected approximately 550 feet south of CW-6.

TCE was also detected in the shallow aquifer between Bos Creek and CW-6. TCE contamination in this shallow aquifer appears to have resulted from the induced infiltration of surface water from Bos Creek, which has been contaminated by the untreated discharge of water from CW-6. The induced surface water recharge of the aquifer is evident from the downward vertical gradients at monitoring well nests in that area. TCE concentrations adjacent to CW-6 discharges were found to be 100 µg/L. TCE concentrations in the ponded area downstream were approximately 70 µg/L. TCE was not detected in surface water samples collected upstream of the CW-6 discharge nor was it detected at the point where Bos Creek enters the Wisconsin River.

Prior to the summer of 1988, CW-6 was pumped directly into Bos Creek. Pumpage of CW-6 served as a barrier well to the rest of the west well field. However, the discharge of CW-6 to Bos Creek apparently created a contaminated groundwater mound between the source area and CW-6. The influence of the groundwater mound may not have fully penetrated the glacial outwash aquifer, but the RI data suggests that the mound served to effectively divide the west well field contaminant plume into northern and southern components, slowing contaminant migration away from the source.

In 1988 the City of Wausau completed a river crossing for a transport pipe to carry contaminated water from CW-6 to an air stripper on the east side of the river. The discharge of contaminated groundwater to Bos Creek was discontinued, and the City was able to put CW-6 back into service with an increase in the pumping rate. These factors would tend to increase the rate of migration from the source area towards CW-6.

In November 1990, Marathon Electric completed the installation of the operable unit extraction well on its property approximately 2100 feet south of CW-6. The extraction well is currently extracting groundwater at approximately 800 gpm. Treated groundwater is discharged to the Wisconsin River. The extraction well effectively contains and collects groundwater VOC contamination on the west side and underneath of the Wisconsin River. The extraction well and CW-6 serve as barrier wells, providing protection for the remaining water supply wells in the west well field.

2.4.2 East Side Source Area

The Wausau Chemical Company (Wausau Chemical) is located between CW-3 and CW-4 on the east bank of the Wisconsin River. The facility, established in 1964, is a bulk solvent distributor and transfer station for the shipment of waste chemicals and solvents from area businesses. The facility experienced two documented PCE spills in 1983 totaling approximately 1,000 gallons. Solvents released by Wausau Chemical are apparently responsible for a large percentage of the shallow groundwater contamination in the east well field. However, there may be other sources not identified at this time.

2.4.2.1 Source Characterization

Soil gas and soil boring data reflecting the distribution of VOCs in the unsaturated soils were collected as part of the soil gas survey and from soil borings for source characterization during the RI. This data indicates higher concentrations of contaminants in the area located in the southern portion of the facility (Wausau Chemical tank farm) with decreasing concentrations within an elongated contaminant zone trending toward the east-northeast and south. Elevated concentrations of PCE were also found in unsaturated soils near the north loading dock. The highest level of PCE in the soil gas was reported from the southern end of the facility at a concentration of 4080 μg/L. Analysis of soil samples indicated 3500μg/kg of PCE in the vicinity of the north loading dock, and 1000 μg/kg at the south end of the property. Again, based on calculations performed during the RI, the total amount of VOCs remaining in the unsaturated soils at Wausau Chemical is approximately 260 pounds. This estimate may vary if contamination is found to exist beneath the Wausau Chemical facility building complex.

During the summer of 1984, approximately 1000 to 1500 cubic yards of solvent impacted soil was removed from the tank farm area and disposed of at a hazardous waste landfill. In October 1985, a groundwater extraction/treatment program was initiated. The groundwater remediation system consists of six submersible pumps alternatively operated in 15 extraction wells. As of January 1991, this system has removed and treated approximately 274 million gallons of impacted groundwater. Influent and effluent to the treatment system is monitored on a monthly basis to determine treatment efficiency and document compliance with WPDES permit.

2.4.2.2 Contaminant Migration

East side monitoring wells indicate three plumes within the east well field area, one deep plume apparently originating from the former City landfill on the west side of the river and two plumes originating southwest of CW-3.

The latter two plumes are restricted to the shallow portion of the aquifer (upper 40 feet) and consist of primarily PCE, TCE and DCE. Both of these plumes are apparently the result of past releases from the Wausau Chemical facility. A large, widely dispersed VOC plume extending eastward from the Wausau Chemical property was identified during the RI. The highest concentrations of VOCs in this plume were detected in the vicinity of the Wausau Chemical tank farm behind the southern part of the building complex (see Plan 2). A second plume was detected north of the Wausau Chemical facility in the vicinity of the northern loading dock. This plume was differentiated from the other plume by the absence of PCE degradation products.

3.0 DESCRIPTION AND QUALIFICATIONS OF PERSONNEL

The PRP Group has retained the firms Conestoga-Rovers & Associates (CRA) and Hydro Geo Chem to prepare the RD/RA Work Plan and perform all associated activities.

CRA and Hydro Geo Chem are well qualified to undertake the specified RD/RA services and any other services as may be required. CRA is fully qualified to conduct and/or manage all required professional services, having extensive experience in the review, design and implementation of similar remedial programs at Superfund and other hazardous waste sites including the operable unit extraction well. CRA will also provide engineering support for the preparation of construction documents.

Hydro Geo Chem has a proven track record in the technology of designing, implementing, and monitoring soil vapor extraction systems at Superfund contaminant sites across the United States, including EPA Region V. Hydro Geo Chem is particularly accomplished in providing accurate predictions of the effectiveness and cost of soil vapor extraction. Hydro Geo Chem's tools for SVE assessment include mobile vacuum extraction trailers for pilot studies, computer programs for simulating and predicting SVE performance and monitoring techniques that provide the data to assess soil vapor extraction system performance. As a result, Hydro Geo Chem is able to evaluate SVE feasibility at candidate sites and modify design configurations to improve performance and minimize cost before the installation of the pilot or full scale working system. A brief description of

Hydro Geo Chem's SVE project experience is provided in an appendix to this Work Plan.

CRA and Hydro Geo Chem have assembled the following project management team and technical resource personnel with the necessary experience and capabilities required for this project. CRA's project management team will consist of Mr. Rovers, Mr. Roberts and Mr. Boevers, who will be supported by the technical resource personnel as required. Hydro Geo Chem's project management team will consist of Dr. Walter, Dr. Bentley and Mr. Weinig. Brief descriptions of all personnel roles and qualifications are listed below, and curricula vitae are included in Appendix A. Figure 3.1 presents an organizational chart for the project team and assigned personnel.

The client project officer is Mr. Joseph Gehin. Mr. Gehin is Utilities Director for the City of Wausau and will be responsible for communicating project activities between the project consultant, the regulatory agencies and the individual members of the PRP Groups.
Mr. Gehin is responsible for the overall management of the City of Wausau utilities including the water supply, water treatment and water distribution. Mr. Gehin has over 20 years experience in wastewater treatment, process control and utilities maintenance.

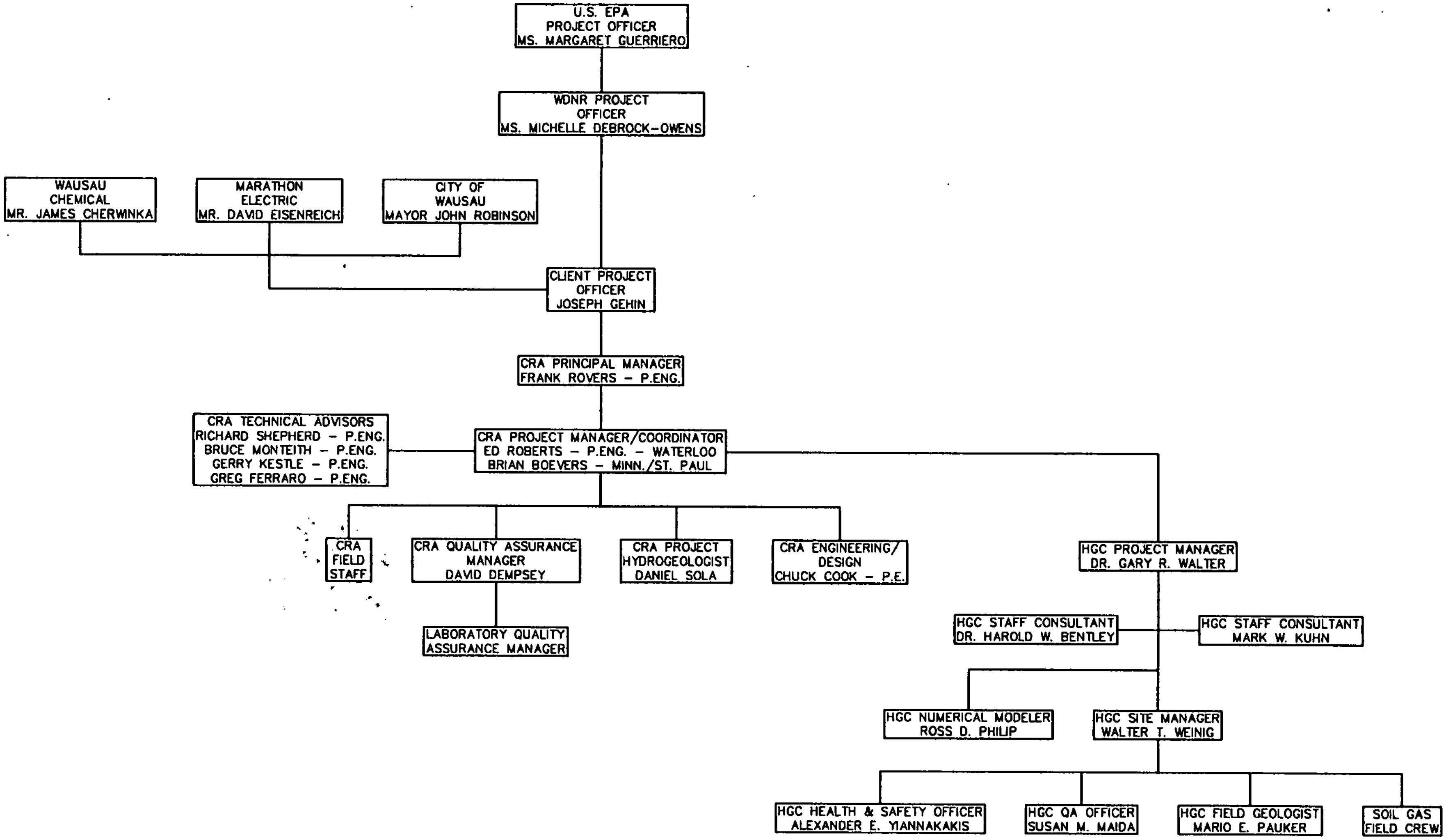

figure 3.1

PROJECT ORGANIZATION CHART
RD/RA WORK PLAN
Wausau Superfund Site

CRA

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3.1 CRA's PROJECT MANAGEMENT TEAM

Project Director - Mr. Frank Rovers, P.Eng

Mr. Frank Rovers, P.Eng., president of CRA will be CRA's project director. The project director's role is to direct the project team's efforts and ensure compliance with scope of work and schedule. The project director will also participate in the definition of amendments to the scope that may be appropriate, the resolution of problems that may develop as the project proceeds and will review all work plans and reports, concentrating on technical quality of the documents. In addition, the project director will be CRA's primary representative of the Project to the PRP Group and regulatory agencies. Mr. Rovers has extensive experience in projects of this nature, has had many management roles on several CERCLA projects and is highly experienced in project representation to clients, regulatory agencies and the general public.

Project Manager - Mr. Ed. Roberts, P.Eng

Mr. Roberts will act as project manager. He will oversee all aspects of the project, represent the PRP Group at technical meetings where required and will be actively involved in the direction of the project. Mr. Roberts has over six years of experience in projects of this nature, including project management of the operable unit groundwater extraction, treatment and discharge system currently being operated by Marathon Electric. Mr. Roberts will ensure that high standards of technical merit and scheduling are maintained throughout all activities.

Project Coordinator - Mr. Brian Boevers

Mr. Boevers, CRA's Minneapolis/St. Paul office manager, will act as project coordinator, supervising day to day tasks. He will provide qualified personnel and ensure that all day to day activities are conducted in a professional and timely manner. Mr. Boevers will keep the project manager and director fully informed on the status of ongoing tasks. He will also attend technical meetings and will coordinate the review and preparation of required reports. Mr. Boevers has over 13 years of related project management experience.

Project Chemist - Mr. David Dempsey

Mr. Dempsey, a chemist with CRA, will be responsible for all off-site analytical laboratories' activities. Mr. Dempsey will review data to ensure the data quality meet project objectives. Mr. Dempsey will also aid in preparing and reviewing reports. Mr. Dempsey has over eight years experience as a chemist, including over two years handling environmental projects for CRA in Region V.

Project Hydrogeologist - Mr. Daniel V. Sola

Mr. Sola is the Senior Hydrogeologist at CRA's St. Paul, Minnesota office. He will be responsible for review and evaluation of the hydrogeological aspects of remediation design and monitoring tasks. Mr. Sola has a variety of experience at large scale groundwater remediation projects such as this.

Project Engineer - Mr. Charles Cooke, P.E.

Mr. Cooke is the senior design engineer at CRA's St. Paul, Minnesota office. He will be responsible for the review, evaluation, co-ordination and implementation of the engineering for the remediation design and construction. Mr. Cooke has a variety of experience in civil engineering and treatment system design, construction and operation.

Technical Advisors/Services

Mr. Rick Shepherd, P.Eng. - Technical Advisor

Mr. Shepherd, a principle in CRA and senior construction engineer, will be consulted during the remedial design. Mr. Shepherd will also be consulted and will be available to the project on an as-required basis.

Mr. Bruce Monteith - Technical Advisor

Mr. Monteith is experienced in RD/RA activities in Region V as a project manager. Mr. Monteith will be consulted on the project and will be briefed regularly during all activities by the other project team members.

Mr. Gerry Kestle, P.Eng./Mr. Greg Ferraro, P.Eng. - Technical Services

Mr. Kestle, a senior mechanical engineer with CRA and Mr. Ferraro, a senior design engineer with CRA, will assist with the remedial design of the SVE collection and treatment systems.

Both Mr. Ferraro and Mr. Kestle have extensive experience in the design and operation of gas collection systems.

3.2 HYDRO GEO CHEM'S PROJECT MANAGEMENT TEAM

Project Manager - Gary R. Walter, Ph.D.

Dr. Walter's extensive experience in contaminant hydrogeology, dual phase air-water numerical modeling and geochemistry will be invaluable to this project. Dr. Walter's specific experience in soil venting includes his management of the feasibility study and predesign investigation for a soil vapor extraction system at the Seymour Superfund site, his participation as consultant to the Pristine Superfund site SVE project, his evaluation of flow and VOC transport in the Phoenix Goodyear project and his expert testimony relating to the evaluation of SVE at the Hardage Superfund site. Dr. Walter's responsibilities will include coordination of overall SVE project activities, supervision of office and field staff, meeting labor and equipment requirements, development of work plans, cost estimates, and task completion schedules; direction of senior consultants, review progress and evaluation of results; and communication with clients and the EPA as required.

Staff Consultant - Harold Bentley, Ph.D.

Dr. Bentley, president of Hydro Geo Chem, will provide valuable expertise in geochemistry particularly in soil gas interpretation and tracer tests. Dr. Bentley is currently project manager for the Pristine Superfund Site's soil vapor extraction project and has been involved in the Seymour SVE design and the SVE pilot study at the Phoenix-Goodyear Airport Superfund site. Dr. Bentley will also provide technical assistance for the overall design and implementation of the proposed predesign investigation and soil vapor extraction pilot test. Dr. Bentley will directly oversee the development and performance of all analytical support work to this project.

Staff Consultant - Mark W. Kuhn

Mr. Kuhn will assist in the design of the SVE systems at the Wausau site. His experience includes project management for the design, installation and operation of SVE systems at the Phoenix-Goodyear Airport Superfund site in Arizona, design analysis of an SVE system at the Seymour Recycling Superfund site in Indiana, design of a deep SVE system at a chemical plant in Texas, and design, construction, operation and data analysis for an SVE system at a Superfund site in Wyoming. Mr. Kuhn will oversee all aspects of the SVE system design, including preparation of construction plans and equipment specifications.

Site Manager - Walter T. Weinig

Mr. Weinig will provide supervision of all field activities at the Wausau site. He will also be responsible for report preparation and analytical data review. Mr. Weinig's SVE experience includes numerical modeling and design studies for the Pristine Superfund site SVE system and the Seymour SVE system, as well as evaluation of contaminant masses and distribution at the Phoenix-Goodyear Airport Superfund site. Mr. Weinig has managed previous field investigations at hazardous waste sites in Arizona and Michigan.

Numerical Modeler - Ross D. Philip

Mr. Philip will provide numerical modeling support for interpretation of the predesign investigation field data and for optimization of the pilot-scale and full-scale SVE system designs. Mr. Philip has been involved in SVE including the Hardage SVE evaluation and modeling vapor extraction from a deep unsaturated zone. He also has extensive experience in modeling multi-phase and unsaturated flow systems.

Health and Safety Officer - Alexander E. Yiannakakis

Mr. Yiannakakis will oversee the preparation of the Health and Safety plans for the Wausau project. He will also be responsible for implementation of the Health and Safety procedures. Mr. Yiannakakis has provided Health and Safety oversight for several projects, including the Seymour Superfund site predesign investigation.

Quality Assurance Officer - Susan M. Maida

Ms. Maida will provide QA oversight for the Wausau project. Her responsibilities will include ensuring that proper QA procedures are followed during field and laboratory operations. Ms. Maida has extensive experience in development and implementation of QA procedures for EPA and DOE investigations.

4.0 RD/RA PROJECT PLANS

A brief description of the various SOW Task I project plans necessary for implementing the RD/RA is provided below. These plans are considered working documents, structured to accommodate changes during the course of the RD/RA implementation. If modifications to the approved plans are proposed, the modifications will be forwarded to EPA for approval, in consultation with the WDNR, prior to commencing any of the work outlined. A summary of plans and reports required for subsequent submittals is included in Section 7.0 of this report.

4.1 HEALTH AND SAFETY PLAN

The site specific Health and Safety Plan (Appendix F) was prepared to protect personnel from potential hazards which may be present at the site as a result of activities conducted during the RA implementation. A site specific Health and Safety Plan for RD implementation is included in the SVE Predesign Work Plan (Appendix B). The plan provides guidance to field personnel as to the potential hazardous materials which may be encountered; specifies the personal protective equipment and levels of protection (clothing, respirators, etc.) necessary for completing various activities at the site; air emissions monitoring to be performed; action levels at which the level of protection must be upgraded; and decontamination procedures. The plan also identifies the available local emergency response groups to be contacted should the need arise.

4.2 COMPLIANCE MONITORING PLAN

The Compliance Monitoring Plan (Appendix E) describes media specific sampling and monitoring procedures to be followed during operation and maintenance of the final remedy. In general, the plan covers the type and frequency of soil, water and vapor samples collected from each element of the final remedy; municipal water supply wells, operable unit well(s) and SVE systems. Specific details of the field sampling and analyses completed as part of the predesign phase are included in the SVE Predesign Work Plan (Appendix B). Detailed sampling and analysis procedure for construction and performance monitoring will be submitted with the Construction Quality Assurance (CQA) program plan.

4.3 QUALITY ASSURANCE PROJECT PLAN FOR THE PREDESIGN TASKS

The SVE Predesign Work Plan (Appendix B) includes a QAPP which describes the quality assurance/quality control procedures which will be followed in completing the predesign tasks. Laboratory QA/QC procedures with regard to the determination of precision and accuracy of the data submitted and a description of analytical methods are included in the plan. As indicated previously, Hydro Geo Chem will be providing analytical support during the predesign phase of the project.

5.0 PREDESIGN AND REMEDIAL DESIGN ACTIVITIES

The remedial design is divided into two phases; predesign and design. The predesign activities and investigation must be completed before the remedial design for some remedy components can be undertaken.

5.1 PREDESIGN ACTIVITIES

As part of the design phase for the Wausau site SVE systems, Hydro Geo Chem will conduct a predesign field investigation. This investigation will be used to determine the current extent of VOC contamination in soils at each of the source areas and to collect data on soil physical properties necessary to design the SVE systems. A detailed SVE Predesign Work Plan is contained in Appendix B. A Predesign Investigation Quality Project Plan is also presented in Appendix B. In general, the predesign investigation consists of three key components:

1. Collection and analysis of additional site-specific data on soil properties and contaminant distributions needed to design the SVE systems;

2. Pilot studies needed to anticipate construction and operational constraints on the SVE systems and off-gas treatment system; and

3. Collection and analysis of data needed to perform the mass flux calculations which will determine the performance standards for the SVE treatment.

A soil gas survey will be performed at each of the source areas to define the current extent of contamination. Soil gas sampling will be performed at depths appropriate to evaluate both the fill and native soils in each source area, with deeper sampling conducted, as necessary, to characterize the distribution of contaminants. The soil gas sampling and analyses will be performed using Hydro Geo Chem's standard procedures; minor modification of the sampling technique may be required in areas of high VOC concentrations. Point air permeability measurements will be made in conjunction with the soil gas sample collection by modifying the vacuum extraction apparatus, which already provides gas flow rate versus time, to include a vacuum transducer sensor.

Soil samples will be collected from the source areas to determine moisture content, bulk density, total organic carbon and porosity at the Wausau Chemical location. Conditions at the former landfill may be more complicated, however, because the soils can be expected to be extensively disturbed and to contain a high percentage of anthropogenic organic matter. Additional investigation of conditions at the landfill may also be required to evaluate the methane and vinyl chloride concentrations in the gases initially removed by the SVE system.

The second part of the predesign investigation at the Wausau site will be SVE system pilot studies. One pilot study will be performed at each source area location. The purpose of these on-site tests is to determine air permeability and air circulation patterns on a scale similar to anticipated SVE well spacing. An additional purpose of the tests will be to evaluate carbon trapping efficiencies for estimation of carbon use during the startup of the full-scale system.

At least one test will be performed at each source area by evacuating a dry well using Hydro Geo Chem's mobile vacuum extraction system while monitoring pressure in soil gas probes. Soil gas pressure measurements will be made in probes installed in the fill and native soils at appropriate lateral distances from the extraction well. Probes will be set at distances determined to be appropriate based on the prior evaluation of air permeabilities and site-specific surface conditions. The exhaust gases from these tests will be passed through vapor-phase activated carbon and the VOC concentrations measured by the mobile laboratory before and after the carbon treatment. This measurement will be used to estimate carbon use for the full scale systems. The pilot SVE wells will be constructed so that they can be included in the full-scale SVE system.

The results of the predesign investigation will be presented in a Final Pilot Study Report, submitted with the 30 percent design submittal. The report will present the basis for the full scale SVE System based on the data collected during the pilot study, the mass flux calculations and the performance standards.

5.2 REMEDIAL DESIGN ACTIVITIES

5.2.1 General

Remedial design activities generally consist of preparing engineering drawings, specifications and supporting calculations for the various components of the remedial construction. The design of each component must also reflect the requirements imposed by permit approvals. This is sometimes an iterative process where a preliminary design is developed and reviewed by the permitting authority before permit approval requirements which affect the final design can be incorporated.

During the initial design phases, each component of the remedy will be evaluated to determine which permit programs are potentially applicable. This will include discussion with local, State and federal agencies. The design requirements that are imposed by the respective permit program will then be incorporated into the later design phases.

5.2.2 Design Process

The remedial design process for each major component of the remedial action is described in this section.

5.2.2.1 SVE System

This subsection is intended as a general discussion illustrating the approach to be taken to SVE system design at the Wausau site. The detailed design will depend on the results of the predesign investigation and will be included in the predesign investigation report and the design documents.

In general, the degree of success, in terms of mass of contaminants removed, of SVE depends on three factors:

1) The air strippability of the volatile organic contaminants,. which is controlled by their vapor pressure, and gas-water and water-solid distribution coefficients;

2) The sweeping efficiency of the extraction system, which is controlled by the air permeability and contaminant distribution in the soil; and

3) The rate of air circulation that can be achieved with a particular extraction system.

SVE was selected for the source remediation at the site based on the air strippability of the VOCs identified at the site and sweeping efficiencies typically encountered with glacial soils similar to those at the site. The third factor in determining SVE success, the rate of air circulation, will be optimized in the SVE design, based on the findings of the soil gas and SVE pre-design work. The specifics of these factors and their applicability at the Site are discussed in more detail in the following sections.

Strippability

Ultimately, the strippability of a volatile organic compound (VOC) depends on its concentration in the soil gas phase relative to its concentration in the liquid and solid phases. The concentration depends on the compound's physical-chemical properties, its state in the soil, and on the physical and chemical properties of the soil.

When the VOC is present as a separate liquid phase within the soil, the gas phase concentration will be largely controlled by the vapor pressure of the VOC. The highest soil vapor concentration will be equal to the saturated vapor density, ρ_s, of the VOC. Such concentrations may be achieved in soils heavily contaminated with low water solubility solvents and petroleum products (DNAPLs and LNAPLs). As long as sufficient free liquid remains in the soil to maintain good contact between the VOC liquid and the soil gas, the rate of mass recovery by vapor extraction will depend directly on the saturated vapor density of the VOC and the rate of air circulation according to:

$$Q_m \leq \rho_s \times Q_a \qquad (1)$$

where Q_m is the mass removal rate [mass/time]

ρ_s is the saturated vapor density [mass VOC/volume gas]

Q_a is the air circulation rate [volume/time]

The maximum rate of mass removal is usually not achieved, however, because of lack of complete equilibrium between the soil gas and the liquid phases and less than perfect sweeping efficiency. A significant reduction in removal efficiency also may occur when VOCs are dissolved in a separate organic liquid phase of low volatility, as with a volatile solvent in heavy petroleum products. For these conditions, the relative lowering of the vapor concentration of the volatile compound can be predicted from Henry's Law (Moore, 1967).

$$C_g = H_{Dl} C_l \qquad (2)$$

where C_g is the vapor phase concentration of the VOC

H_{Dl} is the dimensionless Henry's Law coefficient for the non-aqueous liquid

C_l is the VOC concentration in the non-aqueous liquid

When a separate liquid phase of VOC is not present, the strippability is controlled by the distribution of the VOC between the soil water and soil organic matter. In relatively fine grained soils, that tend to have a high moisture content, and in most soils in humid climates, the vapor phase contaminant concentration will be controlled by the dimensionless Henry's Law coefficient (H_{DW}) which relates the concentration of a compound in the vapor phase to its concentration in the aqueous phase. The water concentration will in turn be controlled by the distribution of contaminants between water and the solid soil matrix. Only in unusually dry soils or where the contaminants are present in coarse soils and gravels is the direct distribution of contaminants between the gas and solid phase likely to be important.

In most soils, the strippability of various contaminants can be evaluated by computing the ratio of their concentration in the soil gas to their total concentration in the soil according to:

$$\frac{C_g}{C_T} = \left[\frac{K_D \rho_b}{H_{DW}} + \frac{\Theta_W}{H_{DW}} + (\Theta_T - \Theta_w)\right]^{-1}$$

where C_g is the concentration in the gas [M/V air]

C_T is the total concentration in the soil [M/V bulk volume soil]

K_D is the water-solid distribution coefficient [M/M solid/M/V water]

ρ_b is the bulk dry soil density [M/V solid]

H_{Dw} is the gas-water distribution coefficient [M/V air/M/V water]

Θ_w is the water filled porosity

Θ_T is the total porosity

The gas-water distribution coefficient is

$$H_{Dw} = C_g/C_w = H/RT \simeq \rho_s/S \qquad (4)$$

where	H	is the Henry's Law coefficient
	R	is the ideal gas constant
	T	is degrees Kelvin
	S	is the water solubility

The water-solid distribution coefficient is approximately

$$K_D = \frac{C_s}{C_w} \simeq \frac{K_{oc} \bullet \%OC}{100} \qquad (5)$$

where	C_S	is the concentration in the solid [mass VOC/mass soil]
	C_W	is the concentration in the water [mass VOC/volume water]
	K_{OC}	is the water-organic carbon distribution coefficient
	$\%OC$	is the percent organic carbon in the soil

In the absence of significant free VOC liquid when the vapor phase concentration is governed by equation (3), the maximum rate of VOC mass removal is

$$Q_m = \frac{C_r}{\left[\frac{K_d \rho_b}{H_D} + \frac{\Theta_w}{H_D} + (\Theta_T - \Theta_w)\right]} \bullet Q_a \qquad (6)$$

In order to more simply describe the strippability of a particular VOC at a specific site, one may define a "strippability factor", ß, which is

$$ß = \frac{\Theta_T - \Theta_W}{\left[\frac{K_{ws}\rho_b}{K_{gw}} + \frac{\Theta_W}{K_{gw}} + (\Theta_T - \Theta_W)\right]} \tag{7}$$

The strippability factor, ß, is simply the ratio of the mass of contaminant in the vapor phase to the total mass in the soil per unit bulk volume of soil. The larger ß, the faster the rate of removal at a given air circulation rate.

As indicated above, the strippability of a particular compound depends both on its chemical properties and on the properties of the soil. Chlorinated ethenes all have chemical properties favorable for vapor extraction. The two key soil properties affecting the removal of chlorinated ethenes by SVE are the moisture content and organic carbon content. The coarse-grained sediments at the site can be expected to be relatively well drained and to have a low organic carbon content. An example of the relative rates at which selected organic constituents can be removed from a soil is given in Table 5.1.

Air Circulation Rates

Air flow rates and patterns induced by SVE systems in soils are generally goverened by Darcy's Law modified to account for the fact that air is a compressible fluid (Carman, 1956). The appropriate form of Darcy's Law is (Al-Hussaing and other, 1966):

$$v = [k(\Theta)/\mu(P)]\nabla P$$

TABLE 5.1

PORE VOLUMES TO REMOVE 90% OF VOLATILE COMPOUNDS

Compound	*High Moisture,[1] High Organic Content*	*Low Moisture,[2] Low Organic Content*
Benzene	117	22
Vinyl chloride	19	6
1,1 Dichloroethene	9	4
Methylene chloride	66	24
1,1 Dichloroethane	58	17
Chloroform	73	22
1,1,1 Trichloroethane	61	11
Carbon Tetrachloride	51	9
Trichloroethene	103	17
Tetrachloroethene	76	11
1,2 Dichloroethane	211	60
cis-1,2 Dichloroethene	88	23
trans-1,2 Dichloroethene	117	19
Toluene	244	34

[1] - Water content = 50% Total porosity, percent organic carbon = 1%

[2] - Water content = 20% Total porosity, percent organic carbon = 0.1%

where:

v	is the Darcian air velocity [L/t]
$k(\Theta)$	is the effective air permeability [L^2]
P	is the absolute pressure [$M/L\text{-}t^2$]
Θ	is the soil moisture content [dimensionless]
μ	is the dynamic viscosity of air [M/L-t]
∇	is the gradient operator [1/L]

Deviations from Darcy's Law may occur close to SVE wells, where air flow rates are high, and in very fine-grained soils where the Klinkenberg effect may occur. Deviations from Darcy's Law near the well are accounted for by evaluating the efficiency of the well at various flow rates. The Klinkenberg effect enhances air flow rates at a given pressure gradient and is generally of little consequence in the design of SVE systems.

As shown in equation (6), the air flow rate depends on the effective air permeability of the soil and the pressure drop imposed by the vapor extraction system. The effective air permeability under field conditions depends both on the geometric properties of the soil and the moisture content of the soil. Even in soils that are not water saturated, the moisture content may be sufficiently high (particularly in fine grained soils) that very few interconnected pathways of air movement exist. The effective air permeability of such soils may be quite low, much less than the permeability that would be inferred from typical estimates or measurements of the water saturated hydraulic conductivity of the soils. The same may be true for soils containing a significant fraction of liquid phase organics.

The air permeability of the soils at the site is not expected to be a limiting factor in the design of the SVE systems except possibly in the landfill. Most of the soils are described as sands and gravels in the RI/FS so that their instrinsic permeability will be high (greater than 1 darcy) and the moisture content low leading to a high air permeability.

Sweeping Zones (Radius of Influence)

The rate at which VOCs are removed from soils by SVE wells depends on the rate of air flow through the soil. Both theory and practical experience show that the rate of air flow decreases away from an individual SVE well according to well known fluid dynamic principles. The zone of effective VOC removal (sweeping zone) created by an SVE well can be computed given a desired rate of cleanup if the pneumatic properties of the soil and vapor phase partitioning properties of the VOC are known. The concept of a "radius of influence" for an SVE well is usually based on the distance at which a measurable pressure drop can be observed. The radius of influence has little to do with the rate of VOC removal, but rather depends on the measurement equipment, the vapor extraction rate, and the pneumatic properties of the soil. The design of SVE systems for the Wausau site will, therefore, be based on sweeping zones computed using numerical or analytical models required to achieve the performance standards in the Consent Decree. A cleanup comparable to that achievable by a 25% overlap of the radii of influence of the SVE wells will be the goal of the performance modeling.

5.2.2.2 SVE Design Issues

With regard to additional site-specific design issues for the SVE systems at the Wausau NPL site, the RI report and the discussion presented above indicate that the soil conditions and contaminant properties in the source areas, Wausau Chemical Corporation and former City landfill/Marathon Electric property, are generally favorable for the use of SVE as a remedial technology. This evaluation is based on the facts that the soils are generally relatively permeable sands and gravels, and that the contaminants of interest (chlorinated ethenes) have physical chemical properties amenable to vapor extraction.

5.2.2.2.1 Wausau Chemical Site

The key design issues for the SVE system at the Wausau Chemical site will be:

1. Definition of VOC source areas;
2. The effect of variable surface conditions and utility corridors on air circulation patterns; and
3. Design of the SVE system to minimize interference with facility operations.

The investigations that will be performed to address the first two design issues are described in the SVE Predesign Work Plan.

Accommodation of existing facility operations will be addressed during the 95% design phase of the project. The approach to the first two design issues are discussed briefly below.

VOC Source Areas

Soil contamination by VOCs at the Wausau Chemical site may have originated from a number of documented and undocumented releases. The predesign investigation provides for a site-wide soil gas survey on approximately 50-foot centers to better define the areas of VOC contamination which require treatment by SVE. The results of the soil gas survey will be used to define VOC source areas and to develop compliance monitoring networks.

Soil and Surface Conditions

The surface and subsurface conditions at the Wausau Chemical site are likely to be sufficiently variable as to result in complex air circulation patterns around and between the SVE wells. Surface conditions which may contribute to complex air circulation patterns are the varying permeability and nature of surface paving materials and the presence of buildings and above-ground tanks. Subsurface conditions which will affect the design and performance of the SVE systems are the variable thickness and properties of fill materials at the site and the presence of underground utility corridors.

The effect of surface conditions on the design of the SVE systems will be addressed by analyzing the pressure response measured during pilot SVE tests at the site. Subsurface conditions will be evaluated by:

1) carefully defining the locations of utility corridors and the construction of building foundations;

2) developing structure contour and isopach maps showing the distribution of fill based on existing soil boring logs; and

3) performing drive-point air permeability tests in conjunction with the soil gas measurements to establish the relative distribution of air permeability in both the fill and native soils.

The data collected from these tests will be used to develop models from which the sweeping zones for alternative SVE well systems can be computed. The sweeping zones will be based on the mid-range of feasible air flow rates from the SVE system so that they can be expanded or contracted by adjusting air flow rates during actual system operations.

5.2.2.2.2 Marathon Electric/Former Landfill Site

The key design issues for the SVE system at the former City landfill/Marathon Electric site will be:

1) Definition of VOC source areas within the former landfill;

2) The effect of heterogeneous soil and fill properties in the landfill on air circulation patterns;

3) The effect of high organic fill materials on VOC removal by SVE; and

4) The effect of landfill methane and vinyl chloride generation and/or enhanced biological decay on SVE operation and off-gas treatment requirements.

The various investigations that will be performed to address these design issues are described below.

VOC Source Areas

The results of the RI investigations on the landfill indicate that VOC contamination is likely to be localized to the eastern one-third of the former landfill. A site-wide soil gas survey on approximately 50-foot centers will be performed to verify the current areas of VOC contamination which require treatment by SVE.

Soil and Surface Conditions

The subsurface conditions at the landfill are likely to be highly variable, resulting in complex air circulation patterns around and between the SVE systems. Surface conditions which may contribute to complex air circulation patterns are the varying permeability and nature of surface paving materials. Subsurface conditions which will affect the design and performance of the SVE systems are the variable thickness and properties of fill materials at the site.

Subsurface conditions will be evaluated by:

1) developing structure contour and isopach maps showing the distribution of fill based on existing soil boring logs;

2) performing drive-point air permeability tests in conjunction with the soil gas measurements to establish the relative distribution of air permeability in both the fill and native soils; and

3) by analyzing the pressure response measured during pilot SVE tests at the site.

The results of these investigations will be used along with air flow models to design an SVE system with appropriate sweeping zones.

High Organic Carbon

The fill materials in the former landfill may contain unusually high concentrations of organic carbon. The high organic content of the fill may limit the rate of VOC removal by SVE. Although the heterogeneous nature of the fill materials revealed in the test pits indicates that collecting undisturbed and representative samples of the fill will be impractical, the cuttings exposed during the drilling of the SVE pilot well and permanent piezometers will be carefully inspected and visual estimates made of their organic debris content. Samples of the fine-grained fill matrix will also be collected and analyzed for total organic carbon.

The data described above will be used to determine the air flow rates needed to accomplish the cleanup goals of the Consent Decree in high organic soils.

Degradation Products

Additional investigation at the landfill will be required to evaluate the methane and vinyl chloride concentrations in the gases initially removed by the SVE system. Methane concentrations in the off-gas will create a potential explosive hazard which must be considered in the design of the off-gas treatment system for this site. Vinyl chloride concentrations may also be high in the gases initially removed from the landfill as a result of anaerobic degradation of the more highly chlorinated compounds. Because vinyl chloride is not effectively removed by activated carbon treatment, the SVE system for the landfill and other areas containing vinyl chloride may need to be designed to operate at low mass emission rates during the initial stage of operation. As aerobic conditions are established in these areas, vinyl chloride production will stop and the rate of air circulation can be increased.

An additional concern in the landfill area will be the effect of circulating oxygenated air through residual organic matter. Under the proper conditions, the stimulation of organic decay by the SVE system could result in spontaneous combustion in the landfill. The potential for such an occurrence at the site depends on the organic content of the fill materials in the areas containing chlorinated ethenes. If the chlorinated ethenes are predominantly in areas with low organic content, then the SVE system can be designed to minimize air flow through the high organic areas. Otherwise, the SVE system design may need to include subsurface temperature sensors to monitor the potential for spontaneous combustion.

5.2.2.3 Relevant SVE Technical Factors

The design of the SVE systems will rely on accepted and proven remedial technologies. Conventional SVE wells will be used in the systems. Standard vapor-phase activated carbon adsorption units will be used for exhaust gas treatment.

Construction of the SVE systems should be straightforward. Usual well construction techniques are sufficient for SVE well installation. Standard activated carbon units will be used in the treatment systems. Because some areas of the site are active industrial facilities, piping for the SVE systems may be installed underground. This should pose no barrier to the construction of the systems. In all cases, accepted construction techniques for wells, piping, pipe trenches and all electrical facilities will be used. Applicable construction codes and engineering standards will be adhered to during installation of the SVE systems. Soils excavated during the installation of the SVE system will be used as backfill to the extent practicable. Any remaining soils requiring disposal will be properly characterized and disposed of in accordance with State and federal regulations.

5.2.2.4 Soil Clean-up Levels Based on Mass Flux Calculations

The Consent Decree specifies that mass flux calculations will be performed to determine the target soil cleanup standards for all contaminants of concern for the SVE system. These cleanup standards will be based on a residual soil concentration which, if left in the soil, will not result in groundwater concentrations exceeding the groundwater cleanup standards specified in the Consent Decree. The outline to perform the mass flux calculations is presented in Appendix C. The proposed soil clean-up levels for the contaminants of concern will be submitted with the 30 percent design submittal. Table 5.2 provides a summary of the identified contaminants of concern requiring soil clean-up levels. (The contaminants of concern are based on compounds identified in the groundwater during the RI at concentrations exceeding WAC NR 140 (October 1988) Standards at more than one location or on subsequent rounds.)

no! only detected

5.2.2.5 Groundwater Modeling

As specified in Paragraph 12.A.3.c. of the CD, the optimum pumping rates for operable unit extraction well EW-1 and municipal wells CW-3 and CW-6 will be determined by performing groundwater modeling. The groundwater model that will be used is discussed in detail in

TABLE 5.2

SOIL CLEAN-UP VOC PARAMETERS

Analyte
Acetone
1-2-Dichloroethene (total)
Trichloroethene
Benzene
Tetrachloroethene
Toluene
Ethylbenzene
Xylenes
Vinyl Chloride
1,1,2-Trichloroethane

Appendix D. The optimum pumping rates for the wells will be submitted with the 30 percent design submittal.

5.2.3 Design Submittals

Design submittals will be made at three stages of development for the remedial design. The three stages are 30%, 95% (pre-final) and 100% (final). At this time, it is expected that the submittals at each stage will be as outlined below:

30% Design

The 30% design submittal will include the results of the predesign investigation in a Final Pilot Study Report and preliminary plans showing the basic detail of each SVE system. This would include preliminary plans showing SVE systems layout, and design calculations.

At the 30% design level, an assessment of permitting requirements will be made. This will include identification of:

1) construction/operating permits potentially required;
2) the permitting authority;
3) regulations governing applications, exemptions and variances;
4) information required by each permit application; and
5) time required by the permitting agency to process the application.

This information will be used to develop a program to ascertain the impact of the respective permit program on the design, and to meet with each of the permitting authorities, if appropriate. Also, the necessity and timing for developing and submitting permit applications will be discussed with EPA during that period. Subsequently, the required permit applications will be developed and submitted.

The 30% design submittal will also present proposed soil clean up levels based on mass flux calculations and recommended pumping rates for the extraction well and City wells CW-3 and CW-6 based on groundwater modeling.

95% Design (Pre-Final)

The 95% design submittal will include:

1) Design Plans and Specifications;
2) Draft Operating and Maintenance Plan;
3) Initial Capital and Operating Maintenance Cost Estimate;
4) Draft Construction and Operation Schedule;
5) Draft Quality Assurance Project Plan (QAPP); and
6) Draft Health and Safety Plan (HSP).

The Remedial Design Plans and Specifications shall include, at a minimum:

1) discussion of design strategy and the design basis;

2) discussion of relevant technical factors;
3) description and justification of assumptions made;
4) discussion of possible sources of error;
5) detailed drawings of proposed design;
6) equipment specifications;
7) material and energy balances; and
8) appendices including sample calculations, derivations, and results.

The Operations and Maintenance Plan will be developed to ensure the safe and effective operation of the SVE system. The elements of the Operation and Maintenance Plan will include discussion of the following items:

1) health and safety plan;
2) normal operation and maintenance;
3) potential operating problems;
4) routine monitoring and testing;
5) corrective actions;
6) long-term monitoring and maintenance;
7) alternative operation and maintenance;
8) equipment description; and
9) required records and reporting mechanisms.

The generic Operations and Maintenance Plans developed during the remedial design will be updated with specifics supplied by vendors for various components of the remedy when the remedial construction is completed.

A cost estimate for SVE system construction, operation and maintenance will be developed. This cost estimate will include costs associated with compliance monitoring as well as routine O&M and construction tasks.

Construction and Operation Schedule

A schedule of construction activities and anticipated SVE system startup and operation will be included with the 95% design submittal. This schedule will address major construction milestones, inspection activities, sampling to be performed prior to system startup, and SVE operation activities. Routine sampling for O&M purposes to be performed during SVE system operation will be scheduled according to the O&M plan. Compliance monitoring sampling will be performed in accordance with Appendix E. A Compliance Monitoring QAPP for RA activities will be developed to ensure that all sampling and analytical activities are properly controlled and documented. The QAPP will be developed based upon EPA guidance and in accordance with the Consent Decree. The QAPP will include:

1) statement of purpose;
2) project description;
3) project organization;
4) project responsibilities;
5) sampling and custody procedures;
6) calibration procedures and frequency;
7) quality assurance objectives;

8) analytical procedures;
9) data analysis and reporting;
10) internal QC checks and frequency;
11) performance and system audits and frequency;
12) preventative maintenance procedures and frequency;
13) method-specific procedures for assessing data precision, accuracy and completeness;
14) corrective actions; and
15) QA reports.

A construction Health and Safety Plan (HSP) will be developed and designed to protect on-site personnel and area residents from physical, chemical and other hazards posed during implementation of the RA. The HSP will address the following items:

1) general requirements;
2) personnel;
3) levels of protection;
4) safety work practices and safeguards;
5) medical surveillance;
6) personnel and environmental air monitoring;
7) personal protective equipment;
8) personal hygiene;
9) decontamination, personal and equipment;
10) site work zones;
11) contaminant migration control;
12) contingency and emergency planning; and

13) logs reports and recordkeeping.

The HSP shall be prepared following U.S. EPA guidance and OSHA requirements as outlined in 29 CFR1910.

100% (Final) Design

The 100% design submittal will include:

1) Final Design Plans and Specifications;
2) Final Construction Cost Estimate;
3) Final Operation and Maintenance Plan;
4) Final Quality Assurance Project Plans (QAPP);
5) Final project schedule;
6) Final Health and Safety Plan (HSP);
7) Final soil clean up levels; and
8) Final groundwater extraction rates.

The quality of the design documents will be such that they could be included in a bid package to invite contractors to submit bids for the construction project.

6.0 REMEDIAL ACTION ACTIVITIES

Remedial action activities involve all aspects of implementing the remedy at the site. This involves contractor selection, remedial construction, operation and maintenance, long-term monitoring and testing to ensure systems are operating effectively, testing to monitor performance, and decommissioning of the SVE systems.

6.1 CONSTRUCTION QUALITY ASSURANCE PROGRAM PLAN

Following approval of the final design report, CRA will submit a Construction Quality Assurance (CQA) Program Plan. The CQA Program Plan will cover the construction (Task III) of the final remedy. The CQA Program Plan will be a document which describes the site specific components of the soil vapor extraction (SVE) systems. The purpose is to insure that the SVE systems will meet all design criteria, plans, and specifications. The CQA Program Plan will address several elements briefly summarized as follows:

1) The responsibility and authority of the organizations involved in the project;
2) SVE contractor qualifications and key personnel involved in the construction of the SVE system including the construction quality assurance officer and supporting personnel;

3) Inspection activities including observations, tests and inspections that will be used to monitor construction, and the frequency of performance of these activities; and

4) The reporting requirements to document CQA activities.

6.2 REMEDIAL CONSTRUCTION

The final remedy shall be constructed and operated in accordance with the approved CQA Program Plan. A construction documentation report including daily summary reports, schedule of data submissions, design acceptance reports, photo documentation and record drawings will be submitted to summarize construction procedures. Progress reports will be prepared summarizing results of performance monitoring of the SVE systems and other components of the final remedy.

At this time, it is envisioned that a separate contract will be established to complete the final remedy. The contract will be established for the construction of the SVE systems.

Contract and bid documents will be prepared by CRA and will be provided to pre-qualified contractors. A remedial contractor will be selected from the bids received.

The selected contractor will carry out the work in accordance with the approved design and CQA and under the supervision of CRA and/or Hydro Geo Chem.

6.3 OPERATION AND MAINTENANCE

Operation and maintenance activities will be conducted in accordance with the approved Operation and Maintenance Plan. The major activities will involve the operation and maintenance of the SVE systems and the groundwater collection and treatment systems.

An Operation and Maintenance (O&M) Plan will be submitted with the pre-final (95%) design package. This plan will include descriptions of the normal operation and maintenance procedures to be followed for each system, the frequency of routine O&M tasks, a description of potential problems and their possible remedies, a description of routine monitoring procedures and a schedule of routine monitoring activities. The O&M plan will also include an analysis of alternative procedures to be followed in the case of partial or total system failure. This section will describe potential vulnerability to anticipated natural or man-made disasters and procedures to be used to limit hazards to workers or the general public in the case of system failure.

The O&M plan will include corrective actions to be taken in the case of anticipated problems with system operation or in the case of the failure of a system to perform as expected. A schedule for detection of potential problems and in initiation of corrective action will be included.

A contractor or individual will be selected to carry out operation and maintenance activities. Hydro Geo Chem and CRA will be directly involved during start up and debugging of the SVE system. Once the system has been stabilized, CRA and Hydro Geo Chem will provide oversight and performance monitoring.

6.4 MONITORING AND TESTING

Long-term monitoring and testing will be conducted to monitor the effectiveness of each component of the remedy. Monitoring of groundwater quality, groundwater treatment effectiveness and SVE system effectiveness will be conducted. Specific long-term monitoring and testing requirements are discussed in the Compliance Monitoring Plan (Appendix E).

6.5 DECOMMISSIONING

Decommissioning of the SVE extraction and treatment systems would occur using a phased approach. The first phase of decommissioning would involve shutting the systems off and maintaining them in an operational state while continuing to monitor . The second phase of decommissioning would involve removal of salvageable components of the systems from the site. All decommissioning activities will be approved by EPA, in consultation with the WDNR, prior to implementation. Any SVE or groundwater monitoring well abandonment will be conducted in accordance with applicable State and Federal requirements including WAC NR 112 and WAC NR 141.

7.0 REPORTS AND DOCUMENTATION

7.1 MONTHLY PROGRESS REPORTS

Monthly progress reports will be provided to EPA and WDNR as required by the Consent Decree and will include the following major items:

1. Description of actions which have been taken toward achieving compliance with the Consent Decree during the previous month, including supporting documentation;
2. Results of sampling and test data which have passed quality assurance and quality control procedures;
3. Plans and procedures completed under the RD/RA Work Plan during the previous month;
4. A description of actions, data and plans which are scheduled for the next month and other information relating to the progress of construction;
5. Information regarding percentage of completion, unresolved delays encountered or anticipated that may affect the future schedule of implementation of the RD/RA SOW or Work Plan, and a description of efforts made to mitigate those delays or anticipated delays; and

6. Proposed departures from the Work Plan and associated documents and proposed variances from the ARARs for the next month.

7.2 DRAFT AND FINAL TASK PLANS AND REPORTS

Upon EPA and WDNR approval of the required project work plan, CRA will continue implementation of the final remedy at the Marathon Electric and Wausau Chemical source areas. The implementation of the final remedy includes the generation of additional plans and reports which are listed below:

Plans:

Project Plans:

Final RD/RA Work Plan (including Final Health and Safety Plan, Quality Assurance Program Plan, Monitoring Program Plan and Project Schedule for Completion of Tasks).

Remedial Design Plans:
Design Plans and Specifications (including Preliminary, Pre-Final and Final submittals).

Draft and Final Operation and Maintenance Plans.

Initial and Final Cost Estimates.

Draft and Final Construction and Operation Schedule.
Draft and Final Quality Assurance Project Plan.

Final Remedy Construction Plans:
Construction Quality Assurance (CQA) Program Plan.

Reports:

Pre-Final Inspection Report
Draft and Final Construction Completion Report
Draft and Final Completion of Final Remedy Report
Notification of Completion of SVE Work and Draft SVE Report
Final SVE Report

These plans and reports will be submitted in accordance with the schedule set forth in Section 9.0 of this Work Plan which is consistent with the SOW.

7.3 PREDESIGN PILOT STUDY REPORT

The results of the predesign SVE pilot study will be provided with the 30% design submittal.

7.4 LONG-TERM OPERATION AND MAINTENANCE AND MONITORING AND TESTING REPORTS

Long-term operation and maintenance and monitoring and testing reports will be completed on a periodic basis (to be specified in the Operation and Maintenance Plan) and will detail operation and maintenance activities and monitoring and testing results. These reports will also include assessments of the progress towards meeting remedial objectives.

8.0 COMMUNITY RELATIONS

A community relations program will be implemented by the EPA and Wisconsin DNR. Support will be provided for community relations activities. This support may include, but is not necessarily limited to, preparation of information to be distributed to the public and attendance at public meetings held to inform the public of the progress of the final remedy at the Wausau site. All community relations support provided to the EPA and the State of Wisconsin will be consistent with the guidelines published by the EPA in the "Guidance for Implementing the Superfund Program" and "Community Relations in Superfund - A Handbook". To assist in community relations support, the City of Wausau will maintain an archive of all reports, plans and data generated during implementation of the final remedy.

9.0 SCHEDULE

Figure 9.1 presents a preliminary schedule for the RD/RA. A schedule of construction activities and anticipated SVE system startup and operation will be included with the 95% design submittal. This schedule will address major construction milestones, inspection activities, sampling to be performed prior to system startup, and SVE operation activities. Routine sampling for O&M purposes to be performed during SVE system operation will be scheduled according to the O&M plan. Compliance monitoring sampling will be performed at the frequency described in Appendix E.

Scheduling of field activities such as the predesign investigation are subject to weather considerations and may be modified as approved by the EPA and WDNR as the project develops.

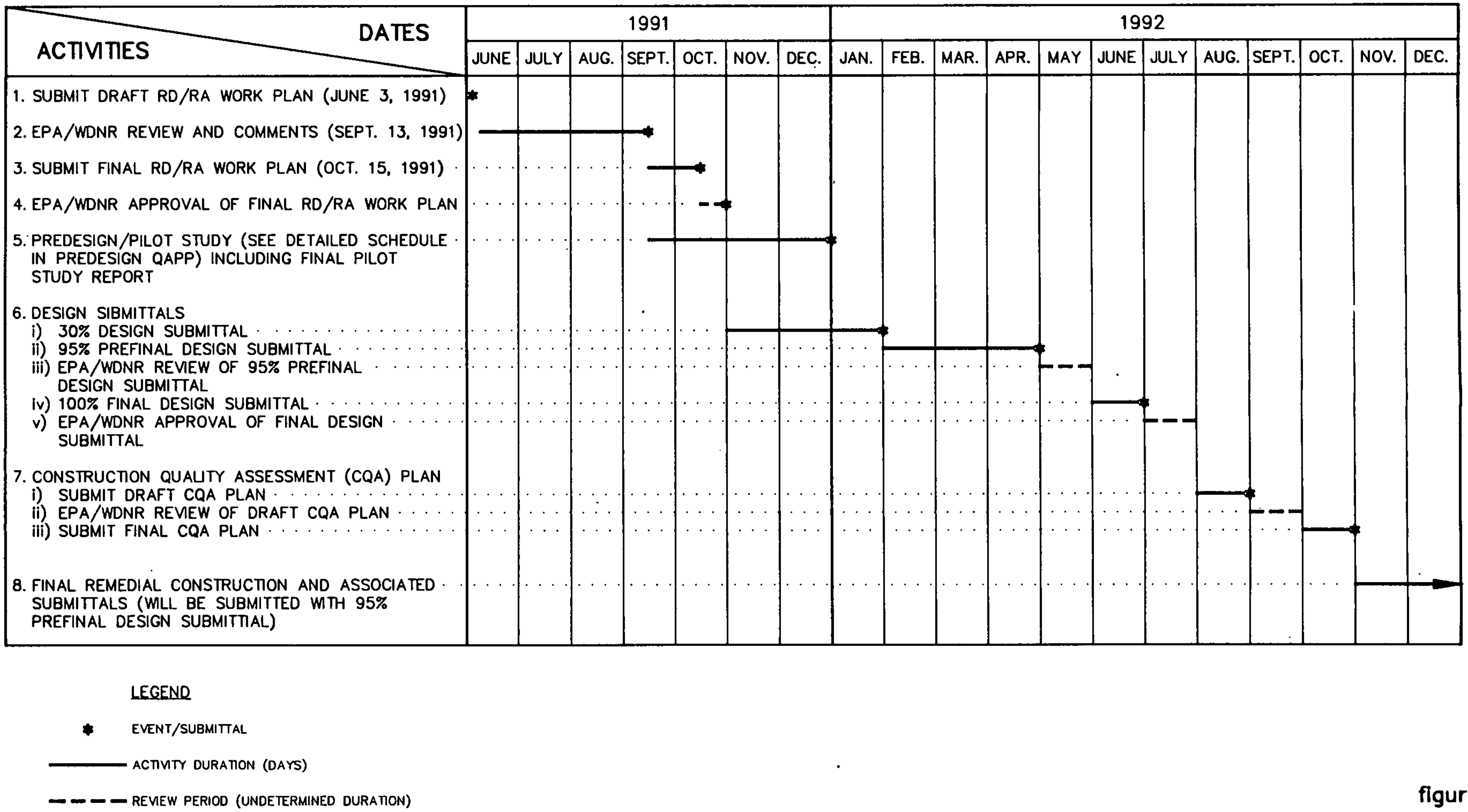


figure 9.1
RD/RA PROJECT SCHEDULE
RD/RA WORK PLAN
Wausau Superfund Site

SOURCE: STS CONSULTANTS LTD.
SHEET No. 18397XH-1

LEGEND

WC1 MONITORING WELL LOCATION AND NUMBER

CW4 PUMPING MUNICIPAL WELL LOCATION AND NUMBER

▲ STAFF GAUGE

● EXTRACTION WELL

—·—·— SITE PROPERTY LINE

Nº	Revision	Date	Initial

Approved

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

SITE DIAGRAM

CRA Consulting Engineers
CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive, Waterloo, Ontario Canada N2V 1C2

Drawn by: J.S.L.
Designed by: E.R.
Checked by: E.R.
Scale: 1"=200'
Date: MAY 1991
File Nº: 01
Rev. Nº:
Field book:
Project Nº: 3978
Drawing Nº: 1

LEGEND

- ⌖ MONITORING WELL
- ✦ MUNICIPAL WELL
- ● PROPOSED SOIL GAS PROBE LOCATIONS
- —·— PROPERTY LINE

SOURCE: STS CONSULTANTS LTD.
SHEET No. 18397XH-2

Nº	Revision	Date	Initial

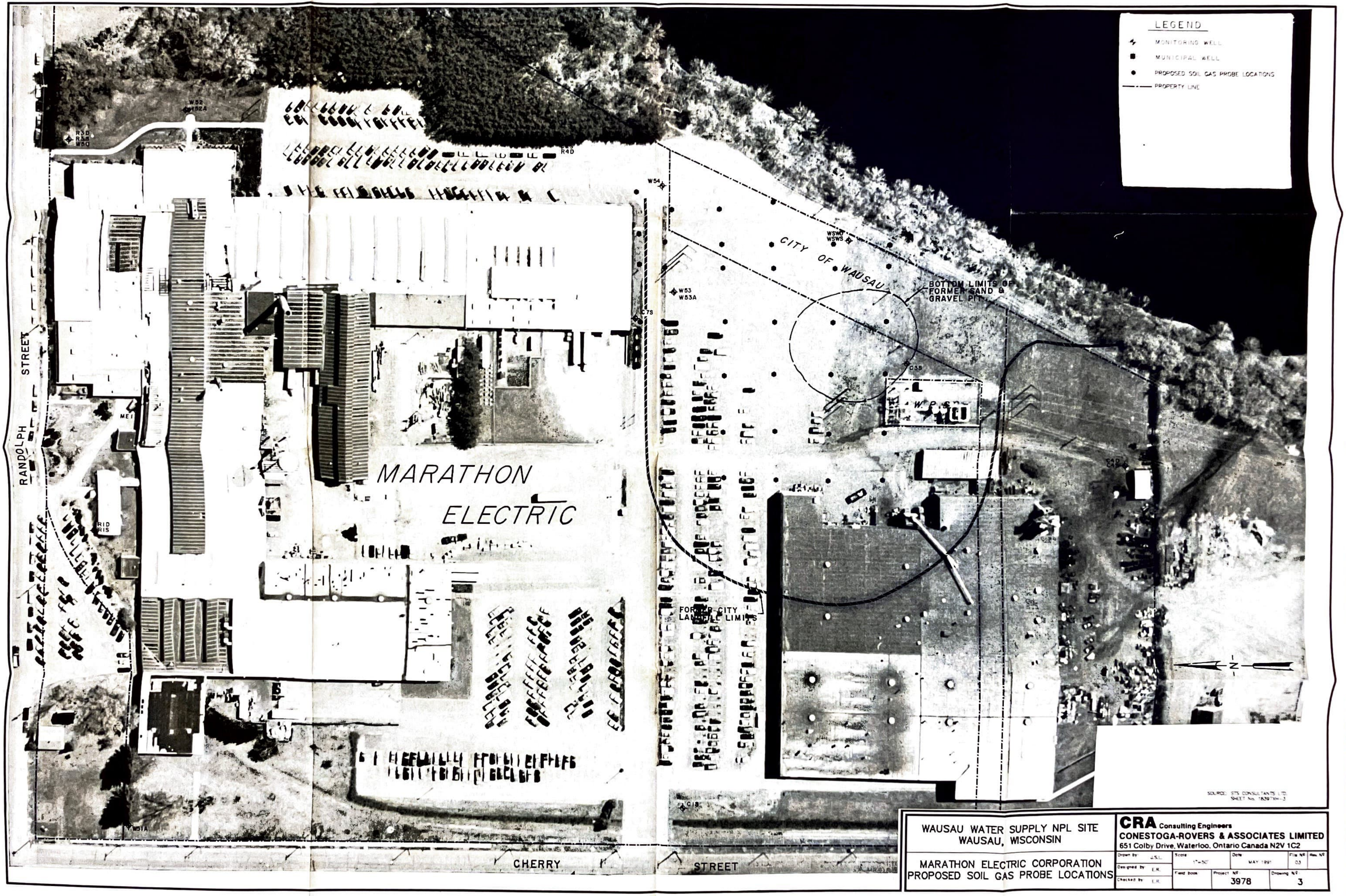
Approved

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WAUSAU CHEMICAL CORPORATION
PROPOSED SOIL GAS PROBE LOCATIONS

CRA Consulting Engineers
CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive, Waterloo, Ontario Canada N2V 1C2

Drawn by: J.S.L.	Scale: 1"=50'	Date: MAY 1991	File Nº: 02	Rev. Nº
Designed by: E.R.				
Checked by: E.R.	Field book:	Project Nº: 3978	Drawing Nº: 2	



SOURCE: STS CONSULTANTS LTD.
SHEET No. 1839?XH-3

WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

MARATHON ELECTRIC CORPORATION
PROPOSED SOIL GAS PROBE LOCATIONS

CRA Consulting Engineers
CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive, Waterloo, Ontario Canada N2V 1C2

Drawn by: J.S.L.	Scale: 1"=50'	Date: MAY 1991	File Nº 03	Rev. Nº
Designed by: E.R.	Field book:	Project Nº: 3978	Drawing Nº: 3	
Checked by: E.R.				

APPENDIX C

CALCULATION OF SOIL CLEANUP LEVELS

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C.1 INTRODUCTION

The purpose of this appendix is to develop a suitable calculation procedure that will allow for the estimation of soil contaminant concentrations such that the levels of VOCs in the saturated portion of the aquifer do not exceed the groundwater quality standards established in Wisconsin Administrative Code NR 140. Paragraph A.2.a of the Consent Decree specifies that the groundwater quality standards are to be met at the boundary of each contamination source area. Therefore, the compliance point in the groundwater will correspond to the boundary of each contaminated source area which may be modified based on the results of the soil gas survey. The boundary of each source area will be approved by the EPA, in consultation with the WDNR.

The estimated soil VOC concentrations will be used as the cleanup standards for the operation of the soil vapor extraction system. The soil cleanup levels must be achieved in order to eliminate source area contaminant loading to the aquifer and thereby contribute to the achievement of the groundwater cleanup standards. Table C.1 provides a list of the VOCs for which soil clean-up levels will be calculated.

TABLE C.1

SOIL CLEAN-UP VOC PARAMETERS

Analyte
Acetone
1-2-Dichloroethene (total)
Trichloroethene
Benzene
Tetrachloroethene
Toluene
Ethylbenzene
Xylenes
Vinyl Chloride
1,1,2-Trichloroethane

C.2 DEVELOPMENT OF SOIL-CLEAN UP EQUATIONS

Figure C.1 presents a schematic of the physical system which exists at the Wausau Superfund site. This system is comprised of basically two flow systems. The vertical flow system represents a portion of the unsaturated zone which extends from the ground surface to the watertable. This vertical flow system contains the Volatile Organic Compound (VOC) contaminated soil as shown in the schematic. The water flow in the vertical flow system is primarily downwards due to the infiltration process which occurs at the atmosphere/ground surface interface. The horizontal flow system represents a portion of the saturated zone and the flow, as shown in the schematic, is from left to right. This flow rate is controlled by the hydraulic gradient and the distribution of hydraulic conductivity within the horizontal system.

The intersection of these two flow systems represents a mixing zone in which the fluid from the vertical flow system is mixed with the fluid in the horizontal flow system. Within this mixing zone the VOC in the vertical flow system is diluted by the fluid in the horizontal flow system.

This groundwater mixing zone is a simplification of the actual situation that exists since the actual mixing zone will be controlled by the governing processes within the saturated portion of the aquifer (e.g. advection, dispersion, and diffusion).

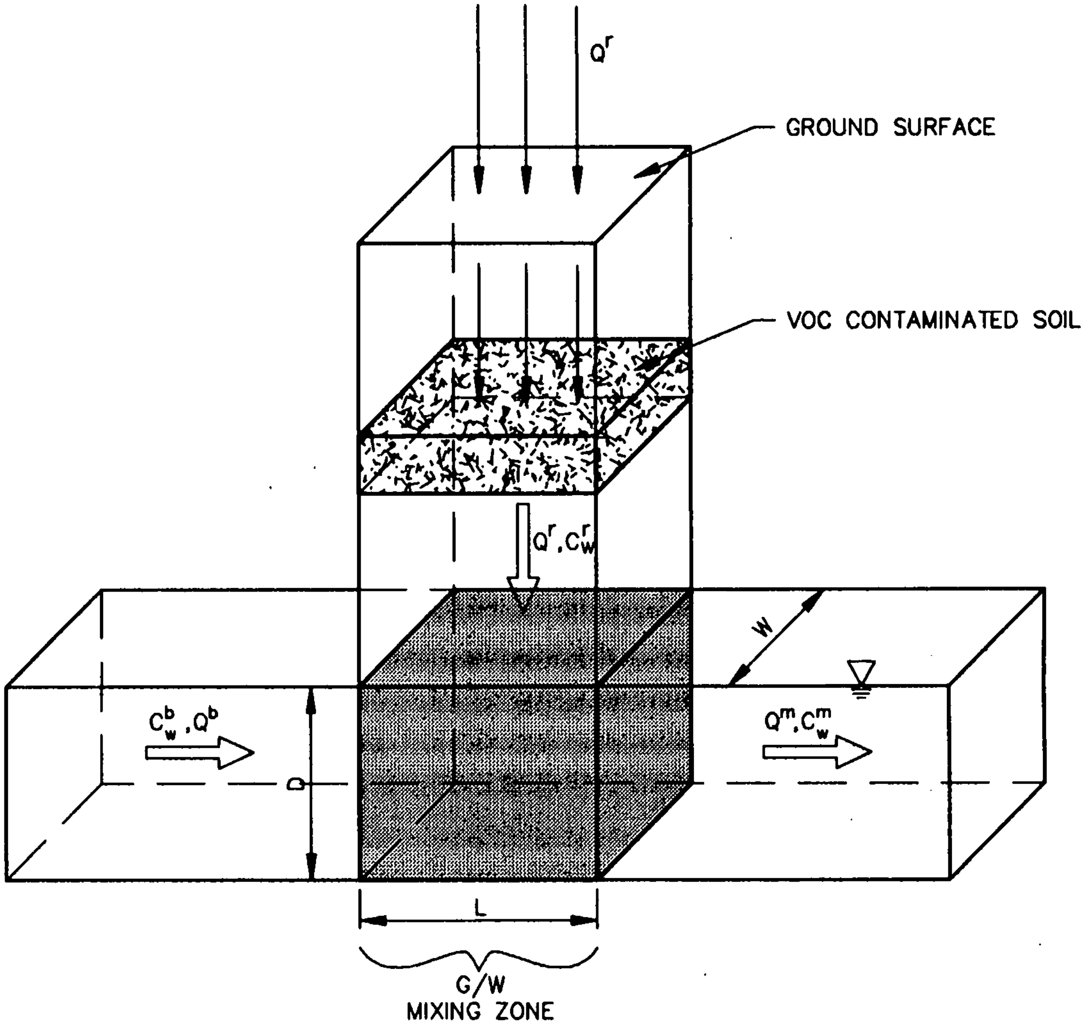


figure C.1

SCHEMATIC OF PHYSICAL SYSTEM
RD/RA WORK PLAN
Wausau Superfund Site

CRA

3978-15/05/91-2-0 (D-01)

In addition to the assumption discussed above, the following major assumptions are pertinent to the development of this soil cleanup equation:

- steady-state conditions are relevant;
- flow in the vertical flow system is controlled by annual recharge value;
- flow in the horizontal flow system is controlled by Darcy's Law, a uniform hydraulic gradient, and a uniform value of hydraulic conductivity;
- within the idealized groundwater mixing zone the fluid is completely mixed;
- the VOC within the unsaturated zone is only in the soil phase (i.e. no pure non-mobile phase exists);
- the partitioning between the soil phase and the aqueous phase is controlled by the linear equilibrium isotherm; and
- the distribution coefficient (k_d) can be determined by the product of the organic carbon partition coefficient and the fraction of organic carbon in the soil.

As a starting point for this development, consider a mass balance equation written for the idealized groundwater mixing zone as

$$C_w{}^b Q^b + C_w{}^r Q^r = C_w{}^m Q^m \tag{C.1}$$

where: Q^b, Q^m, Q^r are the flow rates prior to the mixing zone, after the mixing zone and in the vertical flow system, respectively,

$C_w{}^b$, $C_w{}^m$, $C_w{}^r$ are the aqueous phase VOC concentrations in the fluid prior to the mixing zone and in the vertical flow system.

The flow rate prior to the mixing zone can be determined from:

$$Q^b = qDW \tag{C.2}$$

where:
q is the darcy flux,
D is the depth of the mixing zone, and
W is the width of the entire flow system.

The flow rate in the vertical flow system can be estimated from:

$$Q^r = rLW \tag{C.3}$$

where:
r is the recharge rate,
L is the length of the vertical flow system, and
W is the width of the entire flow system.

The flow rate exiting the groundwater mixing zone is given by:

$$\begin{aligned} Q^m &= Q^r + Q^b = rLW + qDW \\ &= (rL + qD)W \end{aligned} \tag{C.4}$$

Rearranging (C.1) to isolate the aqueous phase VOC concentration in the vertical flow system yields:

$$C_w{}^r = \frac{C_w{}^m Q^m - C_w{}^b Q^b}{Q^r} \tag{C.5}$$

The relationship between the aqueous phase VOC concentration and the soil phase VOC concentration is given by:

$$C_s = k_d C_w{}^r \tag{C.6}$$

where: C_s is the soil phase VOC concentration, and

k_d is the distribution coefficient.

Rearranging (C.6) and substituting into (C.5) produces:

$$C_s = \left[\frac{C_w{}^m Q^m - C_w{}^b Q^b}{Q^r} \right] k_d \tag{C.7}$$

Assuming that there is no aqueous phase VOC in the fluid entering the mixing zone (i.e., $C_w{}^b = 0$), then (C.7) reduces to

$$C_s = \frac{C_w{}^m Q^m k_d}{Q^r} \tag{C.8}$$

Equation (C.8) represents an equation that can be used to estimate the soil phase VOC concentration. For each VOC under investigation, the appropriate water quality standard established in Wisconsin Administrative Code NR 140 can be inserted for $C_w{}^m$. The distribution coefficient can be estimated from

$$k_d = K_{oc}f_{oc}$$

where: K_{oc} is the organic carbon partition coefficient, and
f_{oc} is the fraction organic carbon in the soil.

Representative K_{oc} values will be obtained from the literature for each VOC under investigation, (i.e. Superfund Public Health Evaluation Manual (October 1986)) while f_{oc} values will be determined from soil sample analysis performed during the pre-design study as discussed in Appendix B.

APPENDIX D

GROUNDWATER MODELING PLAN

In order to determine optimum pumping rates for extraction well EW-1 and municipal wells CW-3 and CW-6 and to minimize well interference associated with excessively large cones of influence, groundwater modeling will be performed. Computer modeling will be carried out using the numerical, two-dimensional horizontal aquifer simulation Flowpath (Version 3.0) developed by Waterloo Hydrogeologic Software of Waterloo, Ontario.

The theoretical basis of Flowpath is the governing equation for two-dimensional, steady-state flow in heterogeneous, saturated, anisotropic, porous media (see Attachment D-1). A finite difference method is employed to solve the governing equation for two-dimensional, steady-state horizontal flow. Through this method, a rectangular grid is superimposed over the area of consideration of the groundwater system to discretize the system into grid cells that are small compared to the spatial extent of the entire aquifer. Specifically, Flowpath uses a block-centered finite difference scheme.

Aquifer properties, namely, hydraulic conductivities, porosity, aquifer thickness and aquifer bottom elevation are defined for each block and can be varied from block to block. The flux induced by infiltration or exfiltration from surface water bodies is accounted for by adding a head-dependent flux to the source or sink term. The boundary conditions are specified for any type of boundary, namely, constant head, no-flow and constant flux boundaries. Section 3.16 of Attachment D-1 discusses how the model accounts for different boundary conditions. For example, a no-flow boundary is established by setting the transmissivity for the specified grid blocks at zero.

Aquifer properties which will be used in the model will be estimated from information included in the attached list of sources for hydraulic data. Input parameters will primarily be based on the results of the pumping test at EW-1. The groundwater level database will be reviewed and the most representative and most complete data sets will be selected for model calibration and verification. Aquifer thicknesses and boundaries will be based on available geologic data, primarily borehole data, contained in the referenced reports. It is expected that adjustments will be required to these input parameters during calibration. Multiple scenarios, may need to be run to best estimate some properties, such as the leakage factor for the Wisconsin River.

The groundwater model will be calibrated by varying the hydraulic properties of the aquifer and comparing the results to the actual pumping program conducted in extraction well EW-1. The primary parameter that will be varied will be hydraulic conductivity. Since the model is a steady state solution, storativity is not an issue. The results from modeling will then be compared to the response of the aquifer to historical pumping rates in extraction well EW-1 and municipal wells CW-3 and CW-6 to verify calibration.

SOURCES OF HYDRAULIC DATA

Warzyn Engineering Inc., July 1989. Remedial Investigation Report, Wausau Water Supply NPL Site, Wausau, Wisconsin.

Warzyn Engineering Inc., August 1989. Feasibility Study, Wausau Water Supply NPL Site, Wausau, Wisconsin.

CRA, December 1990. Extraction Well No. 1 - Well Installation and Pump Testing, Marathon Electric Manufacturing Company, Wausau, Wisconsin.

CRA, January 1991. Evaluation of the Pumping Rate in Extraction Well No. 1, Marathon Electric Manufacturing Company, Wausau, Wisconsin.

ATTACHMENT D-1

CHAPTER II - THEORETICAL BACKGROUND

2.1 Two-Dimensional Steady-State Flow

The governing equation for two-dimensional, steady-state flow in heterogeneous, saturated, anisotropic, porous media, is:

$$\frac{\partial}{\partial x}\left(T_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(T_{yy}\frac{\partial h}{\partial y}\right)\pm Q(x,y)=0 \qquad (1)$$

where:

T_{xx} , T_{yy} = principal components of the transmissivity tensor (L^2T^{-1})

h = hydraulic head (L)

$Q(x,y)$ = volumetric fluxes of sinks (-) and sources (+) per unit surface area of aquifer. This term can represent pumping/injection wells, evapotranspiration, infiltration, and leakage from surface water bodies or over- and underlying aquifer-aquitard systems (LT^{-1})

x,y = Cartesian coordinates

The components of the transmissivity tensor are given by:

$$T_{xx}=bK_{xx} \qquad T_{yy}=bK_{yy} \qquad (2)$$

where:

b = saturated thickness for unconfined aquifers, or aquifer thickness for confined aquifers (L)

K_{xx} , K_{yy} = principal components of the hydraulic conductivity tensor (LT^{-1})

2.2 Velocities

The relationship between the properties of the porous medium, the hydraulic gradient and the groundwater flux is given by Darcy's law:

$$q_x = -K_{xx}\frac{\partial h}{\partial x} \qquad q_y = -K_{yy}\frac{\partial h}{\partial y} \tag{3}$$

where:

q_x, q_y = components of the Darcy flux in the directions x and y (LT^{-1})

The components of the average linear groundwater velocity are given by:

$$v_x = \frac{q_x}{\theta} \qquad v_y = \frac{q_y}{\theta} \tag{4}$$

where:

θ = effective porosity for flow (dimensionless)

2.3 Pathline Calculation

Pathlines provide a clear visual description of the groundwater flow regime. In a steady-state flow field with no areally distributed recharge, pathlines coincide with streamlines.

The two-dimensional characteristic equation of a pathline is given by :

$$p(x,y) = p(x_0, y_0) + \int v\,dt \tag{5}$$

where p is a vector containing the x, y coordinates of the pathlines, $p(x_0, y_0)$ defines the starting point of the pathline (initial condition), v is the average linear groundwater velocity and t is time.

2.4 Travel Times

As a by-product of the pathline integration in equation (5), the travel time of a fluid particle is obtained from:

$$t = t_0 + \int dt \tag{6}$$

where dt is an infinitesimal time increment corresponding to the spatial increment vdt and t_0 is initial time.

2.5 Time-Related Capture Zones And Wellhead Protection Areas

The capture zone of a pumping well is defined by the entire recharge area of the well. A time-related capture zone is the surface or subsurface area of an aquifer that provides recharge to the well discharge within a specified time.

According to the US EPA guidelines (1987), one way of delineating a wellhead protection zone is to find the "Zone of Contribution". This zone is equivalent to what has been defined above as a time-related capture zone. Time levels of interest range between 50 days and several years.

A large number of dissolved organic chemicals, bacteria and viruses adsorb to the aquifer material. Adsorption causes the contaminants to move slower than the groundwater. Linear, isothermal adsorption can be accounted for by introducing a retardation factor R in equation (5):

$$R = 1 + \frac{\rho_b}{\theta} K_d \tag{7}$$

where ρ_b is the bulk density of the aquifer material, θ is the effective porosity and K_d is the partitioning coefficient. Equation (5) can be re-written as:

$$p(x, y) = p(x_0, y_0) + \int v^* dt \tag{8}$$

where $v^* = v/R$.

This leads to a smaller wellhead protection area than in the case of a conservative chemical (e.g. chloride). It is therefore economical to account for the effect of adsorption in the process of delineating wellhead protection areas. However, in most cases it is not known a priori which chemicals or microbes the wellhead should be protected for. Looking at the sensitivity of the size of the wellhead protection area with respect to the retardation coefficient can, however, provide useful information about the behavior of the aquifer system. A retardation mechanism has therefore been implemented in FLOWPATH.

CHAPTER III - NUMERICAL IMPLEMENTATION

3.1 Flow Equation

A finite difference method is employed to solve the governing equation (1) for two-dimensional steady-state horizontal flow. The finite difference method has been commonly used in groundwater modeling (e.g. Pinder and Bredehoeft, 1968; Prickett and Lonnquist, 1971; Kinzelbach, 1986; McDonald and Harbaugh, 1984). In equation (1) the partial differentials ∂x and ∂y are approximated by finite lengths Δx and Δy. The aquifer is subdivided (discretized) into a number of blocks with side lengths of Δx and Δy and thickness b. Thus the governing equation takes the form of a fluid mass balance formulated for an ensemble of finite volumes of the aquifer. The two-dimensional formulation neglects any vertical gradients of hydraulic heads and velocities.

A rectangular grid is superimposed over the map of the groundwater system to discretize the system into grid cells that are small compared to the spatial extent of the entire aquifer. In the limiting case for an infinite number of cells (i.e. for infinitely small grid spacings Δx and Δy) the solution approaches the exact solution. The intersections of the grid lines are called nodes; they are referenced with a column (i) and a row (j) co-linear with the x and y directions, respectively (figure 1).

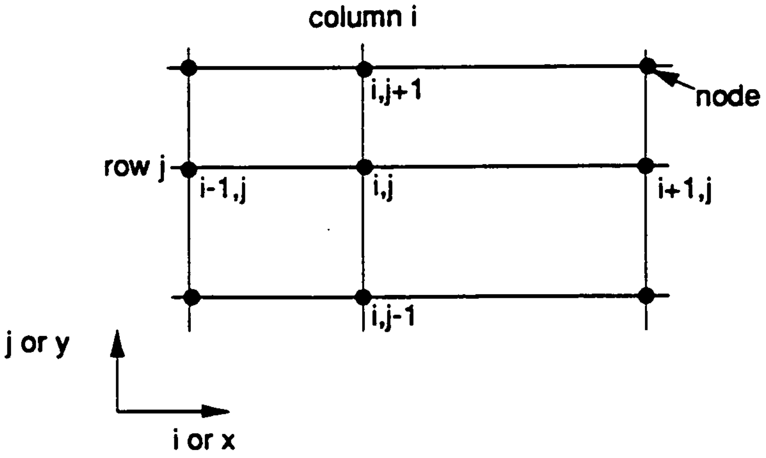


Figure 1 - Grid definition

FLOWPATH uses a block-centered finite difference scheme. Aquifer properties (hydraulic conductivities, porosity, aquifer thickness, aquifer bottom elevation) are defined for each block and can vary from block to block. Figure 2 shows the block representation corresponding to node i,j of figure 1.

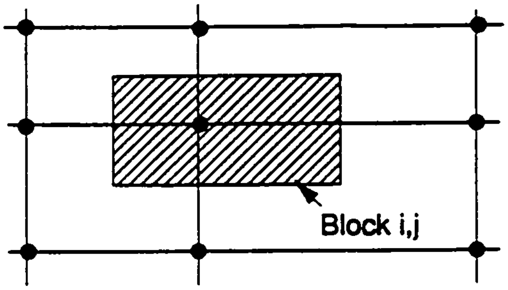


Figure 2 - Block definition

3.1.1 Confined Aquifers

Considering an internal node i,j in a confined aquifer, the finite-difference form of equation (1) may be written as:

$$\frac{1}{\Delta x_{i,j}}\left\{\left[\frac{T_{xx_{i+1/2,j}}(h_{i+1,j}-h_{i,j})}{\Delta x_{i+1/2,j}}\right]-\left[\frac{T_{xx_{i-1/2,j}}(h_{i,j}-h_{i-1,j})}{\Delta x_{i-1/2,j}}\right]\right\}+ \tag{9}$$
$$\frac{1}{\Delta y_{i,j}}\left\{\left[\frac{T_{yy_{i,j+1/2}}(h_{i,j+1}-h_{i,j})}{\Delta y_{i,j+1/2}}\right]-\left[\frac{T_{yy_{i,j-1/2}}(h_{i,j}-h_{i,j-1})}{\Delta y_{i,j-1/2}}\right]\right\}=Q_{i,j}$$

where:

$T_{xx_{i-1/2,j}}$, $T_{xx_{i+1/2,j}}$ = aquifer transmissivities between nodes i,j and $i-1,j$, and nodes i,j and $i+1,j$, respectively. These values are taken as the weighted harmonic mean between the transmissivities of blocks $[(i,j);(i-1,j)]$ and $[(i,j);(i+1,j)]$:

$$T_{xx_{i-1/2,j}}=\frac{(\Delta x_{i,j}+\Delta x_{i-1,j})T_{xx_{i,j}}T_{xx_{i-1,j}}}{T_{xx_{i,j}}\Delta x_{i,j}+T_{xx_{i-1,j}}\Delta x_{i-1,j}} \quad , \quad T_{xx_{i+1/2,j}}=\frac{(\Delta x_{i,j}+\Delta x_{i+1,j})T_{xx_{i,j}}T_{xx_{i+1,j}}}{T_{xx_{i,j}}\Delta x_{i,j}+T_{xx_{i+1,j}}\Delta x_{i+1,j}}$$

$T_{xx_{i,j}} = K_{xx_{i,j}} b_{i,j}$

$b_{i,j}$ = aquifer thickness of block i,j (L)

$K_{xx_{i,j}}$ = hydraulic conductivity of block i,j in x direction (LT^{-1})

$T_{yy_{i,j-1/2}}$, $T_{yy_{i,j+1/2}}$ = aquifer transmissivities between nodes i,j and $i,j-1$, and nodes i,j and $i,j+1$, respectively. These values are taken as the weighted harmonic mean between the transmissivities of blocks $[(i,j);(i,j-1)]$ and $[(i,j);(i,j+1)]$.

$T_{yy_{i,j}} = K_{yy_{i,j}} b_{i,j}$

$K_{yy_{i,j}}$ = hydraulic conductivity of block i,j in y direction (LT^{-1})

$\Delta x_{i,j}$ = length of block i,j in x direction (L)

$\Delta x_{i-1/2,j}$, $\Delta x_{i+1/2,j}$ = distance between nodes i,j and $i-1,j$; and nodes i,j and $i+1,j$, respectively (L) (figure 3)

$\Delta y_{i,j}$ = length of block i,j in y direction (L) (figure 3)

$\Delta y_{i,j-1/2}$, $\Delta y_{i,j+1/2}$ = distance between nodes i,j and $i,j-1$; and nodes i,j and $i,j+1$, respectively (L) (figure 3)

$h_{i,j}$ = hydraulic head at node i,j (L)

$Q_{i,j}$ = volumetric fluxes of sinks (-) and sources (+) per unit surface area of aquifer at node i,j. This term can represent pumping/injection wells, evapotranspiration, infiltration, and leakage from surface water bodies or over- and underlying aquifers. For pumping or injection wells, FLOWPATH automatically divides the total flow rate of the well by the block surface area $\Delta x_{i,j} \Delta y_{i,j}$ to obtain the flux at node i,j (LT^{-1})

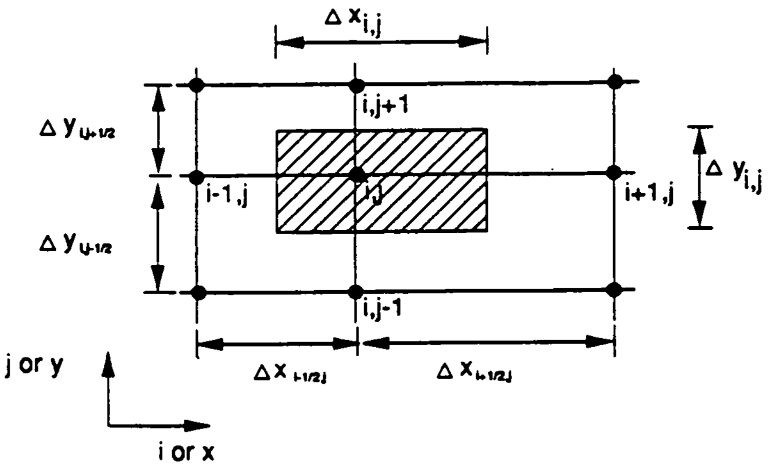


Figure 3 - Definition of block dimensions

3.1.2 Unconfined Aquifers

For unconfined aquifers the saturated thickness $b_{i,j}$ is a function of the hydraulic heads. A priori, both the hydraulic heads and the saturated thickness are unknown. Mathematically, this leads to non-linear behavior. An initial guess for the saturated thickness is required in order to estimate the aquifer transmissivities $T_{xx_{i,j}}$ and $T_{yy_{i,j}}$.

An iterative scheme must be used to calculate the hydraulic head distribution, update the transmissivities and check if the discrepancy between the previously estimated saturated thickness and the updated one is greater than a specified tolerance (see also section 3.1.7).

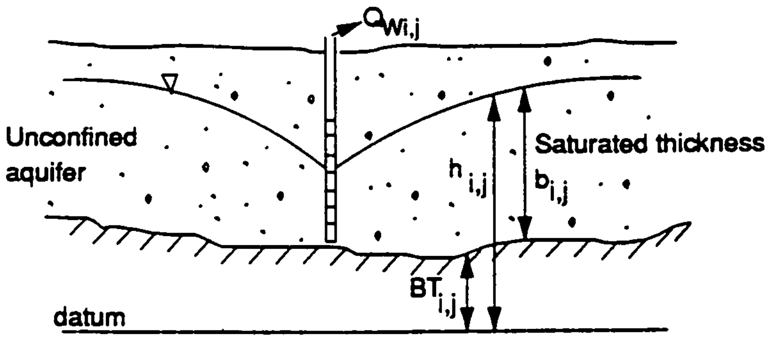


Figure 4 - Schematic representation of an unconfined aquifer

The directional transmissivities between adjacent nodes $T_{xx_{i+1/2,j}}$, $T_{yy_{i,j+1/2}}$ are calculated by multiplying harmonic averages of hydraulic conductivities by geometric averages of saturated thickness (Butler, 1957).

$$T_{xx_{i+1/2,j}} = K^{*}_{xx_{i+1/2,j}}\sqrt{(h_{i+1,j}-BT_{i+1,j})(h_{i,j}-BT_{i,j})} \qquad (10)$$

$$T_{yy_{i,j+1/2}} = K^{*}_{yy_{i,j+1/2}}\sqrt{(h_{i,j+1}-BT_{i,j+1})(h_{i,j}-BT_{i,j})}$$

where:

$BT_{i,j}$ = aquifer bottom elevation at node i,j (figure 4)

$K^{*}_{xx_{i+1/2,j}}$, $K^{*}_{yy_{i,j+1/2}}$ = hydraulic conductivities between blocks i,j and $i+1,j$; and blocks i,j and $i,j+1$, respectively.

$$K^{*}_{xx_{i+1/2,j}} = \frac{(\Delta x_{i,j}+\Delta x_{i+1,j})K_{xx_{i+1,j}}K_{xx_{i,j}}}{K_{xx_{i+1,j}}\Delta x_{i+1,j}+K_{xx_{i,j}}\Delta x_{i,j}} \qquad (11)$$

$$K^{*}_{yy_{i,j+1/2}} = \frac{(\Delta y_{i,j}+\Delta y_{i,j+1})K_{yy_{i,j+1}}K_{yy_{i,j}}}{K_{yy_{i,j+1}}\Delta y_{i,j+1}+K_{yy_{i,j}}\Delta y_{i,j}}$$

3.1.3 Leaky Aquifers

A leaky aquifer condition such as the situation shown in figure (5) is simulated by introducing exchange fluxes with the overlying and the underlying aquifers as source- or sink-terms. The exchange terms are formulated according to Darcy's law; thus, the flow between neighboring aquifers is proportional to their head-difference. Let $H_{1_{i,j}}$ and $H_{2_{i,j}}$ be the constant hydraulic head in the overlying and underlying aquifers, respectively. Then the steady-state flux exchanged between these aquifers and the modelled aquifer at node i,j is represented as:

$$q_{L1_{i,j}} = L_{1_{i,j}}(H_{1_{i,j}}-h_{i,j}) \qquad q_{L2_{i,j}} = L_{2_{i,j}}(H_{2_{i,j}}-h_{i,j}) \qquad (12)$$

where $L_{1_{i,j}}$ and $L_{2_{i,j}}$ are the leakage factors for the overlying and the underlying aquifers, respectively. The leakage factors are defined as:

$$L_{1_{i,j}} = \frac{K_{f1_{i,j}}}{d_{1_{i,j}}} \quad , \quad L_{2_{i,j}} = \frac{K_{f2_{i,j}}}{d_{2_{i,j}}} \tag{13}$$

where $K_{f1_{i,j}}$ and $K_{f2_{i,j}}$ are the hydraulic conductivities, and $d_{1_{i,j}}$ $d_{2_{i,j}}$ are the thicknesses of the overlying and underlying aquitards respectively.

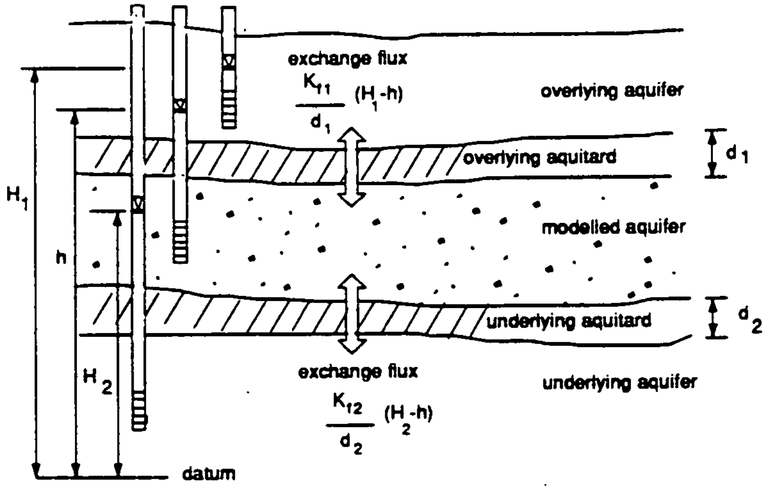


Figure 5 - Schematic representation of a leaky aquifer

3.1.4 Surface Water Bodies

The flux induced by infiltration or exfiltration from surface water bodies is accounted for by adding a head-dependent in(out)flux $q_{L_{i,j}}$ to the source or sink term $Q_{i,j}$. By assuming that the rate of flow through a streambed is directly proportional to streambed area, hydraulic conductivity of the streambed, and head difference between the aquifer and the stream (figure 6), this flux can be represented by:

$$q_{L_{i,j}} = L_{r_{i,j}}(H_{r_{i,j}} - h_{i,j}) \qquad \text{if} \qquad h_{i,j} > BR_{i,j} \tag{14}$$

$$q_{L_{i,j}} = L_{r_{i,j}}(H_{r_{i,j}} - BR_{i,j}) \qquad \text{if} \qquad h_{i,j} < BR_{i,j}$$

$BR_{i,j}$ is the elevation of the river or lake bottom, $H_{r_{i,j}}$ is the surface water table elevation in the river or lake at node i,j. Note that the effect of partial penetration of a surface water body is neglected and the head in the stream or lake is assumed to remain constant. $L_{r_{i,j}}$ is a leakage factor defined at each streambed node:

$$L_{r_{i,j}} = \frac{K_{r_{i,j}}}{d_r} R_{a_{i,j}} \tag{15}$$

where:

$K_{r_{i,j}}$ = hydraulic conductivity of the river or lake bed (LT^{-1})

d_r = thickness of the river or lake bed (L)

$R_{a_{i,j}}$ = correction factor for ratio of surface areas of finite difference block and river or lake in the block (figure 7).

The correction factor for the area ratio $R_{a_{i,j}}$ is employed because the leakage area $A_{i,j}$ of the river or lake bed within a block i,j maybe smaller than the area of the block itself $(\Delta x_{i,j} \Delta y_{i,j})$. Thus, the correction factor is written as:

$$R_{a_{i,j}} = \frac{A_{i,j}}{\Delta x_{i,j} \Delta y_{i,j}} \tag{16}$$

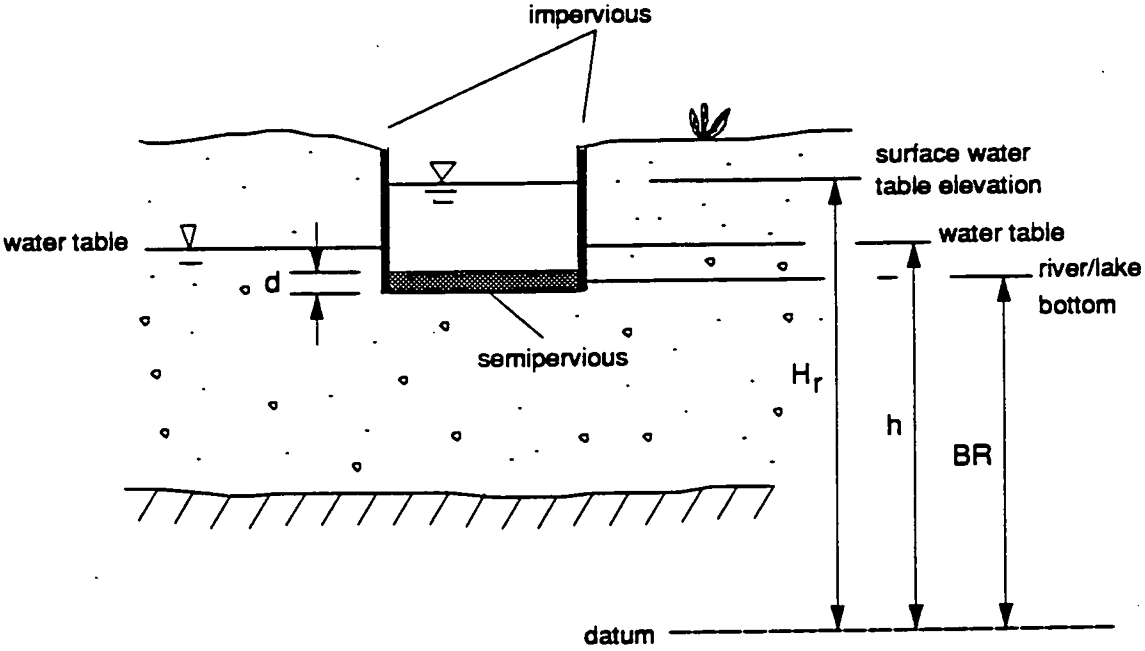


Figure 6 - Leakage from Surface Water Bodies (after Kinzelbach, 1986)

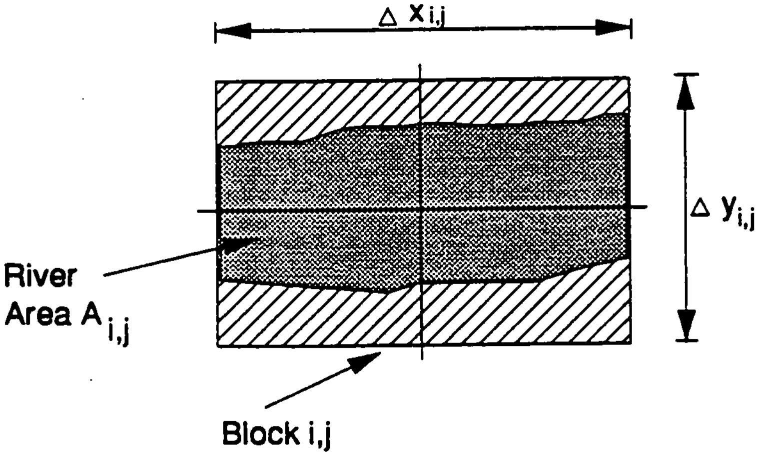


Figure 7 - Correction for Area Ratio

Note that the flux $q_{L_{i,j}}$ in equation (13) remains constant as long as the groundwater table lies below the river or lake bottom. However, if the groundwater table lies above the river bottom, the flux becomes a function of the head difference between the aquifer and the surface water body; this results in a non-linearity in the system and iteration is necessary (see section 3.1.7).

3.1.5 Infiltration and Evapotranspiration

Surface infiltration or evapotranspiration remain constant throughout the simulation, independent of the hydraulic heads. Infiltration and evapotranspiration rates are defined as flow rates per unit aquifer surface area. They are added directly to the source/sink term $Q_{i,j}$ in equation (9).

3.1.6 Boundary Conditions

The boundary conditions are specified at the center of a block (figure 8) for any type of boundary condition.

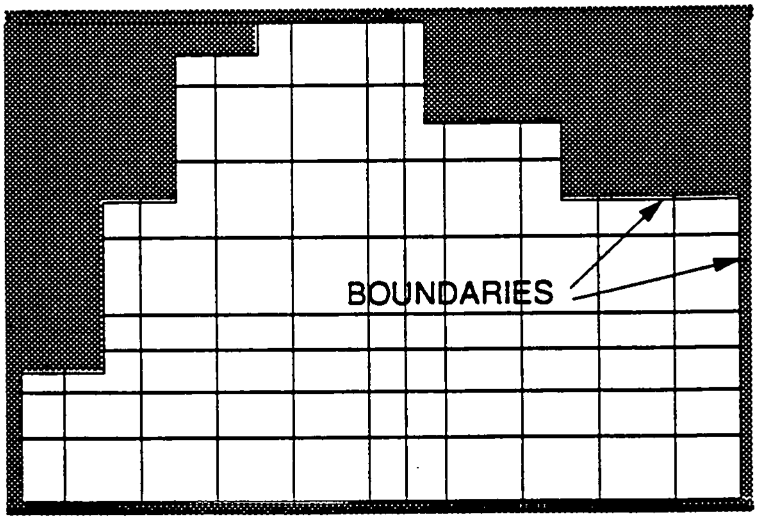


Figure 8 - Definition of grid boundaries

Three types of boundary conditions can be defined: constant head node, no-flux (i.e. impermeable boundary), and constant flux boundary (figure 9).

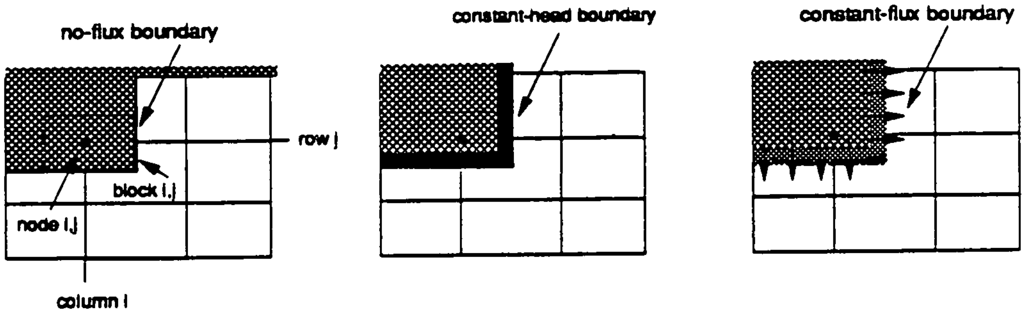


Figure 9 - Boundary types

By default, all blocks outside the modeled region are assigned zero transmissivities, thus forming an impermeable boundary around the whole domain. All blocks inside of an impermeable region do not contribute to flow. These default conditions, however, can be redefined by specifying a constant-flux boundary as a flow per unit length of boundary per unit thickness of aquifer (q at figure 10). Internally this flow rate is multiplied by the length of the block (half space between two successive nodes) and by the total saturated thickness of the aquifer and then added to the source or sink term $Q_{i,j}$ in equation (9).

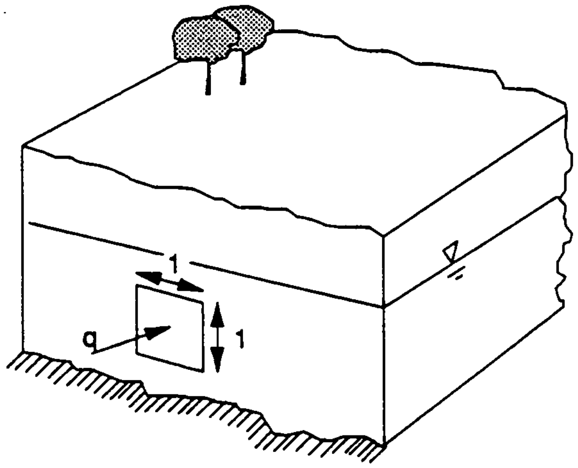


Figure 10 - Constant-flux boundary

3.1.7 Solution Method

By writing an equation of the same form as equation (9) for every node of the finite-difference grid, a large set (NX*NY) of simultaneous algebraic equations is obtained and must be solved for the unknown heads. There are many methods available for solving such systems. FLOWPATH uses the modified iterative alternating direction implicit method (IADI) because of its small memory requirements. The method was originally developed by Peaceman and Rachford (1958) and is described in detail by Prickett and Lonnquist (1971). A predictor-corrector method is also included for improved convergence.

The IADI technique is an iterative technique; iterations required for solving non-linear problems, such as the ones arising due to free watertable aquifers, surface water bodies, leakage, etc., are therefore automatically accounted for.

It can be shown that the systems of equations for groundwater flow are always diagonally dominant. For such systems the IADI method is unconditionally stable (Kinzelbach, 1986). The behavior of the iterative solution has to be monitored. For every iteration the solution is checked against a convergence criterion. It is assumed that convergence is achieved if, for every node, the discrepancy between the current value $h_{i,j}^{new}$ and the previous value $h_{i,j}^{old}$ is less than 0.2 percent of the maximum head difference in the system:

$$\left| \frac{h_{i,j}^{new} - h_{i,j}^{old}}{h^{\max} - h^{\min}} \right| \leq 0.2\% \tag{17}$$

The number of iterations is limited to a maximum of 100.

The described convergence criterion and the maximum number of iterations, however, are only suggested default values that can be altered to the specific needs of any particular problem. It is strongly recommended not to change the default values to avoid premature termination of the hydraulic head calculation which would cause erroneous results.

3.2 Velocity Calculation

The internodal components of the Darcy flux q_x and q_y are obtained by differentiation of the calculated hydraulic heads :

$$q_{x_{i+1/2,j}} = K_{xx_{i+1/2,j}} \frac{(h_{i+1,j} - h_{i,j})}{\Delta x_{i+1/2,j}} \tag{18}$$

$$q_{y_{i,j+1/2}} = K_{yy_{i,j+1/2}} \frac{(h_{i,j+1} - h_{i,j})}{\Delta y_{i,j+1/2}}$$

where:

$\Delta x_{i+1/2,j}$, $\Delta y_{i,j+1/2}$ = distance between nodes i,j and $i+1,j$; and nodes i,j and $i,j+1$, respectively (L)

$K_{xx_{i+1/2,j}}$, $K_{yy_{i,j+1/2}}$ = hydraulic conductivities between nodes i,j and $i+1,j$ at x direction; and nodes i,j and $i,j+1$ at y direction, respectively. These values are taken as the weighted harmonic mean between the hydraulic conductivities of adjacent blocks:

$$K_{xx_{i+1/2,j}} = \frac{(\Delta x_{i,j} + \Delta x_{i+1,j}) K_{xx_{i,j}} K_{xx_{i+1,j}}}{K_{xx_{i,j}} \Delta x_{i,j} + K_{xx_{i+1,j}} \Delta x_{i+1,j}} \quad ,$$

$$K_{yy_{i,j+1/2}} = \frac{(\Delta y_{i,j} + \Delta y_{i,j+1}) K_{yy_{i,j}} K_{yy_{i,j+1}}}{K_{yy_{i,j}} \Delta y_{i,j} + K_{yy_{i,j+1}} \Delta y_{i,j+1}}$$

From the Darcy fluxes the pore velocities are calculated as:

$$v_{x_{i+1/2,j}} = \frac{q_{x_{i+1/2,j}}}{\theta_{i+1/2,j}} \quad , \quad v_{y_{i,j+1/2}} = \frac{q_{y_{i,j+1/2}}}{\theta_{i,j+1/2}} \tag{19}$$

where:

$\theta_{i+1/2,j}$, $\theta_{i,j+1/2}$ = effective porosities between nodes i,j and $i+1,j$; and nodes i,j and $i,j+1$, respectively. These values are taken as the weighted arithmetic mean between the porosities of adjacent blocks:

$$\theta_{i+1/2,j} = \frac{\theta_{i,j}\Delta x_{i,j} + \theta_{i+1,j}\Delta x_{i+1,j}}{\Delta x_{i,j} + \Delta x_{i+1,j}} \qquad (20)$$

$$\theta_{i,j+1/2} = \frac{\theta_{i,j}\Delta y_{i,j} + \theta_{i,j+1}\Delta y_{i,j+1}}{\Delta y_{i,j} + \Delta y_{i,j+1}}$$

This formulation yields a discrete distribution of internodal velocities as shown in figure 11.

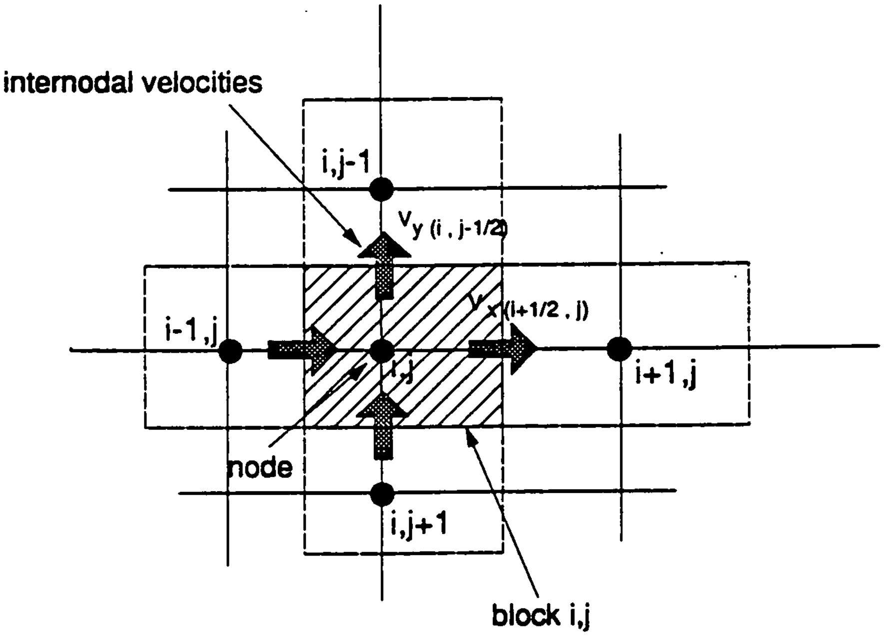


Figure 11 - Velocity locations

3.3 Particle Tracking

3.3.1 Pathline and Travel Time Calculation

Equation (5) is written in discretized form as an explicit time-stepping scheme:

$$x_{t+\Delta t} = x_t \pm v^*_{x_t} \Delta t \qquad y_{t+\Delta t} = y_t \pm v^*_{y_t} \Delta t \tag{21}$$

with $v^* = v/R$

where Δt is the time increment, v_{x_t}, v_{y_t} are the upstream components of the average linear groundwater velocity, R is the retardation factor, and x, y are the pathline coordinates.

The plus-sign in equation (21) corresponds to a forward tracking mode, the minus-sign corresponds to a reverse tracking mode. By using forward tracking, one can predict the location of a particle at a future time; by using reverse tracking one can determine where a particle, whose present location is known, came from.

The travel times are obtained from a simple summation of all time increments :

$$t = t_0 + \sum \Delta t \tag{22}$$

where t is the total travel time, and t_0 is the initial time level.

The pathlines obtained with this upstream weighted Eulerian time integration scheme are piecewise linear. The quality of the Euler integration is a function of the length of the spatial step Δs :

$$\Delta s = v \Delta t \tag{23}$$

The accuracy of the velocity v at the current particle location strongly affects the quality of the pathline calculation. An interpolation scheme has to be used to process the discrete velocity field obtained from equation (19). In order to guarantee smooth and accurate pathlines, the spatial steps have to be small in areas where large changes in the direction and magnitude of the velocity field occur and they can be larger in areas of more uniform flow. These accuracy requirements are reflected in the automatic adjustment of the spatial and temporal increments.

3.3.2 Velocity Interpolation

The internodal velocities $v_{x_{i+1/2,j}}$, $v_{y_{i,j+1/2}}$ are defined at discrete points. In order to calculate accurate and smooth pathlines the velocity components must be calculated at any location in the domain. The velocity vector at an arbitrary particle location is calculated from a weighted average of the four nearest discrete velocity components. A scheme proposed by (Soell, 1988) has been modified to allow for irregular grid spacing and heterogeneous aquifers (figure 12). The weights are inversely proportional to the distance between the current particle location and the points at which the velocity components are defined:

$$v_x(x,y) = \frac{\sum_{i=1}^{4} \frac{v_{x_i}}{r_{x_i}}}{\sum_{i=1}^{4} \frac{1}{r_{x_i}}} \qquad v_y(x,y) = \frac{\sum_{i=1}^{4} \frac{v_{y_i}}{r_{y_i}}}{\sum_{i=1}^{4} \frac{1}{r_{y_i}}} \tag{24}$$

where r_{x_i}, r_{y_i} are the distances of the particle from the i-th velocity vector, and v_{x_i}, v_{y_i} are the velocity components defined at discrete locations on the finite difference grid.

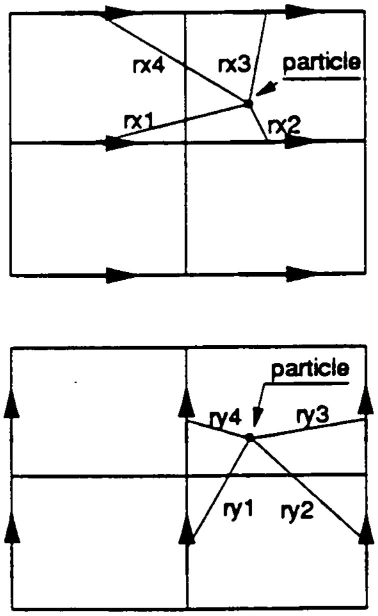


Figure 12 - Velocity interpolation

3.3.3 Automatic Step Control

A predictor-corrector method is used to control the time step : using the velocity components at the current particle location x_{old}, y_{old}, a tentative particle location x_{new}, y_{new} is computed from equation (21). At the new location the new velocity components are evaluated and can now be used to check the accuracy of the tentative step by performing a "reverse" step from the tentative particle location :

$$x_{back} = x_{new} - v_{x_{new}} \Delta t \qquad y_{back} = y_{new} - v_{y_{new}} \Delta t \tag{25}$$

Note that this relationship holds for the forward tracking mode. For reverse tracking, the "reverse" particle location is obtained by exchanging the minus-signs in equation (25) with plus-signs.

The discrepancy d between the original particle location x_{old}, y_{old} and the "reverse" particle location x_{back}, y_{back} is calculated from

$$d = \sqrt{(x_{old} - x_{back})^2 + (y_{old} - y_{back})^2} \tag{26}$$

The discrepancy d has to be smaller than a specified accuracy criterion ε. ε is expressed as a percentage of the average grid spacing ds :

$$\varepsilon = 0.05ds \tag{27}$$

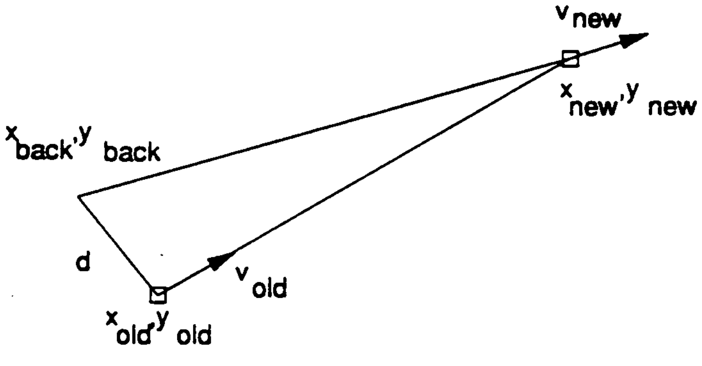


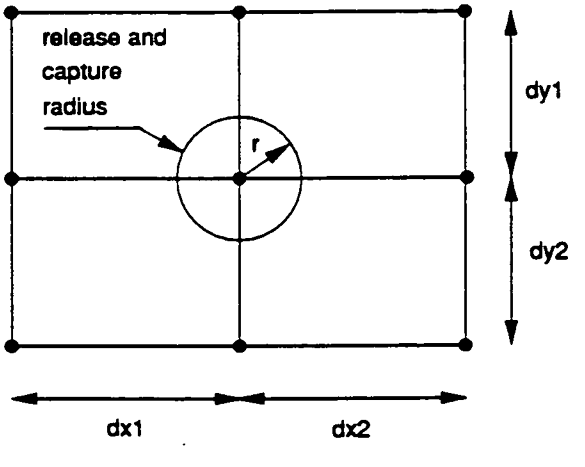
Figure 13 - Automatic time step control

If the discrepancy *d* exceeds the accuracy criterion ε the tentative particle location is rejected and the time increment is reduced by 50 percent. This procedure is repeated until the pathline accuracy satisfies the error tolerance. In a relatively uniform flow field the discrepancy *d* is small; if the discrepancy *d* is smaller than 0.5ε, the tentative particle location becomes a pathline coordinate and the time increment is doubled. In all other cases the time increment does not change.

3.3.4 Capture Mechanism and Pathline Termination

Particles are followed until they are discharged either by singularities or leave the domain.

In the direct vicinity of singularities such as pumping or injection wells, the interpolation scheme in equation (24) is not valid; it produces an artificial stagnation point in the center of the well. If a particle approaches a pumping well (forward tracking) or an injection well (reverse tracking) closer than 30 percent of the grid spacing directly adjacent to the well center, then the pathline calculation for that particular particle is terminated. The pathline ends at the well coordinates.



$r = 0.3 * \mathrm{Min}(dx1,dx2,dy1,dy2)$

Figure 14 - Capture and release radius

To avoid particle oscillations around a stagnation point, the pathline computation is terminated if a particle's velocity is near zero. A particle could also oscillate around "weak" singularities that occur in areas of strong recharge events or near surface water bodies such as lakes, etc. With the automatic step control mechanism described in section 3.3.3, such oscillations lead to decreasing spatial steps; the pathline calculation is terminated if the step length falls below 0.5 percent of the average grid spacing.

3.3.5 Release Radius

Injection zones and capture zones are obtained by releasing a number of imaginary particles on a circle around an injection well (forward tracking) or a pumping well (reverse tracking), respectively, approximating the well perimeter. The radius of the release circle is a function of the grid spacing directly at the well (due to velocity interpolation problems at singularities; see section 3.3.4). The velocity interpolation scheme implemented in FLOWPATH gives accurate velocities at a distance equal or greater than 0.3 times the distance between the well and the nearest grid intersection. This distance is used as the release radius (figure 14).

3.3.6 Time-Related Capture Zones and Wellhead Protection Areas

Time-related capture zones are calculated as a set of pathlines originating on a circle around the well of interest. The pathlines are only calculated up to the specified time level. The last time increment is adjusted such that the specified time level is reached precisely. Travel times are calculated according to equation (22).

A wellhead protection area that is based on time of travel, is equivalent to a time-related capture zone. As stated above, many chemicals, bacteria and viruses adsorb to the aquifer material. If the wellhead protection area is to be designed for a specific contaminant, a retardation factor can be used to delineate the wellhead protection zone more accurately. In general, the time-related capture zone and the resulting wellhead protection area are smaller for sorbing solutes than for conservative ones and the assumption of conservative chemical behaviour leads to a conservative estimate for the size of the required wellhead protection zone.

APPENDIX E

COMPLIANCE MONITORING PLAN

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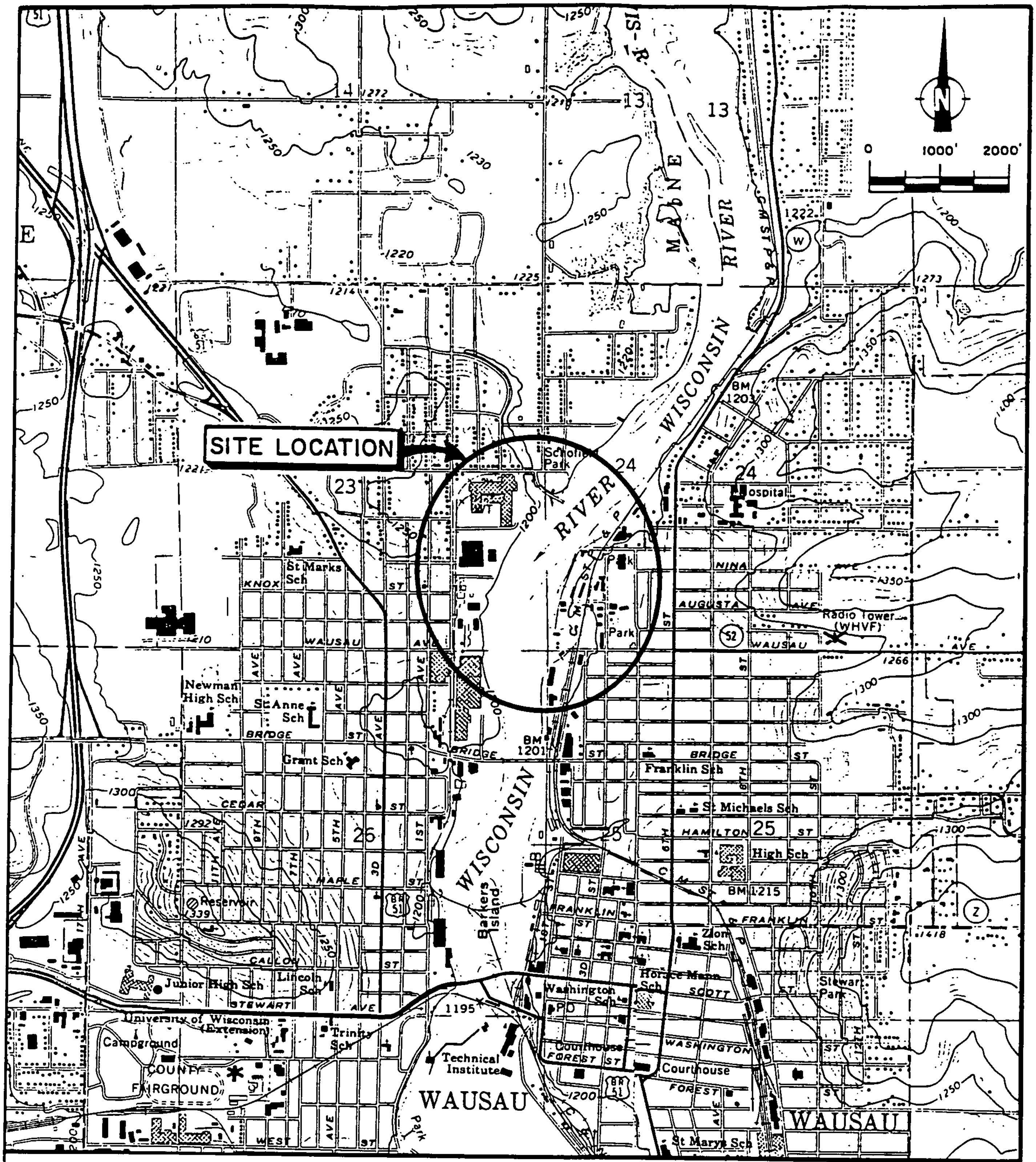
E.1.0 INTRODUCTION

E.1.1 BACKGROUND

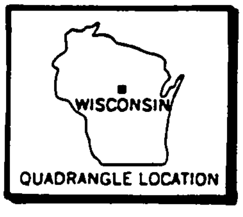
In accordance with the September 29, 1990 Record of Decision (ROD) and the Consent Decree (CD) entered with the court on January 24, 1991, the PRP Group is implementing the final remedial action for the Wausau Superfund Site (site) in Wausau, Wisconsin. Figure E.1 locates the site. The remedial action consists of:

- Installation of soil vapor extraction (SVE) systems to remove VOCs in soils at each of three identified source areas;
- SVE off-gas treatment using vapor phase carbon;
- Groundwater remediation utilizing municipal supply wells and operable unit extraction wells; and
- Treatment of groundwater utilizing existing City air strippers and the operable unit extraction well treatment system.

This Compliance Monitoring Plan (CMP) has been developed to address the monitoring requirements necessary to assess the impact of the SVE and groundwater remediation systems at the site and to assure compliance with the ROD and CD.



SOURCE U.S.G.S. WAUSAU WEST QUADRANGLE MAP.



QUADRANGLE LOCATION

figure E.1
SITE LOCATION
Wausau Superfund Site

CRA

3978-22/05/91-2-0

E.1.2 ZONE OF COMPLIANCE

The Zone of Compliance (ZOC) for the site is defined as the area in which Wisconsin Administrative Code (WAC) NR140 (October 1988) Standards must be achieved at specified monitoring points. For the identified VOC contaminants of concern, these levels are:

1.8 ug/l	Trichloroethylene (TCE)
1.0 ug/l	Tetrachloroethyle (PCE)
70 ug/l	1,2-Dichloroethylene (DCE)

Additionally, NR140 (October 1988) levels will apply to any other contaminants of concern identified during the monitoring for the final remedy. Based on the data collected during the RI/FS process, the ZOC includes the majority of the site as shown in Figure E.2. The ZOC will be reevaluated based on data collected during the compliance monitoring program.

not
necessarily
this will
always be
the zone of
compliance

E.1.3 OBJECTIVES

The CMP will be implemented as part of the final remedy at the site to monitor the operation and performance of the SVE and groundwater remediation systems by monitoring the site soils, soil gas, hydraulic capture and water quality performance during systems operations. Groundwater monitoring at the site will be broken into four zones based on the groundwater extraction systems. Source area monitoring will be conducted based on the final configuration of the SVE systems.

The objectives of the CMP are separated based on the three principal elements of the final remedy; SVE, groundwater extraction and groundwater treatment.

SVE SYSTEMS

- to monitor the long term effectiveness of the SVE systems by collection and analysis of soil samples for VOCs;
- to monitor VOC mass removal from source areas by collection and analysis of SVE extracted air prior to carbon treatment;
- to monitor the potential for additional contaminants at the three source areas by chemical analyses at selected monitoring wells in the vicinity of the sources on an annual basis.

GROUNDWATER EXTRACTION

- to monitor the horizontal and vertical hydraulic zone of capture, within the pumped aquifer, by collection and assessment of groundwater levels;
- to monitor flow patterns at the site, as modified by groundwater remediation operation and Wisconsin River fluctuation, by the collection and assessment of groundwater levels;

- to monitor the long term improvement in groundwater quality at the Site by the collection and chemical analysis of groundwater samples from monitoring and extraction wells;

GROUNDWATER TREATMENT

- to monitor the treatment of extracted groundwater for VOC removal efficiencies by the collection and chemical analysis of influent and effluent water samples from the treatment systems;

E.1.4 SCOPE

In order to provide representative data to satisfy the above objectives, the CMP presented herein presents the monitoring requirements to be followed during the operation of the final remedy.

Groundwater compliance monitoring is a combination of hydraulic and water quality monitoring designed to verify that the groundwater extraction wells are achieving the necessary contaminant capture and that groundwater quality is improving based on source remediation and VOC removal from the aquifer.

Groundwater VOC remediation, at a site like Wausau, is a long-term process that can't be readily measured on a short term basis using water quality data alone. Because of the time necessary to achieve various levels of groundwater remediation, containment of contaminated groundwater is a measurable, achievable short-term objective. At Wausau, there are currently four active groundwater extraction systems designed to contain VOC contaminated groundwater during the long-term groundwater remediation program.

The best way to measure contaminant capture for the extraction wells is to measure the hydraulic gradients in proximity to the extraction wells to show that groundwater containing VOCs is flowing toward the wells and are therefore being removed by pumping. The water level monitoring network includes the necessary monitoring points to show that necessary capture is occurring.

Actual remediation of the groundwater is a slower process that is much more difficult to measure using field data on a short-term basis. Accordingly, water quality data is measured periodically on a long-term basis to show the downward trend of VOC concentrations in groundwater. Significant VOC reductions are measured over a period of years rather than weeks or months.

The proposed groundwater monitoring network is designed to measure the long-term water quality improvement by the collection and chemical analysis of groundwater samples from a comprehensive list of wells located at the site on an annual basis. Appreciable changes are not expected on a more frequent basis. In order to verify that significant changes aren't occurring, a group of core locations have been selected for quarterly monitoring to verify the water quality trends.

This approach has been accepted and has been shown to be effective at several other sites including sites in Region V.

The monitoring plan will address Zone of Compliance by the collection and analysis of samples from groundwater monitoring wells located on the fringes of the Site to verify which area(s) exceed WAC NR 140 (October 1988) levels. Hydraulic data will be utilized to show that groundwater exceeding WAC NR 140 (October 1988) levels are being captured by the various extraction wells.

Extraction well performance will be evaluated utilizing water level monitoring data to define the zones of capture from each of the extraction wells. In addition, the extraction wells will be sampled and chemically analyzed to estimate mass removal. Indicator monitoring wells in the centers of the plume will be chemically analyzed to show the reduction of VOCs in the groundwater over time.

E.2.0 REMEDIAL ACTION MONITORING PROGRAM

E.2.1 SOIL MONITORING

The soil monitoring program will meet the first objective of the CMP. As required by the Consent Decree, soil samples shall be collected prior to SVE system startup, at the midpoint of SVE system operation, and at the completion of operation of each SVE system. The soil sampling locations and depths will be selected based on the results of the predesign investigation. Locations will be selected to provide results which document the level of VOC contamination across the entire zone of compliance at each source area. Specifics of the sampling locations, depths, frequencies and parameters will be provided in the construction QAPP/SAP.

The sampling grid will be determined on the basis of a stratified random design as described in Soil Sampling Quality Assurance User's Guide (EPA 1989). The zones of compliance will be divided into subregions based on the results of the predesign investigation soil gas survey. The subregions will be defined to include regions of high contamination and regions of low contamination. A systematic sampling grid will be superimposed on each subregion. Samples will be collected from each node of the sampling grid in each subregion. This procedure will insure that samples from all regions of the zones of compliance will be collected while minimizing the number of samples necessary to characterize each subregion.

The primary goal of the soil performance objective testing is to document the reduction in soil VOC contamination at the Wausau site.

It is therefore appropriate to sample subregions with known high concentrations of contaminants at a closer grid spacing than zones of low contaminant concentration. The spacing of the systematic grid design in each subregion will be based on the soil gas concentrations measured during the predesign study. It is anticipated that the grid spacing for the performance objective soil monitoring will be similar to the grid spacing of the soil gas monitoring network. This will provide a basis for comparison between the monitoring events and improve the reliability of the overall SVE monitoring program. This testing program will be undertaken to determine when the SVE systems can be decommissioned.

E.2.2 SOIL GAS MONITORING

A network of permanent soil gas sampling probes will be installed to monitor the reduction in VOC concentrations at each source area. The placement of these probes will be determined on the basis of the results of the predesign investigation and SVE system design. Probes will be placed at locations and depths selected to provide results documenting the removal of contaminated portions of the zones of compliance determined in consultation with the EPA and the WDNR.

The soil gas monitoring network will be sampled bi-monthly using a portable PID connected to a fitting on the soil gas probe. More frequent measurements may be made during initial systems operation or as appropriate, based on the observed rate of cleanup. The PID results will be used to document the reduction in total VOC concentrations in the soil gas phase during the operational life of the SVE systems.

On a quarterly basis, soil gas samples will be collected and sent to an off-site laboratory for analysis of volatile organics. The first quarterly samples will be collected prior to system startup at each source area. The soil gas analyses will be used as a basis for determining when compliance soil samples should be taken.

E.2.3 GROUNDWATER LEVEL MONITORING

The groundwater level monitoring task will meet the fourth and fifth objectives of the CMP, namely assessing groundwater capture and hydraulic flow patterns.

An extensive list of monitoring wells, will be monitored twice per year. These wells are listed on Table E.1 and located on Figure E.3. These data will be utilized to prepare detailed groundwater contour maps of the Site in order to monitor the zone of capture for the various groundwater extraction and municipal wells. In addition, water levels will be taken from the core monitoring wells on a quarterly basis at the time of sample collection.

These locations and frequencies will be reevaluated after each year of operation.

TABLE E.1

WATER LEVEL MONITORING WELL NETWORK

Monitoring Well

Zone 1 - Wausau Chemical Source	Well Depth*
WC2	24.0
WC3	161.0
WC3B	24.0
WC4	60.0
WC4A	30.0
WC5	70.0
WC5A	30.0
WC6	70.0
WC6A	30.0
WC7	60.0
WC7A	30.0
MW10A	76.5
MW10B	35.0
MW11	35.0
FVD5	20.5
E22	93.7
E22A	22.0
E24	85.7
E24A	35.0
E25	135.0
E25A	37.5
E26	95.0
E26A	23.0
E37A	26.0

* Well depth measured from top of casing

TABLE E.1

WATER LEVEL MONITORING WELL NETWORK

Monitoring Well

Zone 2 - CW3 Capture Area	Well Depth*
HURD	100.0
MW14	45.0
WW1	40.0
WW2	40.0
WW4	40.0
WW5	37.0
WW6	41.0
FVD7	18.5
TCT2 (41)	22.1
TCT3 (42)	54.0
TCT4 (43)	23.8
TCT5 (44)	23.0
GM5D	114.0
GM6D	126.0
GM7D	123.0
GM9S	20.0
E21	129.5
E21A	22.0
E27	136.5
E28A	37.0
E29A	29.0
E30	132.8
E31	135.5
E37A	26.0
IWS	15.0
IWM	77.3
IWD	140.4

* Well depth measured from top of casing

TABLE E.1

WATER LEVEL MONITORING WELL NETWORK

Monitoring Well

Zone 3 - EW1 Capture Area	Well Depth*
EW1	143.5
C2S	37.9
C3S	38.9
C4S	32.2
C4D	104.2
C6S	39.5
C7S	36.0
R1S	40.5
R1D	121.0
R3S	32.0
R3D	136.0
R4D	133.0
W50	82.8
W51A	44.7
W52	124.0
W52A	36
W53	125.5
W53A	41.3
W54	65.5
WSWS	18.6
WSWD	152.4
MW1	39.6
MW2	40.9
MW3	41.4

* Well depth measured from top of casing

TABLE E.1

WATER LEVEL MONITORING WELL NETWORK

Monitoring Well

Zone 4 - CW6 Capture Area	Well Depth*
CW9 OBS	78.0
CW10	-
MW1A	130.0
MW3A	140.0
MW3B	74.7
MW4A	100.0
MW4B	60.5
MW4C	40.0
MW5	45.0
MW6	45.0
MW7	45.0
MW8	45.0
MW9	50.0
Plum St.	95.0
R2S	28.0
R2D	135.0
GM1S	37.0
GM2S	34.0
GM3S	37.0
GM4S	36.0
GM4D	145.0
W55	115.5
W55A	43.0
W56	66.5
W56A	20.0
W57	77.5

* Well depth measured from top of casing

E.2.4 GROUNDWATER QUALITY MONITORING

The groundwater quality monitoring task will meet the third and sixth objectives of the CMP, namely, to monitor the long term improvement of groundwater quality and to monitor for additional contaminants of concern at the Site.

Clean-up standards for the interim remedial action are based on WAC NR 140 (October 1988) Groundwater Quality Standards. The primary contaminants of concern are TCE, PCE and DCE. In addition, any contaminants specified in WAC NR 140 (October 1988) or in the Hazardous Substance List (HSL), which may be detected during the monitoring program will at that time be considered to be additional contaminants of concern. In accordance with the Consent Decree, the extraction well system will be operated until:

1) the concentration of the contaminants of concern are reduced to 1.8 ppb TCE, 1.0 ppb PCE and 70 ppb DCE within the specified ZOC.

2) the concentrations of additional contaminants of concern (as listed in WAC NR 140 (October 1988) or in the HSL) are reduced to the following levels:

   a) For additional contaminants which are specified by WAC NR 140 (October 1988), the levels specified for those additional contaminants by WAC NR 140 (October 1988); or

b) For additional contaminants not specified by WAC NR 140 (October 1988), the levels required by the Safe Drinking Water Act MCLs; or

c) For additional contaminants not specified by WAC NR 140 (October 1988) and not having a specified MCL, the levels required by the applicable Clean Water Act WQC; or

d) For additional contaminants not specified by WAC NR 140 (October 1988) and not having a specified MCL, and not having an applicable WQC level, health based levels set by U.S. EPA in consultation with the WDNR; and

3) a demonstration is made that the Water Quality Criteria (water discharge limits) have been complied with (for any discharge to the Wisconsin River).

Two networks of monitoring wells have been identified for quarterly sampling and analysis. For organization purposes, the Site has been divided into four monitoring zones. Figure E.4 illustrates the four monitoring zones.

The monitoring zones were chosen to represent the significant hydraulic and chemical regions at the site. Zone I comprises the Wausau Chemical Corporation source area. Zone II comprises the approximate capture area of CW-3. Zone III comprises the Marathon Electric

Site and EW-1. Zone IV comprises the approximate capture area of CW-6. Based on these four monitoring zones two networks of monitoring wells were selected.

A core well network was selected to provide essential monitoring data from each of the four monitoring zones to show general short-term trends in groundwater quality. Wells were selected to monitor plume center (indicator wells) and the plume fringe (sentry wells) for each zone. Table E.2a presents the core network monitoring wells and the rationale for each. Figure E.5 locates all core network monitoring wells.

A comprehensive well network was selected to provide sufficient data to construct detailed plume maps and to show long-term trends in groundwater quality improvement. Table E.2b lists the wells in the comprehensive network. Figure E.6 locates all comprehensive network monitoring wells. It is to be noted that the comprehensive monitoring well network includes all core network wells.

The core network wells will be sampled quarterly and analyzed for the Site Specific VOC compounds listed in Table E.3. In this manner, any unforeseen plume variations which may impact the effectiveness of the system would be identified on a quarterly basis. Monitoring well IWD will not be monitored during the months of December, January or March, or if it is inaccessible due to weather conditions. If it is inaccessible the EPA project manager will be notified as soon as possible.

TABLE E.2a

GROUNDWATER MONITORING
CORE WELL NETWORK

Monitoring Well	*Well Depth**	*Historical Total VOCs Concentration Approximate (ug/L)*	*Function*
ZONE 1 - WAUSAU CHEMICAL SOURCE AREA			
WC2	24.0	800	Indicator Well
WC4	60.0	2	Sentry Well - West
MW11	35.0	22	Sentry Well - East
ZONE 2 - CW3 CAPTURE AREA			
IWD	140.4	300	Sentry Well
E27	136.5	1000	Indicator Well
GM9S	20.0	2400	Indicator Well near CW3
ZONE 3 - EW1 CAPTURE AREA			
C4D	104.2	60	Sentry Well
W53	125.5	1800	Indictor Well
R4D	133.0	3200	Indicator Well near EW1
ZONE 4 - CW6 CAPTURE AREA			
R2S	28.0	55	Sentry Well - Shallow
R2D	135.0	1000	Sentry Well - Deep
W55A	43.0	45	Indicator Well - Shallow
W55	115.5	4200	Indicator Well - Deep

* Well depth measured from top of casing

TABLE E.2b

GROUNDWATER MONITORING COMPREHENSIVE WELL NETWORK

Monitoring Well	*Well Depth**	*Historical Total VOCs Approximate Concentration (µg/l)*
<u>Zone 1 - Wausau Chemical Source Area</u>		
× WC2	24.0	800
× WC3B	24.0	130
– WC4	60.0	2
– WC4A	30.0	0
– WC5	70.0	4
× WC5A	30.0	200
– WC6	70.0	9
– WC6A	30.0	580
× MW11	35.0	22
× E24A	22.0	310
<u>Zone 2 - CW3 Capture Area</u>		
– WW4	40.0	0
× WW5	37.0	8
× FVD7	18.5	200
– GM6D	126.0	17
× GM9S	20.0	2,400
× E27	136.5	1,000
× E30	132.8	10
– E37A	26.0	19
× IWD	140.4	300
– CW3	92.0	100
<u>Zone 3 - EW1 Capture Area</u>		
C2S	37.9	1,230
C4S	32.2	1,350
C4D	104.2	60
R3S	32.0	35
R3D	136.0	13
R4D	133.0	3,200
W52	124.0	420
W53	125.5	1,800
W53A	41.3	26
W54	65.5	460
WSWD	152.4	480
EW1	143.5	400

* Well depth measured from top of casing

TABLE E.2b

GROUNDWATER MONITORING
COMPREHENSIVE WELL NETWORK

Monitoring Well	*Well Depth**	*Historical Total VOCs Approximate Concentration (µg/l)*
Zone 4 - CW6 Capture Area		
MW4B	60.5	6
MW5	45.0	0
R2S	28.0	55
R2D	135.0	1,000
W55	115.5	4,200
W55A	43.0	45
W56	66.5	20
W56A	20.0	11
GM1S	37.0	1
CW6	100.0	150

* Well depth measured from top of casing

TABLE E.3

SITE SPECIFIC VOC ANALYTE LIST

Analyte
Acetone
1,2-Dichloroethene (total)
Trichloroethene
Benzene
Tetrachloroethene
Toluene
Ethylbenzene
Xylenes
Vinyl Chloride
1,1,2-Trichloroethane

The comprehensive network will be sampled annually and analyzed for the Site Specific VOC compounds listed in Table E.3. These data will be utilized to construct detailed VOC plume maps for the site.

Groundwater monitoring conducted during the RI/FS included analysis for Target Compounds List (TCL) organic parameters and Target Analyte List (TAL) inorganic parameters at a significant number of monitoring wells. The RI/FS results only identified one semi-volatile compound and three metals at more than one location. Based on these results, it appears that VOCs are the only significant contaminants of concern and are, therefore, the basis of the remediation and monitoring programs. As a precautionary measure, in addition to the VOC analyses conducted on samples collected from monitoring and extraction wells, the selected indicator wells listed in Table E.4 for each source area will be initially analyzed for TCL organic parameter analysis and for TAL inorganic parameter analysis to verify that no new contaminants have leached into the groundwater over the past four years. Tables E.5 through E.8 summarize the TCL and TAL parameters that will be analyzed. Subsequent to assessment and review of the data, it will be determined, in conjunction with the EPA and WDNR, whether a second round of groundwater samples is required to be collected from the selected indicator wells for full or partial TCL/TAL analysis. The sample locations will be sampled annually, thereafter, and will be analyzed for the full or partial TCL/TAL parameters based on the initial sampling as determined necessary in conjunction with the EPA and WDNR. These analyses will be conducted during the comprehensive well network sampling

TABLE E.4

INDICATOR WELLS FOR TCL AND TAL ANALYSES

	*Well Depth**	*Historical Total VOCs Concentration Approximate (μg/L)*
Zone I		
WC2	24.0	800
Zone II		
GM9S	20.0	2400
Zone III		
W53	125.5	1800
R4D	133.0	3200
Zone IV		
W55	115.5	4200
R2D	135.0	1000

* Well depth measured from top of casing

TABLE E.5

TCL VOLATILE ORGANIC COMPOUNDS (VOCs)

Compound	*CAS Number*
Acetone	67-64-1
Benzene	21-43-2
Bromodichloromethane	75-27-4
Bromoform	75-25-2
Bromomethane	74-83-9
Butanone	78-93-3
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroethane	75-00-3
Chloroform	07-00-3
Chloromethane	74-87-3
Bromochloromethane	74-97-5
1,1-Dichloroethane	75-35-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene	75-35-4
cis-1,2-Dichloroethene	156-59-4
trans-1,2-Dichloroethene	156-60-5
1,2-Dichloropropane	78-87-5
cis-1,3-Dichloropropene	10061-01-5
trans-1,3-Dichloropropene	10061-02-6
Ethylbenzene	100-41-4
2-Hexanone	591-78-6
Methylene Chloride	75-09-2
4-Methyl-2-pentanone	108-10-1
Styrene	100-42-5
1,1,2,2-Tetrachloroethane	29-34-5
Tetrachloroethene	127-18-4
Toluene	108-88-33
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
Vinyl chloride	75-01-4
Xylenes (total)	1330-20-7
Dibromochloromethane	124-48-1
1,2-dibromoethane	106-93-4
1,2-dibromo-3-chloropropane	96-12-8

TABLE E.6

TCL BASE-NEUTRAL-ACID EXTRACTABLE ORGANIC COMPOUNDS (BNAs)

Semivolatiles	*CAS Numbers*
Phenol	108-95-2
Bis(2-Chloroethyl)ether	111-44-4
2-Chlorophenol	95-57-8
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
1,2-Dichlorobenzene	95-50-1
2-Methylphenol	95-48-7
Bis(2-Chloroisopropyl)ether	108-60-1
4-Methylphenol	106-44-5
N-Nitroso-di-*n*-dipropylamine	621-64-7
Hexachloroethane	67-72-1
Nitrobenzene	98-95-3
Isophorone	78-59-1
2-Nitrophenol	88-75-5
2,4-Dimethylphenol	105-67-9
Bis(2-chloroethoxy)methane	111-91-1
2,4-Dichlorophenol	120-83-2
1,2,4-Trichlorobenzene	120-82-1
Naphthalene	91-20-3
4-Chloroaniline	106-47-8
Hexachlorobutadiene	87-68-3
4-Chloro-3-methylphenol (*para*-chloro-*meta*-cresol)	59-50-7
2-Methylnaphthalene	91-57-6
Hexachlorocyclopentadiene	77-47-4
2,4,6-Trichlorophenol	88-06-2
2,4,5-Trichlorophenol	95-95-4
2-Chloronaphthalene	91-58-7
2-Nitroaniline	88-74-4
Dimethylphthalate	131-11-3
Acenaphthylene	208-96-8
2,6-Dinitrotoluene	606-20-2
3-Nitroaniline	99-09-2
Acenaphthene	83-32-9

TABLE E.6

TCL BASE-NEUTRAL-ACID EXTRACTABLE ORGANIC COMPOUNDS (BNAs)

Semivolatiles	*CAS Numbers*
2,4-Dinitrophenol	51-28-5
4-Nitrophenol	100-02-7
Dibenzofuran	132-64-9
2,4-Dinitrotoluene	121-14-2
Diethylphthalate	84-66-2
4-Chlorophenyl-phenyl Ether	7005-72-3
Fluorene	86-73-7
4-Nitroaniline	100-01-6
4,6-Dinitro-2-methylphenol	534-52-1
N-Nitrosodiphenylamine	86-30-6
4-Bromophenyl-phenyl Ether	101-55-3
Hexachlorobenzene	118-74-1
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Anthracene	120-12-7
Carbazole	86-74-8
Di-*n*-butylphthalate	84-74-2
Fluoranthene	206-44-0
Pyrene	129-00-0
Butylbenzylphthalate	85-68-7
3,3'-Dichlorobenzidine	91-94-1
Benzo(a)anthracene	56-55-3
Chrysene	218-01-9
Bis(2-ethylhexyl)phthalate	117-81-7
Di-*n*-octylphthalate	117-84-0
Benzo(b)fluoranthene	205-99-2
Benzo(k)fluoranthene	207-08-9
Benzo(a)pyrene	50-32-8
Indeno(1,2,3-cd)pyrene	193-39-5
Dibenz(a,h)anthracene	53-70-3
Benzo(g,h,i)perylene	191-24-2

TABLE E.7

TCL PESTICIDES AND POLYCHLORINATED BIPHENYLS (PEST/PCBs)

Pesticides/PCBs	*CAS Number*
alpha-BHC	319-84-6
beta-BHC	319-85-7
delta-BHC	319-86-8
gamma-BHC (Lindane)	58-89-9
Heptachlor	76-44-8
Aldrin	309-00-2
Heptachlor Epoxide	1024-57-3
Endosulfan I	959-98-8
Dieldrin	60-57-1
4,4'-DDE	72-55-9
Endrin	72-20-8
Endosulfan II	33213-65-9
4,4'-DDD	72-54-8
Endosulfan Sulfate	1031-07-8
4,4'-DDT	50-29-3
Methoxychlor	72-43-5
Endrin Ketone	53494-70-5
Endrin Aldehyde	7421-36-3
alpha-Chlordane	5103-71-9
gamma-Chlordane	5103-74-2
Toxaphene	8001-35-2
Aroclor - 1016	12674-11-2
Aroclor - 1221	11104-28-2
Aroclor - 1232	11141-16-5
Aroclor - 1242	53469-21-9
Aroclor - 1248	12672-29-6
Aroclor - 1254	11097-69-1
Aroclor - 1260	11096-82-5

TABLE E.8

TAL PARAMETERS

Analyte

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Cyanide

All sampling locations and frequencies will be reevaluated after each year of operation.

Verification of compliance with groundwater clean-up standards will consist of four quarters of data from all compliance monitoring wells. The samples will be analyzed for specific parameters detected above applicable standards based on previous sampling events.

Sampling procedures are detailed in Section E.3.3.

E.2.5 TREATMENT EFFICIENCY MONITORING

The treatment monitoring task will meet the seventh objective of the CMP, namely, evaluating the quantities of VOCs removed from the soils and groundwater.

EW-1, CW-3, CW-6 and effluent samples from the Wausau municipal air stripper treatment plant and the EW-1 treatment structure will be collected for analysis of the VOCs listed on Table E.3 on a monthly basis. This effort is required to monitor the efficiency of the treatment system and to characterize effluent water quality for end use. In addition, effluent will be monitored for pH and any metals determined necessary based on initial TAL analyses.

Once each year a sample of treated water will be collected from each groundwater extraction center and analyzed for TCL and TAL compounds. This effort is intended to assess the overall quality of the groundwater extracted and treated under the remedial action. The results of these sample analyses will identify the presence of any compounds other than those routinely monitored for following treatment.

E.2.6 AIR MONITORING

Air emissions from groundwater treatment centers will be calculated by comparing influent VOC mass loading with effluent VOC mass. The difference between these accurately represents the VOC mass removed and discharged by the air stripping systems.

Air monitoring of the exhaust gases from the SVE systems will meet the second objective of the CMP. The Performance Standards for the SVE systems outlined in the Consent Decree specify, in part, that the systems "reduce the concentration of total exhaust gas VOCs to 1% of the initial exhaust gas VOC concentration". Measurements of SVE exhaust gas VOC concentrations will be performed quarterly to coincide with soil gas monitoring. More frequent monitoring may be required as part of the recommended routine operation and maintenance of the SVE systems. Samples of the SVE exhaust gas will be collected for analysis of TCL VOC concentrations in accordance with the QAPP.

The first quarterly samples will be collected prior to SVE system startup at each source area.

A summary of the Compliance Monitoring Program is presented in Table E.9.

E.3.0 PROTOCOLS

All field protocols will be conducted using the following procedures. Any revisions will be reviewed and approved by EPA and WNDR.

E.3.1 WATER LEVEL MONITORING PROTOCOL

Water level measurements will be taken quarterly in accordance with Section E.2.2 and prior to purging and sampling for chemical analysis.

All water levels in monitoring wells will be measured according to the following protocols:

1) The sampler will measure and record the depth to water in each well to the nearest 0.01 foot using an electric tape or plopper.

2) The bottom three feet of the measuring device will be rinsed with distilled water prior to use in each well.

Water level in the extraction well will be recorded from a continuous monitoring instrument located at its well head. Water levels in the Wisconsin River and Bos Creek will be recorded from staff gages SG1 and SG2, respectively.

E.3.2 SOIL SAMPLING PROTOCOL

E.3.2.1 Drilling and Sampling Procedure

All boreholes will be advanced with hollow-stem augers with an inside diameter of 4-1/4 inches. However, if difficulties occur with installation procedures a larger diameter (6-1/4 inches inside diameter) will be used. During the completion of the borehole, continuous split-spoon samples will be collected to define the stratigraphy of the borehole.

All soil samples will be obtained in accordance with ASTM D1586-84. They will be collected with either a split spoon or hand auger (depending on local conditions). The split-spoon sampler will be attached to the drill rod and driven into the soil the full depth (24 inches) using a 140-pound hammer, free-falling 30 inches. The driving resistance (number of hammer blows) will be recorded for each 6-inch increment of penetration. If the soil is loose, wet, or in any way unconsolidated (as expected), clean basket retainers will be used to retain the soil in the split spoon. Between each sampling, the split spoon and/or hand auger will be cleaned as per Section E.3.2.2.

All soil samples will be described and classified according to the Unified Soil Classification System and then stored in glass jars for geologic record. A record of all soil sampling will be recorded on borehole logs which will be maintained by the Site geologist. All samples retained for geologic record will be stored on Site.

The soil samples collected in the split-spoon samplers and hand augers will be prepared in the following manner for chemical analyses:

1. The sampling tool and all other instruments used in extracting the soil samples for chemical analyses will be precleaned using the prescribed rinse sequence (Section E.3.2.2). A new pair of disposable latex gloves will be used for each sample handled. Disposable gloves and rinsings will be collected and contained for proper disposal.

2. Each soil sample for chemical analyses will be obtained and prepared in the following manner:

    a) Using a clean cutting tool (stainless-steel knife), the soil sample will be extracted from the split spoon, attempting to ensure that a representative sample is collected.

    b) For VOC samples, the sample core will be transferred to sample jars without breaking apart the core, if possible. The remaining soil will be placed into proper sample jars for other analysis.

3. Containers for sample collection will be prepared in accordance with the QAPP. QA/QC samples (blind field duplicate, matrix spike and matrix spike duplicate, rinsate blank and VOC trip blanks) will be collected or prepared as specified in the QAPP.

4. Soil samples will be labeled noting the sampling location, depth, time and sampler's initials. A separate hard-cover field book will be maintained to document all soil samples and sampling events (including: date and time collected, sample handling and storage, preservation and labeling, field measurements, characteristics of each sample taken, and weather conditions).

5. Samples will be placed on ice or cooler packs in laboratory supplied coolers after collection and labeling.

E.3.2.2 Equipment Cleaning

Upon mobilization of the drill rig to the Site, and prior to commencing drilling, the rig and all associated equipment will be thoroughly steam cleaned to remove oil, grease, mud and other foreign matter. Cleaning will take place in the designated on-site decontamination area (see HSP, Appendix F of RD/RA Work Plan). Subsequently, before initiating drilling at each borehole, the augers, cutting bits, drill steel and associated equipment will be steam cleaned to prevent cross-contamination from the previous drilling location.

Decon water will be collected and either discharged to the sanitary sewer or the storm sewer. Decon water will not be discharged to the storm sewer if PID screening indicates elevated levels of contaminants in the rinse water (i.e. PID readings greater than background). In such cases the decon water will be discharged to the sanitary sewer. Cleaning of soil sampling equipment (e.g. split spoon samples) will be accomplished by flushing and wiping the components to remove all visible sediments followed by:

i) clean with tap water and laboratory detergents, using a brush if necessary, to remove particulate matter and surface films;

ii) rinse thoroughly with tap water;

iii) rinse with isopropanol;

iv) allow the equipment to air dry as long as possible;

v) final distilled water rinse; and

vi) wrap with aluminum foil, if appropriate, to prevent contamination if the equipment is going to be stored or transported.

Following final rinse, openings will be visually inspected to verify they are free of soil particulates and other solid material which may contribute to possible sample cross-contamination.

Fluids used for cleaning will not be recycled. All wash water and rinse water will be collected and either discharged to the sanitary sewer or the storm sewer. Rinse water will not be discharged to the storm sewer if PID screening indicates elevated levels of contaminants in the rinse water (i.e. PID readings greater than background). In such cases the rinse water will be discharged to the sanitary sewer. Decontamination fluids (isopropanol) will be collected and stored in containers for disposed in accordance with State and Federal regulations.

E.3.3 GROUNDWATER SAMPLING PROTOCOL

The order of sample collection for each sample fraction will be as follows:

1) Volatile fraction
2) Metals fraction
3) Base, Neutral/Acid fraction
4) Pesticide/PCB fraction
5) Cyanide fraction

E.3.3.1 Monitoring Well Sampling

All monitoring wells will be sampled according to the following protocols:

1. New disposable latex gloves will be used when sampling each well. Additional glove changes will be made for each sampling.

2. The sampler will measure and record the depth to water in each well to the nearest 0.01 foot using an electric tape or plopper.

3. Prior to sampling, each well will be purged, using a bottom-filling stainless steel or teflon bailer attached to new nylon rope; or a teflon bladder stainless steel pump fitted with teflon purging and air supply lines attached to a nylon rope. A minimum of three times the standing water volume in the well will be removed, or until conductivity, temperature and pH stabilize in the purge water. In the event that a well is purged dry prior to achieving three well volumes, groundwater will be permitted to recover to a level sufficient for sample collection. The time that the well was purged dry will be noted and well recovery will be monitored. Upon recovery, a precleaned bailer or bladder pump will then be used for sample collection. Prior to use in each well, the bailer or bladder pump will be precleaned as follows:

   1) Washed thoroughly with Alconox or equivalent;
   2) Rinsed with potable water;
   3) Rinsed with isopropanol;
   4) Allowed to air dry;
   5) Wrap with new aluminum foil; and
   6) A final distilled water rinse prior to purging.

   All waste groundwater, not used for samples, will be collected and either discharged to the sanitary sewer or to the storm sewer. Waste groundwater will not be discharged to the storm sewer if HNu screening (or equivalent) shows elevated levels of contaminants in the groundwater (HNu readings greater than background). In such cases, the rinse water must be discharge to the sanitary sewer.

4. Field measurements of pH and conductivity (using a DspH-3 pH/3 RGE Conductivity Meter or equivalent) and temperature (using a YSI Model 33 SCT meter or equivalent) will be recorded prior to sample collection. Calibration of field instruments will be conducted as specified in the QAPP.

5. After the required standing well water has been purged, water samples will be collected using a bottom-filling stainless steel or teflon bailer attached to a nylon rope; or a teflon bladder stainless steel pump, fitted with teflon purging and air supply lines, attached to a nylon rope. The groundwater samples will be collected from the bottom-filling bailer or collected directly from the purge line of the bladder pump used to purge the well. New nylon rope, where applicable, will be used for each monitoring well.

6. Containers for sample collection and preservation requirements will be prepared in accordance with the QAPP. QA/QC samples (blind field duplicate, matrix spike and matrix spike duplicate, rinsate blank and VOC trip blanks) will be collected or prepared as specified in the QAPP.

7. All disposable gloves and nylon ropes will be placed in DOT approved 55-gallon drums and stored at a designated area. All drummed waste will be disposed of in accordance with State and Federal regulations. All rinsings will be handled as discussed in item (3), above.

8. Samples will be labeled noting the well location, date, time and sampler's initials. A separate hard-cover bound field notebook will be maintained describing the sampling history (including: date and time of collection, sample handling and storage, preservation and labeling, field measurements, details pertaining to well purging and characteristics of each sample taken, and weather conditions).

9. Samples will be placed on ice or cooler pack in laboratory supplied coolers after collection and labeling.

E.3.3.2 Well Head Sampling

The production and extraction well (influent) head sampling will be conducted in accordance with the following protocols:

1. New disposable latex gloves will be used when collecting the water samples.

2. The samples will be collected by the grab sample method directly into the precleaned sample containers. The samples will be collected at the well head directly from sampling ports.

3. Containers for sample collection and preservation requirements will be prepared in accordance with the QAPP. QA/QC samples (blind field

duplicate, matrix spike and matrix spike duplicate, and VOC trip blanks) will be collected or prepared as specified in the QAPP.

4. Samples will be labeled noting the sampling location, date, time and sampler's initials. A separate hard-cover field book will be maintained to document all samples and sampling events. Weather conditions at the time of sampling will be noted.

5. Samples will be placed on ice or cooler packs in laboratory supplied coolers after collection and labeling.

E.3.3.3 Treated Groundwater Effluent Sampling

The treated groundwater (effluent) samples will be collected in accordance with the following protocols:

1. New disposable latex gloves will be used when collecting the sample.

2. The samples will be collected by the grab sample method directly into the precleaned sample containers. The Marathon Electric extraction sample will be collected from the rip rap lined discharge structure immediately prior to the point where the treated groundwater enters the Wisconsin River. The City of Wausau sample will be collected from the effluent from the air stripping towers.

3. Containers for sample collection and preservation requirements will be prepared in accordance with the QAPP. QA/QC samples (blind field duplicate, matrix spike and matrix spike duplicate, and VOC trip blanks) will be collected or prepared as specified in the QAPP.

4. Samples will be labeled noting the sampling location, date, time and sampler's initials. A separate hard-cover field book will be maintained to document all samples and sampling events. Weather conditions at the time of sampling will be noted.

5. Samples will be placed on ice or cooler packs in laboratory supplied coolers after collection and labeling.

E.3.3.4 SVE Exhaust Gas Monitoring

The SVE exhaust gas samples will be collected from the exhaust side of the SVE vacuum blower upstream from the first activated carbon unit. The samples will be collected in accordance with the following protocols:

1. New disposable latex gloves will be used when collecting the sample.

2. The samples will be collected by attaching a pre-evacuated, 6-liter Summa gas canister to the exhaust sampling port using Swageloc compression tube connectors.

3. The samples will be collected while the vacuum blower is operating at its nominal flow rate and pressure by opening both the sample port valve and the Summa canister valve.

4. The valves will be left open until the pressure on the canister has equilibrated with that on the SVE exhaust line as indicator by a pressure gauge on the intake of the canister.

5. The valve on the canister will be closed and then the valve on the exhaust port will be closed.

6. The canister will be labeled with the location, time, date, sampler name and exhaust pressure as specified in the QAPP. QA/QC samples (duplicates, trip blanks) will be collected as specified in the QAPP.

7. The samples will be shipped to the laboratory within 24 hours of collection.

E.3.3.5 Soil Gas Monitoring

Soil gas samples will be collected from the permanent monitoring probes according to the following protocols:

1. New disposable latex gloves will be used when collecting the sample.

2. Samples will be collected after the SVE system has been shut-off at least 48 hours.

3. Samples will be collected by attaching a pre-evacuated Summa gas canister and portable vacuum pump with a T-connector to the probe with the valves on the probe and canister closed.

4. The probe will be evacuated for a sufficient time to remove three probe volumes of gas at standard temperature and pressure. The probe evacuation volume will be calculated based on the volume of the tubing leading to the sampling interval and the approximate pore volume of the sand pack in the sampling interval.

5. After purging is complete but prior to shutting off the vacuum pump, the valve between the pump and the T-connector will be closed. The vacuum pump will then be shut off.

6. With the probe valve open and the canister valve shut, the probe will be allowed to equilibrate to ambient pressure.

7. After the vacuum gauge on the probe has read zero vacuum for one minute, the valve on the Summa canister will be opened to collect the sample. Sampling will be complete after the vacuum gauge on the probe has read zero vacuum for one minute and the valves on the canister and the probe will be closed.

8. The canister will be labeled with the location, time, date and sampler name as specified in the QAPP. QA/AC samples (duplicates, trip blanks) will be collected as specified in the QAPP.

9. The samples will be shipped to the laboratory within 24 hours of collection.

E.3.5 REPORTING

E.3.5.1 Compliance Monitoring Reports

As specified in Section 7.4 of the RD/RA Work Plan, compliance monitoring and testing reports will be completed on a periodic basis (to be specified in the Operation and Maintenance Plan) and will detail monitoring and testing results. These reports will also include assessments of the progress towards meeting remedial objectives.

E.3.5.2 Modifications

Modifications to the CMP and performance criteria may be suggested by the PRP Group, or required by EPA/WDNR, based on the compliance monitoring reports. Any modifications to the CMP will require approval by EPA in consultation with WDNR.

SOURCE: RMT INC. FIGURE I, 5/14/87.

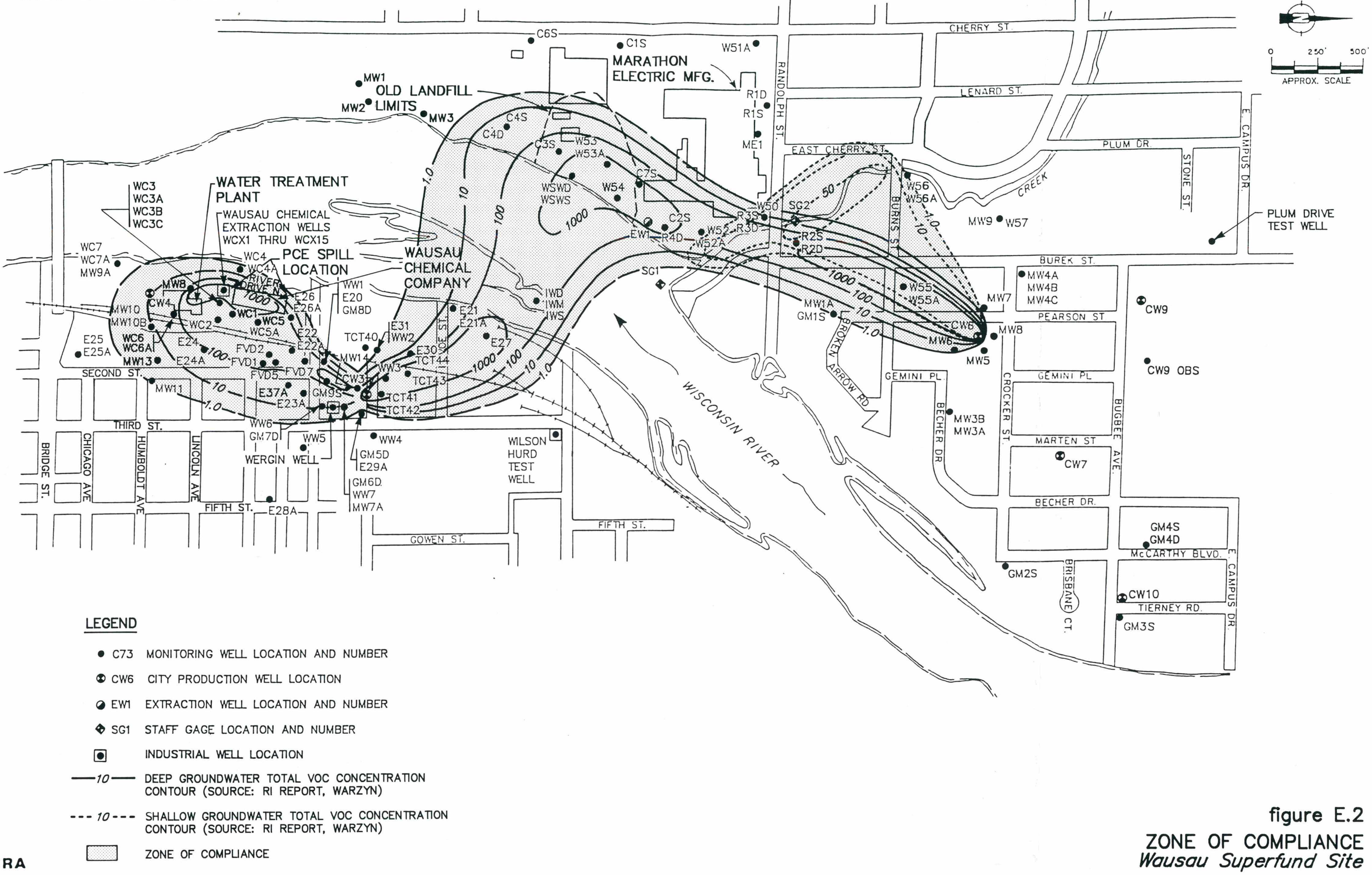


figure E.2

ZONE OF COMPLIANCE

Wausau Superfund Site

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SOURCE : RMT INC. FIGURE I, 5/14/87.

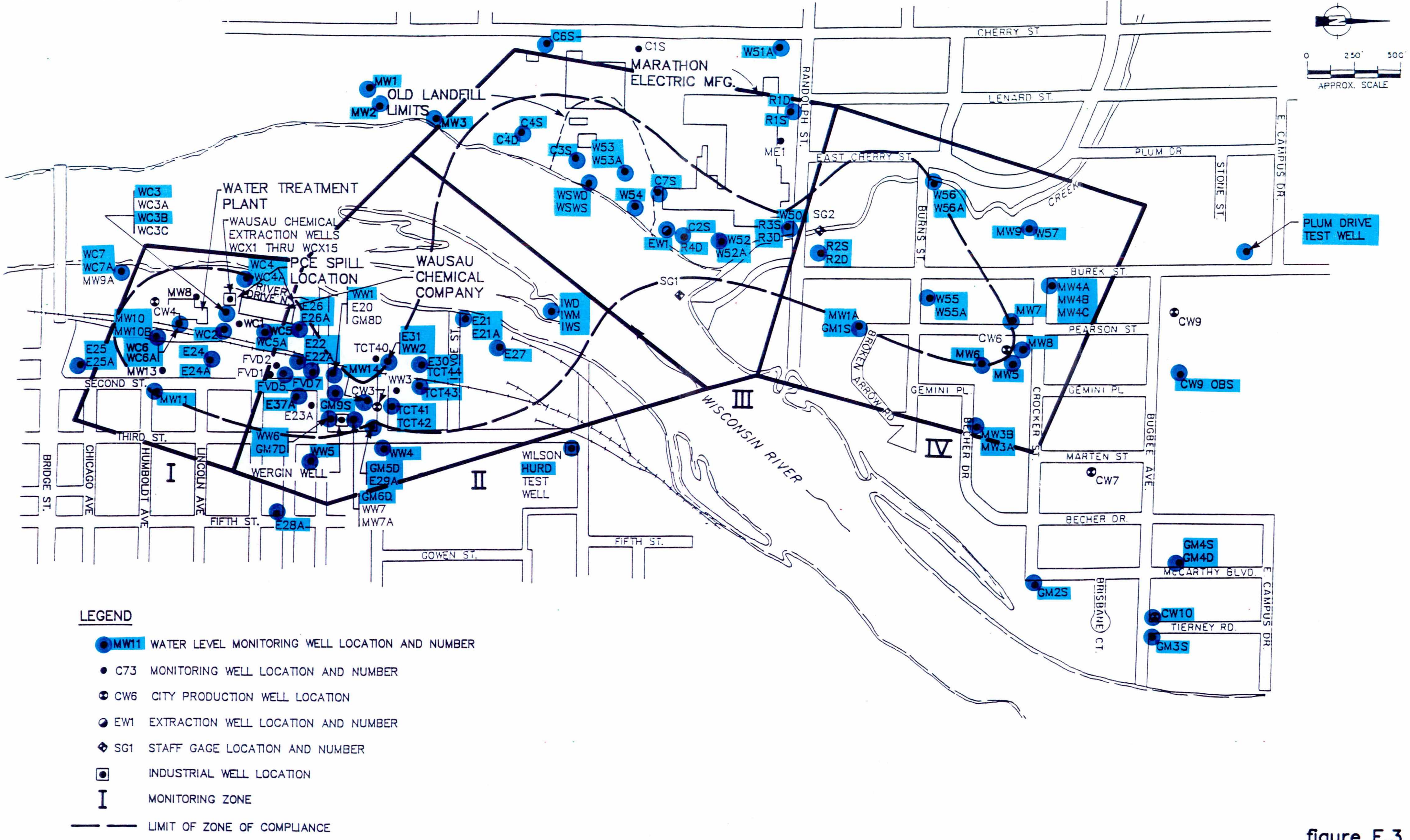

figure E.3

WATER LEVEL MONITORING WELL NETWORK

Wausau Superfund Site

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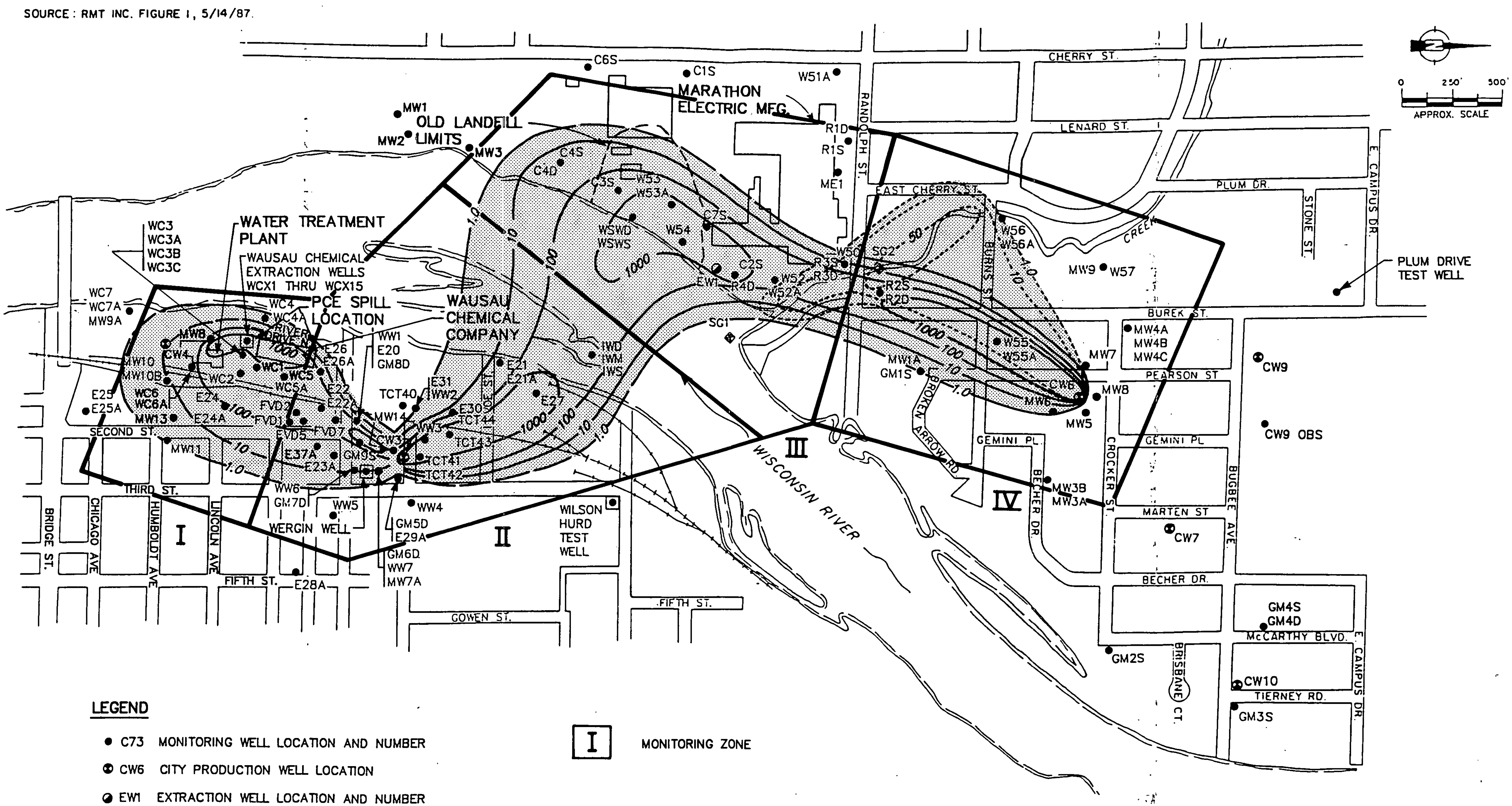
SOURCE: RMT INC. FIGURE 1, 5/14/87.



LEGEND

- ● C73 MONITORING WELL LOCATION AND NUMBER
- ⊕ CW6 CITY PRODUCTION WELL LOCATION
- ◐ EW1 EXTRACTION WELL LOCATION AND NUMBER
- ◈ SG1 STAFF GAGE LOCATION AND NUMBER
- ▣ INDUSTRIAL WELL LOCATION
- —10— DEEP GROUNDWATER TOTAL VOC CONCENTRATION CONTOUR (SOURCE: RI REPORT, WARZYN)
- - - 10 - - - SHALLOW GROUNDWATER TOTAL VOC CONCENTRATION CONTOUR (SOURCE: RI REPORT, WARZYN)
- ▨ ZONE OF COMPLIANCE
- I MONITORING ZONE

CRA

figure E.4

MONITORING ZONES

Wausau Superfund Site

SOURCE: RMT INC. FIGURE I, 5/14/87.

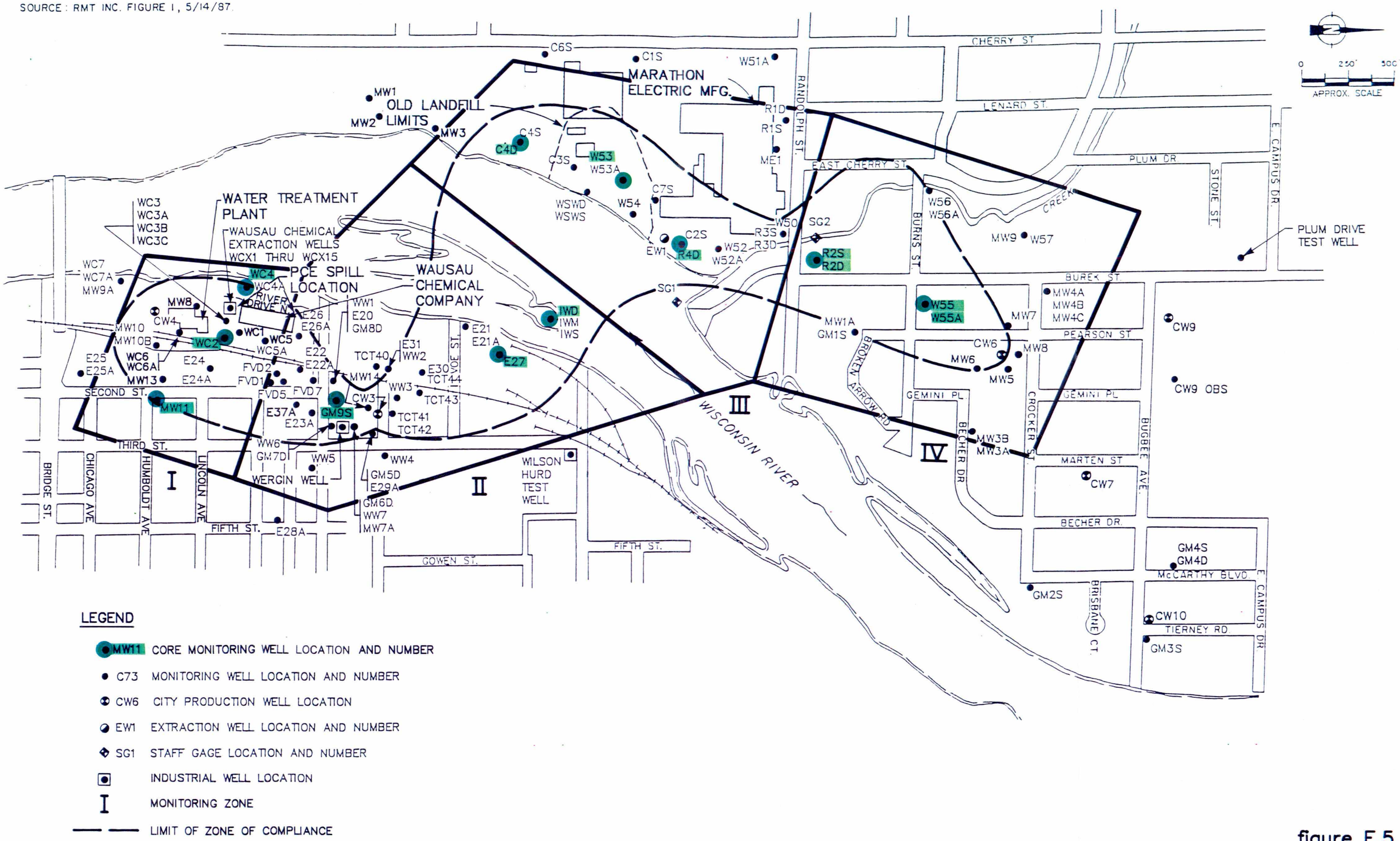


figure E.5

CORE MONITORING WELL NETWORK

Wausau Superfund Site

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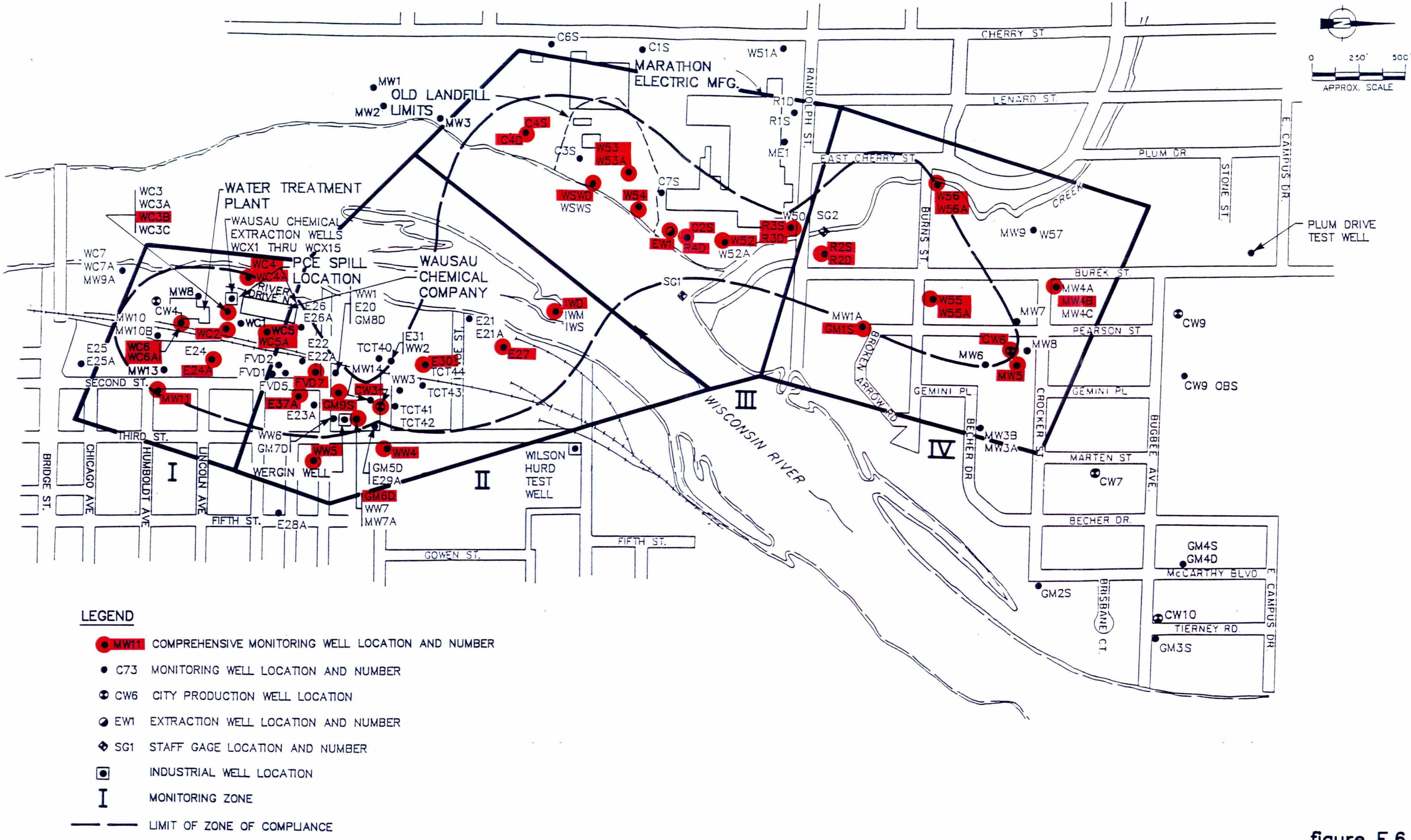

SOURCE: RMT INC. FIGURE 1, 5/14/87.

figure E.6

COMPREHENSIVE MONITORING WELL NETWORK

Wausau Superfund Site

CRA

TABLE E.9

COMPLIANCE MONITORING SUMMARY

Task	*Locations*	*Frequency*	*Parameters*
Soil Monitoring	Source Areas[1]	Before, mid-point and at end of SVE operation period	Site VOCs[2]
Soil Gas Monitoring	Source Areas[1]	Bi-Monthly (PID) Quarterly (off-Site Lab)	VOCs Site VOCs
SVE System Monitoring	SVE Exhaust Gas	Quarterly	TCL VOCs
Water Level Monitoring	Wells listed in Table E.1	Semi Annual, Quarterly from core wells	Water Levels
Groundwater Quality Monitoring	Core Locations - Table E.2a Comprehensive Locations - Table E.2b Indicator Wells - Table E.4	[illegible] Quarterly ~~initial round plus~~ quarterly Annual for ~~first~~ year anything detected previously Annual start up ~~a~~ (initial round)	Site VOCs & anything else detected during the first year Site VOCs TCL, TAL
	final monitoring -	4qtrs. of VOC's & any metals detected	
Groundwater Treatment Monitoring quaterly first year annually thereafter for VOC & detected	Treatment System Influent	Monthly	Site VOCs
	Treatment System Effluent	Monthly	pH, Site VOCs and site metals[3]
	Treatment System Effluent	Annual	TCL, TAL

Notes:

1. Source Areas - Specific soil sampling and gas probe locations will be based on the SVE pre-design study results.
2. Site VOCs - Site specific VOCs listed in Table E.3.
3. Site Metals - Any metals required based on TAL analyses. If no metals are identified at levels of concern, monthly metals analyses would not be conducted.

APPENDIX F

COMPLIANCE MONITORING
HEALTH AND SAFETY PLAN

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F.1 INTRODUCTION

F.1.1 GENERAL PROJECT DESCRIPTION

This Health and Safety Plan (HSP) has been developed to satisfy a requirement of the Consent Decree (CD) negotiated between the EPA, Wausau Chemical Corporation, Marathon Electric Manufacturing Corporation and the City of Wausau (the PRP Group) to implement the final remedy for the Wausau Superfund Site (site). The final remedy includes:

- Installation of soil vapor extraction (SVE) systems to remove Volatile Organic Compounds (VOCs) in soils at each of the three identified source areas;

- Treatment of off-gases from the SVE operation using vapor phase carbon units which shall be regenerated at an off-site RCRA approved site;

- Implementation of Monitoring Program;

- Groundwater remediation utilizing specified pumping rates of the municipal supply wells in order to expedite removal of the groundwater contaminant plumes affecting these wells;

- Groundwater remediation utilizing a specified pumping rate of the operable unit extraction well, with provisions for the addition of a second operable unit extraction well, if necessary; and

- Treatment of groundwater utilizing existing City air strippers and operable unit extraction well treatment system.

The Scope of Work (SOW), attached to the CD, specifies that a HSP is required during the implementation and compliance monitoring for the final remedy. Pursuant to discussions with the EPA and WDNR, a separate HSP has been developed to perform predesign investigations at the site, and is included in Appendix B of the RD/RA Work Plan. Also, as discussed in Section 5.2.3 of the RD/RA Work Plan, a construction HSP will be developed and designed as part of the RD, to protect on-site personnel and area residents from hazards posed during installation of the RA. Therefore, this HSP has been developed to perform compliance monitoring activities associated with the final remedy.

Compliance monitoring activities will include, but not necessarily limited to, the following:

- Borehole installations;
- Soil sample collection;
- Soil gas monitoring;
- Water level monitoring; and
- Water sample collection.

The HSP presented herein will be implemented during compliance monitoring activities to provide a safe and minimal risk working environment for on-site personnel. It also provides for emergency response procedures and corrective procedures.

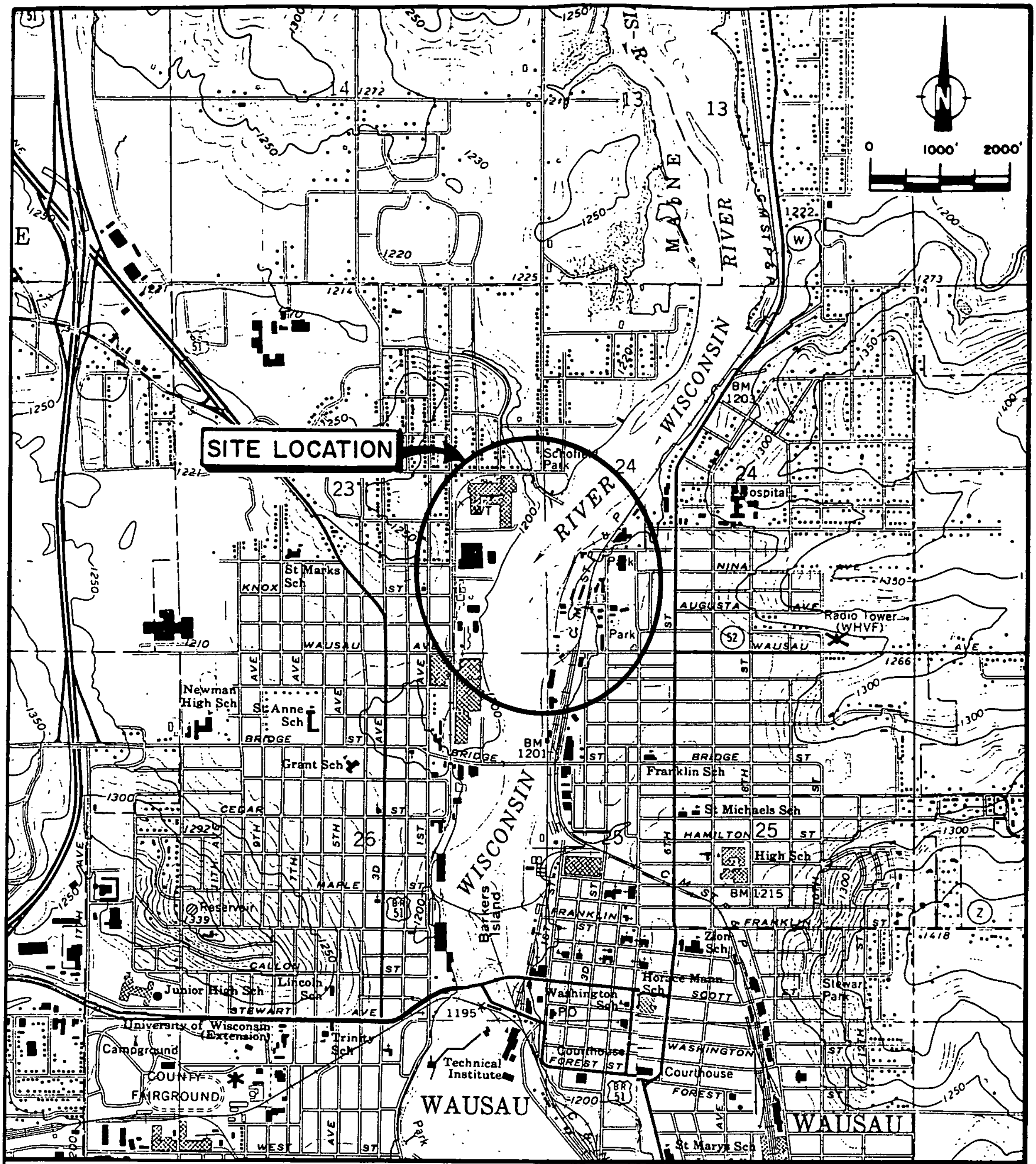
Modifications to the HSP during the compliance monitoring period may be suggested by the PRP Group, or required by EPA/WDNR. Any modifications to the HSP will require approval by EPA in consultation with WDNR.

F.1.2 SITE DESCRIPTION

F.1.2.1 Site Location

The Wausau Superfund Site (site) is located within the City of Wausau which is located in north-central Wisconsin along the Wisconsin River, Marathon County, Wisconsin. Figure F.1 shows the location of the site. The site consists of two areas separated by the Wisconsin River. The property comprising the former City of Wausau landfill is presently owned by Marathon Electric Company and is located on the west side of the Wisconsin River. The east side location is owned by the Wausau Chemical Corporation. These two locations are considered source areas for contaminants in the aquifer which is the source of drinking water for the City of Wausau. Figure F.2 identifies the location of the former City landfill limits and Wausau Chemical Corporation.

The City presently operates seven production wells, six of which are located on the north side of the City. The seventh well, CW-8, is located adjacent to the Wausau Municipal Airport on the south side of the City. Plan 1 shows the location of City water supply wells within the site.



SOURCE: U.S.G.S. WAUSAU WEST QUADRANGLE MAP.

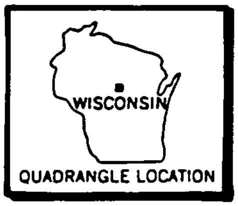


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figure F.1
SITE LOCATION
Wausau Superfund Site

3978-22/05/91-2-0

SOURCE: RMT INC. FIGURE 1, 5/14/87.

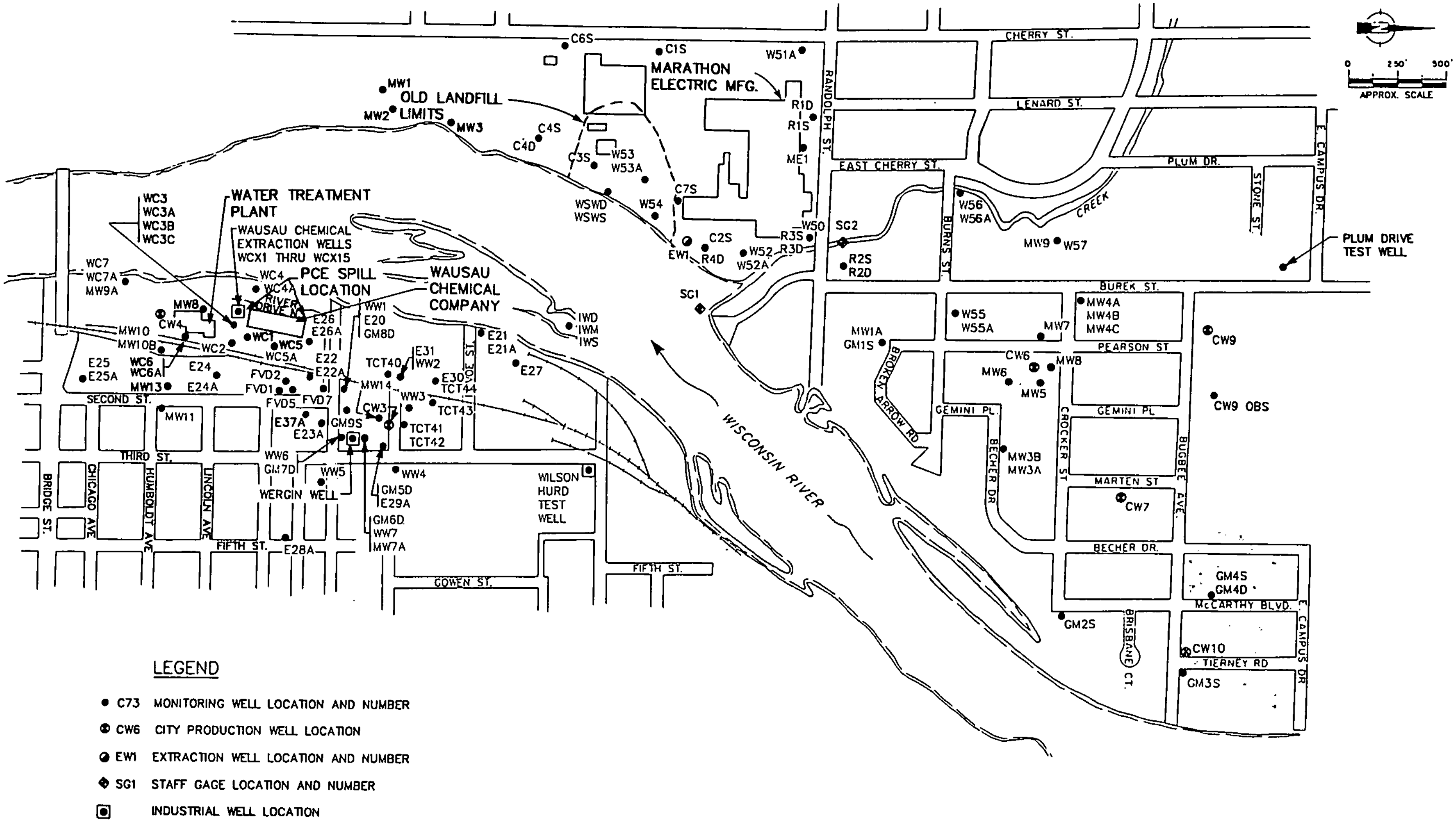

figure F.2

SITE PLAN

Wausau Superfund Site

CRA

3978-22/05/91-2-0

Production wells CW-6, CW-7, CW-9 and CW-10 are located west of the Wisconsin River and are collectively referred to as the west well field. Production wells CW-3 and CW-4 are located on the east side of the Wisconsin River and are referred to as the east well field. Presently, the water from CW-8 has a high concentration of iron and is used only during peak demand periods. The water from CW-4 is also used only during peak demand periods. Figure F.2 locates the City water supply wells.

The west well field is located in a predominantly residential area. The east well field is located in a predominantly industrial section of the City. Wausau Chemical Corporation is located between production wells CW-3 and CW-4. The former City of Wausau landfill is located on the south side of the Marathon Electric property, south of the City of Wausau's west well field. Figure F.2 locates the east and west well fields.

F.1.2.2 Site History

The City of Wausau discovered in early 1982, that its production wells CW-3, CW-4 and CW-6 were contaminated with volatile organic compounds (VOCs). Tetrachloroethylene (PCE), trichloroethylene (TCE) and 1,2-dichloroethene (DCE) were the predominant contaminants found. TCE was the primary VOC detected at CW-6, however, PCE and DCE have also been reported. Since TCE was first detected, the concentrations at CW-6 have ranged from 26 to over 200 micrograms per liter (μg/L). Sample results from the east well field (CW-4 and CW-3) indicate PCE, TCE and DCE contamination. CW-4 has generally shown a steady decrease in concentrations of these three constituents since 1984. CW-3 has shown decreases in PCE and DCE since they were discovered. TCE concentrations, however, have remained relatively constant at concentrations ranging between 80 and 210 μg/L. Toluene, ethylbenzene and xylene were also detected in well CW-4.

The City instituted a blending program whereby uncontaminated water from CW-9 and CW-7 was blended with water from CW-3, CW-4 and CW-6 in order to decrease VOC levels to acceptable drinking water quality prior to distribution. However, the program was largely ineffective due to continuing increases in VOC concentrations and groundwater quality which exceeded regulatory limits at that time.

In the fall of 1983, the EPA awarded the City a federal grant to help fund the design and installation of research units (GAC and Air Strippers) to reduce contaminants and provide sufficient water of acceptable quality to City residents. However, during the interim, the DNR requested assistance from the EPA emergency response team to evaluate possible response to the contaminant levels in the City's drinking water supply. Under emergency response, the EPA installed and operated a temporary granular activated carbon (GAC) treatment system at CW-6 starting in July 1984. As part of the research effort, full-scale packed tower VOC strippers were operational in August 1984 at the City water treatment plant (see water plant location on Plan 2) to treat water from wells CW-3, CW-4 and CW-6. The air stripping towers proved to be very effective for removal of the VOCs from the City's water supply. The temporary GAC system was subsequently removed from service in October 1984.

In December 1985, the site was nominated for inclusion on the National Priorities List (NPL). A remedial investigation/feasibility (RI/FS) study was conducted for the EPA by Warzyn Engineering, Inc. The RI/FS entailed two phases of field sampling. Phase I of the field work was conducted between August 1987 and January 1988. An Operable Unit Record of Decision (ROD) and Interim Consent Decree to address the west side contamination plume was signed in September 1988. Phase II of the RI/FS field work was conducted between June and September 1988. Results of the Phase II study are summarized in the RI/FS report dated August 1989. The remedial alternative selected is outlined in the ROD issued by the EPA in September 1989. A negotiated Consent Decree incorporating the ROD in the final remedy was negotiated by the settling defendants and EPA in 1990. The Consent Decree was lodged with the United States District Court for the Western District of Wisconsin on November 9, 1990. The Consent Decree establishes a schedule by which settling defendants must design and construct the final remedy.

The remedial design and construction of the operable unit groundwater extraction well on the Marathon Electric Corporations property north of the old landfill has been completed. The approximate location of the operable unit extraction well is shown on Figure F.2. The groundwater extraction well was put into operation on November 14, 1990 and initially extracted groundwater at an approximate flow rate of 1,600 gallons per minute (gpm). In December 1990, CRA submitted a report entitled "Extraction Well No. 1, Well Installation and Pump Testing, Marathon Electric Manufacturing Company, Wausau, Wisconsin", which summarized the installation and pump testing of the extraction well. In January 1991, CRA submitted a report entitled "Evaluation of Pumping Rate in Extraction Well No. 1, Marathon Electric Manufacturing Company, Wausau, Wisconsin". The report recommended that the pumping rate for the extraction well be reduced to approximately 800 gpm. The EPA provided written approval of the reduction in the pumping rate and on January 31, 1991, the pumping rate for the extraction well was reduced. The extraction well is currently operating at approximately 800 gpm.

F.1.2.3 Environmental Setting

Marathon County is situated near the margin of the exposed Precambrian Shield. The bedrock in the Wausau area is predominantly Precambrian igneous and metamorphic rocks of Lower and Middle Proterozoic age.

Glacial deposits underlying the site consist of glacial outwash and alluvial sediments which have filled in the preglacial stream valley where the Wisconsin River now follows. The surface topography of the project area is controlled by the underlying Precambrian bedrock topography, glacial deposition and post-glacial erosion.

The seven production wells for the City of Wausau provides drinking water for approximately 33,000 people. These wells are screened in the glacial outwash and alluvial sand and gravel deposits which underlie and are adjacent to the Wisconsin River. This alluvial aquifer ranges from 0 to 160 feet thick and has an irregular base and lateral boundaries. The boundaries of the aquifer are defined by the relatively impermeable bedrock which underlie it and form its lateral boundaries within a preglacial valley.

Groundwater flow within the unconfined glacial aquifer has been drastically changed by the installation and operation of the operable unit extraction well and the City production wells. Under natural conditions, groundwater would flow toward and discharge to the Wisconsin River and its tributary, Bos Creek. Under existing conditions, however, groundwater flows toward the extraction well and production wells during pumping. Prior to operation of the extraction well the natural groundwater flow directions were frequently reversed due to the City well pumping. The pumping of the east well field has appeared to have affected groundwater flow west of the Wisconsin River. Monitoring well nests located at the Marathon Electric Corporation property indicated very slight downward gradients adjacent to the Wisconsin River. Pumpage of the east well field induced recharge of surface water into the aquifer and induced groundwater below the river and on the west side of the river to flow toward CW-3. Based on water level data collected since commencing operation of the extraction well, the extraction well has created a cone of influence which extends below the river. The extraction well appears to be achieving the goals as set forth in the Interim Action Work Plan.

F.1.2.4 Source Areas for Contaminants of Concern

Previous investigations have identified several potential point sources of VOC contamination surrounding the City of Wausau production well fields. Results of groundwater quality analyses for VOCs conducted during the RI in 1987 and 1988 show a vertical and lateral distribution of total chlorinated ethenes which suggests that a minimum of three sources are affecting the City well field; these are described below. Three primary chorinated ethenes have been identified for the site; these are PCE, TCE and DCE. Additional contaminants of concern may be identified during implementation of the RD/RA.

F.1.2.4.1 West Side Source Area

The former City landfill/Marathon Electric property occupies a former sand and gravel pit located on the west bank of the Wisconsin River. The landfill, which consists of approximately 4.5 acres, operated between 1948 and 1955 and accepted the majority of commercial, industrial and residential waste generated within the City of Wausau. The majority of the landfill is currently being used as a parking lot and is covered with a bituminous pavement; the southern portion is vegetated. The appropriate limits of sand and gravel pit and the estimated extent of the former landfill are shown on Plan 3 enclosed.

F.1.2.4.1.1 Source Characterization

The predominant source of contamination to CW-6 and CW-3 appears to be the former City landfill/Marathon Electric property. Elevated concentrations of TCE were detected in groundwater, soil and soil gas samples obtained from the northern portion of the landfill. Soil gas TCE concentrations within the landfill ranged from below detection limits (1.0 µg/L) to approximately 107 µg/L. Soil samples obtained from borings in the vicinity of the landfill contained TCE concentrations of approximately 200 µg/L. Groundwater samples obtained from the vicinity of the landfill indicate TCE concentrations range from 16 µg/L to 1900 µg/L. Also detected in the vicinity of the landfill were 1,1,1-trichloroethane (TCA), 1,2 dichloroethene, chloroform and carbon tetrachloride at concentrations below 100 µg/L.

F.1.2.4.1.2 Contaminant Migration

West side monitoring wells delineate a deep (greater than 100 feet deep) north-south trending TCE plume. The vertical distribution of TCE throughout the aquifer near the old City landfill also suggests that the source of contamination lies within the northern portion of the landfill. The plume appears to have migrated northward under influence of the pumpage of CW-6 and eastward, under the Wisconsin River, toward CW-3. The highest TCE concentration (4200 µg/L) in the plume was detected approximately 550 feet south of CW-6.

TCE was also detected in the shallow aquifer between Bos Creek and CW-6. TCE contamination in this shallow aquifer appears to have resulted from the induced infiltration of surface water from Bos Creek, which has been contaminated by the untreated discharge of water at CW-6. The induced surface water recharge of the aquifer is evident from the downward vertical gradients at monitoring well nests in that area. TCE concentrations adjacent to CW-6 discharges were found to be 100 µg/L. TCE concentrations in the ponded area downstream were approximately 70 µg/L. TCE was not detected in surface water samples collected upstream of the CW-6 discharge nor was it detected at the point where Bos Creek enters the Wisconsin River.

Based on calculations performed for the RI, the total amount of VOCs remaining in the unsaturated soils in the northern portion of the landfill is estimated to be approximately 270 pounds. However, the total amount could vary considerably if contamination exists beneath the fill and/or if areas of undetected high concentrations dense non-aqueous phase liquids (DNAPLs) are present.

Prior to the summer of 1988, CW-6 was pumped directly into Bos Creek. Pumpage of CW-6 served as a barrier well to the rest of the west well field. However, the discharge of CW-6 to Bos Creek apparently created a contaminated groundwater mound between the source area and CW-6. The influence of the groundwater mound may not have fully penetrated the glacial outwash aquifer, but the RI data suggests that the mound served to effectively divide the west well field contaminant plume into northern and southern components, slowing contaminant migration away from the source.

In 1988 the City of Wausau completed a river crossing for a transport pipe to carry contaminated water from CW-6 to an air stripper on the east side of the river. The discharge of contaminated groundwater to Bos Creek was discontinued, and the City was able to put CW-6 back into service with an increase in the pumping rate. These factors would tend to increase the rate of migration from the source area towards CW-6.

In November 1990, Marathon Electric completed the installation of the operable unit extraction well on its property approximately 2100 feet south of CW-6. The extraction well is currently extracting groundwater at approximately 800 gpm. Treated groundwater is discharged to the Wisconsin River. The extraction well effectively contains and collects groundwater VOC contamination on the west side and underneath of the Wisconsin River. The extraction well and CW-6 serve as barrier wells, providing protection for the remaining water supply wells in the west well field.

F.1.2.4.2 East Side Source Area

The Wausau Chemical Company (Wausau Chemical) is located between CW-3 and CW-4 on the east bank of the Wisconsin River. The facility, established in 1964, is a bulk solvent distributor and transfer station for the shipment of waste chemicals and solvents from area businesses. The facility experienced two documented PCE spills in 1983 totaling approximately 1,000 gallons. Solvents released by Wausau Chemical are apparently responsible for a large percentage of the shallow groundwater contamination in the east well field.

F.1.2.4.2.1 Source Characterization

Soil gas and soil boring data reflecting the distribution of VOCs in the unsaturated soils were collected as part of the soil gas survey and from soil borings for source characterization during the RI. This data indicates higher concentrations of contaminants in the area located in the southern portion of the facility (Wausau Chemical tank farm) with decreasing concentrations within an elongated contaminant zone trending toward the east-northeast and south. Elevated concentrations of PCE were also found in unsaturated soils near the north loading dock. The highest level of PCE in the soil gas was reported from the southern end of the facility at a concentration of 4080 µg/L. Analysis of soil samples indicated 3500µg/kg of PCE in the vicinity of the north loading dock, and 1000 µg/kg at the south end of the property. Again, based on calculations performed during the RI, the total amount of VOCs remaining in the unsaturated soils at Wausau Chemical is approximately 260 pounds. This estimate may vary if contamination is found to exist beneath the Wausau Chemical facility building complex.

During the summer of 1984, approximately 1000 to 1500 cubic yards of solvent impacted soil was removed from the tank farm area and disposed of at a hazardous waste landfill. In October 1985, a groundwater extraction/treatment program was initiated. The groundwater remediation system consists of six submersible pumps alternatively operated in 15 extraction wells. As of January 1991, this system has removed and treated approximately 274 million gallons of impacted groundwater. Influent and effluent to the treatment system is monitored on a monthly basis to determine treatment efficiency and document compliance with WPDES permit.

F.1.2.4.2.2 Contaminant Migration

East side monitoring wells indicate three plumes within the east well field area, one deep plume apparently originating from the former City landfill on the west side of the river and two plumes originating southwest of CW-3.

The latter two plumes are restricted to the shallow portion of the aquifer (upper 40 feet) and consist of primarily PCE, TCE and DCE. Both of these plumes are apparently the result of past releases from the Wausau Chemical facility. A large, widely dispersed VOC plume extending eastward from the Wausau Chemical property was identified during the RI. The highest concentrations of VOCs in this plume were detected in the vicinity of the Wausau Chemical tank farm behind the southern part of the building complex (see Plan 2 enclosed). A second plume was detected northwest of the Wausau Chemical facility in the vicinity of the northwestern loading dock.

This plume was differentiated from the other plume by the absence of PCE degradation products.

F.2 RESPONSIBILITIES AND ADMINISTRATION

An appointed Site Representative shall be responsible for all decisions regarding operations and work stoppage due to health and safety considerations. The Site Representative(s) will have successfully completed the required training in accordance with 29 CRF 910.120 (40-hour supervisors plus eight-hour additional training).

The Site Representative's responsibilities include:

- field supervision of all on-site activities, including drilling; soil, soil gas and water sample collection; and, water level monitoring,
- ensure samples are properly collected, stored and subject to the appropriate chain-of-custody protocols,
- supervision and enforcement of safety equipment usage, including the required use of extra equipment if appropriate,
- supervision and inspection of equipment cleaning,
- personnel training in safety equipment usage and emergency procedures,
- maintain Exclusion Zone (EZ) and Contaminant Reduction Zone (CRZ) work area during drilling activities,

- implementation of health and safety program including air monitoring program,

- has authority to suspend work activity due to unsafe working conditions,

- coordination of emergency procedures, and

- maintain a hard-cover, bound log of compliance monitoring activities including: date, weather conditions, summary of daily activities and results of air monitoring.

Subcontractors working at the site shall be responsible for providing the Site Representative with appropriate documentation of worker training and medical records. The Site Representative's responsibility to the subcontractor are identical to those listed above. If a subcontractor is not conducting the approved work activities in a proper manner or is not adhering to all items in the health and safety plan, the Site Representative has the authority to remove the subcontractor (or individual subcontractor personnel) from the site.

F.3 PERSONNEL TRAINING AND EDUCATION

Prior to commencing compliance monitoring activities, a Health and Safety/Site Indoctrination Session will be presented. Attendance is mandatory for all personnel who will be or are expected to be, involved with the compliance monitoring program at the site.

The training program will stress the importance that each attendee understands the basic principles of personnel protection and safety, be able to perform their assigned job tasks in a safe and environmentally responsible manner and be prepared to respond in an appropriate manner to any emergency which may arise. A brief history of the site will be included and the various components of the project Health and Safety Plan will be presented following which an opportunity to ask questions will be provided to ensure that each attendee understands the Plan. The possibility of heat stress and cold exposure will also be reviewed during the site indoctrination program. Procedures for preventing, monitoring and dealing with heat stress and cold exposure are contained in Attachment F-1. Personnel not successfully completing the indoctrination training program will not be permitted to enter or work in the Exclusion Zone.

This training will be given in addition to the basic training required under OSHA and is not intended to meet the requirements of 29 CFR 1910.120. Prior to working in or entering an Exclusion Zone Environment (as defined in Section F.4), all personnel will be required to provide documentation to the Site Representative indicating successful completion of the training requirements of 29 CFR 1910.120.

A copy of this Health and Safety Plan will be provided to all subcontractors involved in on-site activities.

F.4 SITE OPERATION AND ORGANIZATION

The scope of work for this project involves installing boreholes, collecting soil, soil gas and groundwater samples, and performing water level monitoring.

F.4.1 SITE CONTROL MEASURES

Designated work areas will be set up during drilling activities. The purpose of these procedures is to limit access to potentially contaminated areas, and prevent the migration of potentially hazardous materials into adjacent non-contaminated areas. These areas are as follows:

i) The Exclusion Zone (EZ) is the area immediately surrounding the drilling operation. Sufficient area will be provided for efficient movement of personnel and equipment as well as contaminant control. The EZ will be delineated in the field with flagging material. Boundaries are modifiable depending on operational requirements. The Site Representative will be responsible for maintaining the boundaries of this area. Personnel entering this area are required to wear the PPE as defined in Section F.5. Exclusion Zones shall be set up at each drilling location.

In the event that unauthorized personnel enter the EZ, work will stop. Work will not resume until the unauthorized personnel have been removed from the EZ or have been moved to an acceptable on-site area. A log of all visitors to the site, including the EZ, will be maintained.

At the conclusion of each working day all drill cuttings will be collected and placed in 55-gallon DOT approved drums. Other waste materials and spent protective equipment shall also be secured in sealed drums at the site. Drums will be labelled and will be stored in a designated area on site. The drum storage area will be designated as an EZ, and be signed, delineated and secured accordingly. Drums will be stored until completion of the drilling program, at which time they will be characterized and hauled off site for disposal in accordance with all appropriate state and federal regulations. All off-site disposal of waste from the site will be in accordance with EPA's off-site Policy.

ii) The Contaminant Reduction Zone (CRZ) lies immediately upwind of the EZ. Personnel entering or leaving the EZ will use the CRZ for donning and disposing of PPE. Labelled drums will be provided for disposal purposes. Supplemental safety equipment, such as fire extinguishers, portable eyewash and extra quantities of PPE may be stored in this area.

F.4.2 PERSONNEL PROTECTIVE EQUIPMENT

The following section describes the levels of protection which may be implemented during the compliance monitoring activities. If upgraded from one level to another is required, authorized compliance monitoring visitors will be advised at that time.

Level E

Level E is to be implemented when monitoring activities (e.g. water level monitoring) take place where there are no anticipated or known environmental health hazards. Level E may include the following:

- steel toe boots
- hard hat
- disposable latex gloves (when needed)
- coveralls
- participation in medical monitoring program and Health and Safety trained, according to OSHA 20 CFR 1910.120.

Level D

Level D is to be worn during activities which do not suggest any initial respiratory protection, but where dermal protection is warranted (e.g. groundwater sample collection and soil gas sampling). The following list outlines the personal protective equipment to be utilized for Level D:

- Polyethylene (PE) coated Tyvek coveralls
- steel toe/steel shank leather work boots with latex overboots or steel toe/steel shank neoprene boot

- disposable latex gloves
- Nitrile or neoprene gloves
- eye protection (safety glasses or face shield)
- hard hat

Level C

Level C is to be worn when work area organic vapor air contamination is between 2 ppm over background concentration and 200 ppm greater than background (according to the PID readings). The following outlines this level of protection.

- PE coated tyvek coveralls
- steel toe/steel shank leather work boots with latex overboots or steel toe/steel shank neoprene boots
- disposable latex gloves
- nitrile or neoprene gloves
- full face, air purifying respirator with combination organic vapor/dust and mist cartridge
- hard hat

Level B

Level B protection is worn when work area organic vapor air contamination is between 200 and 500 ppm (according to PID readings). The following outlines this level of protection:

- PE coated tyvek coveralls
- Steel toe/steel shank leather work boots with latex overboots or steel toe/steel shank neoprene boots
- disposable latex gloves
- nitrile or neoprene gloves
- positive pressure self-contained breathing apparatus (SCBA) or airline supplied respirator with 5-minute escape pack
- hard hat

PPE will be maintained in a clean sanitary condition and ready for use. Disposable coveralls shall be discarded when torn or soiled and as an employee leaves the EZ zone. Respirators shall be cleaned after each day's use. Respirators will be replaced at breakthrough or at a minimum weekly. More frequent use may dictate more frequent replacement of respirator cartridges. A sufficient quantity of potable water shall be supplied for washing, cleaning PPE and drinking during borehole drilling. A potable water supply for washing and cleaning PPE will be maintained adjacent to the CRZ described in Section F.4.1. Fresh potable water for drinking will be supplied on a daily basis during drilling and be maintained at a location removed from the active work area.

The order in which safety equipment is to be donned is as follows:

- Tyvek suit,
- rubber boot,
- respirator, if required,

- hard hat, and
- gloves.

The following order applies when removing safety equipment:

- wash off boots prior to removal
- Tyvek suit
- gloves
- hard hat
- respirator, if appropriate

Additional PPE usage guidelines are as follows:

a. Prescription eyewear used on site shall be safety glasses equipped with side shields. Contact lenses shall not be used.

b. All respiratory usage will be in accordance with the action levels presented in Section F.7. Written standard operating procedures governing the selection and use of respirators at the site will be distributed to all workers at the initial site meeting. These procedures will include information and guidance necessary for proper respirator selection, use and care. All EZ workers will have received training in the usage of self-contained breathing apparatus which may be required in an emergency.

c. Steel toed leather footwear shall be covered with neoprene overboots prior to entering the EZ and immediately upon entering the CRZ.

d. Safety footwear and hard hats are to be worn by site personnel at all times.

F.4.3 ADDITIONAL HEALTH AND SAFETY PROTOCOLS

EZ personnel also carry certain responsibilities for their own health and safety, and are required to observe the following safe work practices:

i) Familiarize themselves with this Health and Safety Plan.

ii) Use the "buddy system" when working in a potentially contaminated operation.

iii) Use the safety equipment in accordance with training received, labeling instructions and common sense.

iv) Maintain safety equipment in good condition and proper working order.

v) Refrain from activities that would create additional hazards (i.e. smoking, eating, etc. in restricted areas, leaning against dirty, contaminated surfaces).

vi) Smoking and eating will be prohibited except in designated areas. These designated areas may change during the duration of the project to maintain adequate separation from the active work area(s). Designation of these areas will be the responsibility of the Site Representative.

vii) Soiled disposable outerwear shall be removed prior to washing hands and face, eating, using lavatory facilities or leaving the site.

F.5 SAFETY AND HEALTH RISK EVALUATION

This section identifies the general and specific risks and hazards associated with each identified compliance monitoring activity. Compliance monitoring field activities include:

- drilling operations/soil sample collection;
- groundwater and soil gas sampling; and
- water level monitoring.

Each of the field activities are discussed below with a description of the specific risks and hazards associated with each and the levels of protection required for each task. Table F.1 presents a summary of the activities, the specific chemical risks and hazards, and the appropriate personnel protection required.

F.5.1 ACTIVITY SPECIFIC RISKS/HAZARDS AND STANDARD OPERATING PROCEDURES

F.5.1.1 Drilling Operations/Soil Sample Collection

Boreholes will be required to be completed in order to collect soil samples for chemical analyses. Boreholes will be completed using hollow stem augers. Soil samples will be collected as the borehole is advanced.

TABLE F.1

ANTICIPATAED ACTIVITY CHEMICAL HAZARDS/RISKS AND APPROPRIATE PRECAUTIONS

Activity	*Anticipated Hazards/Risks*	*Required Personnel Protection*
Drilling Operations/ Soil Sample Collection	- contact with potentially contaminated soil	Level D, may require respirator usage (Level C) based on air monitoring*
	- inhalation of potential dust and/or vapor emissions	
Groundwater and Soil Gas Sampling	- contact with potentially contaminated water	Level D, may require respirator usage (Level C) based on air monitoring*
	- minimal exposure to potential vapor emissions	
Water Level Monitoring	- minimal contact with potentially contaminated water	Level E with latex gloves
Equipment Decontamination	- minimal contact with potentially contaminated water and soil	Level D

* See Section F.7.2

Hazards/Risks

- direct contact with potentially contaminated soil,
- inhalation of contaminated vapor emissions during soil sampling,
- noise levels exceeding the OSHA PEL of 90 dBA are both a hazard and a hinderance to communication,
- fumes (carbon monoxide) from the drill rig,
- overhead utility wires, i.e. electrical and telephone, can be hazardous when the drill rig boom is in the upright position,
- underground pipelines and utility lines can be ruptured or damaged during active drilling operations,
- moving parts i.e. augers and cat heads, on the drill rig may catch clothing. Free or falling parts from the cat head may cause head or eye injury,
- moving the drill rig over uneven terrain may cause the vehicle to roll over or get stuck in a rut or mud. Be aware of hazards associated with moving heavy machinery and other associated injury,
- high pressure hydraulic lines and air lines used on drill rigs are hazardous when they are in ill repair or incorrectly assembled.

Hazard Prevention

- review the contaminants suspected to be on site and perform air monitoring as required. Shut down drill rig and/or divert exhaust fumes,
- wear appropriate personnel protective equipment as specified with SOPs,
- all chains, lines, cables should be inspected daily for weak spots, frays, etc.,
- ear muffs and ear plugs effectively reduce noise levels,

- hard hats and safety glasses should be worn at all times when working around a drill rig. Secure loose clothing. Check boom prior to approaching drill rig,
- to avoid contact with any overhead lines, the drill rig boom should be lowered prior to moving the rig. Overhead utilities should be considered "live" until determined otherwise,
- the rig mast should not be erected within 10 feet of an overhead electrical line until the line is deenergized, grounded, or shielded and an electrician has certified that arcing cannot occur.
- Minimum working distances around "live" overhead power lines are: Minimum working and Voltage range [(phase to phase)kilovolt] clear hot stick distance

2.1 to 15	2 ft. 0 in.
15.1 to 35	2 ft. 4 in.
35.1 to 46	2 ft. 6 in.
46.1 to 72.5	3 ft. 0 in.
72.6 to 121	3 ft. 0 in.
138 to 145	3 ft. 6 in.
161 to 169	3 ft. 8 in.
230 to 242	5 ft. 0 in.
345 to 362	7 ft. 0 in.
500 to 552	11 ft. 0 in.
700 to 765	15 ft. 0 in.

- A thorough underground utilities search should be conducted before the commencement of a drilling project.

- All high pressure lines should be checked prior to and during use.

SOPs

- Level D Protection required (upgrade to level C or B based on air monitoring),
- only essential personnel should be in the work area,
- operate drilling equipment in a safe manner,
- adhere to equipment and personnel decontamination protocols prior to leaving site,
- during drilling in landfill area monitor environment of the drilling rig using a combustible gas indicator (CGI). If alarm sounds, shut off rig ignition and evacuate area.

F.5.1.2 Groundwater and Soil Gas Sampling

Groundwater and soil gas sampling will be conducted as part of the compliance monitoring program.

Hazards/Risks

- direct contact with potentially contaminated water,
- inhalation of contaminated vapor emissions during soil gas sampling,
- exposure to vapors of volatile organics when the well head is initially opened,

- back strain due to lifting bailers or pumps from down-well depths and moving equipment (generators) well locations,
- slipping on wet, muddy surfaces created by spilled water,
- electrical hazards associated with use of electrical equipment around water or wet surfaces,
- possible water splashing in eyes during sampling.

Hazard Prevention

- review the contaminants suspected to be on site and perform air monitoring as required,
- wear appropriate personnel protective equipment as specified under SOPs,
- to minimize exposure to volatiles when the well head is initially opened, a monitoring instrument (HNu, OVA) should be placed near the opening to monitor organic levels. The breathing zone should also be monitored. The action levels on the instruments should be chosen before site work begins, and should be outlined in the safety plan. To prevent contact with contaminated groundwater, or product material, provide adequate protective equipment as specified under SOPs,
- back strain can be prevented by employing proper lifting and bailing techniques. Heavy equipment, such as pumps and generators, should be only lifted with the legs, preferably using two or three personnel,
- slipping on wet surfaces can be prevented by placing all purged water in drums for removal. Also, if the area is wet, wear boots with good treads and be alert of where personnel are walking to decrease the chance of slipping,

- ground fault interrupter should be used in the absence of properly grounded circuitry or when pumps are used around wet conditions,
- electrical extension cords should be protected or guarded from damage (i.e., cuts from other machinery) and be maintained in good condition,
- eye protection should be worn as appropriate to prevent water splashing into eyes.

SOPs

- During soil gas sampling, personnel shall remain at least 10 feet from soil gas sampling pump exhaust,
- Level D Protection required,
- Air monitoring is not anticipated for these activities (see Section F.7.1.3),
- adhere to equipment and personnel decontamination protocols prior to leaving site.

F.5.1.3 Water Level Monitoring

This activity consists of the measurement of water levels in existing monitoring wells, production wells and extraction well(s).

Hazards/Risks

- direct contact with potentially contaminated water.

Hazard Prevention

- wear latex gloves when handling water level meter.

SOPs

- Level E Protection required,
- Air monitoring is not anticipated for this activity.

F.5.1.4 Equipment Decontamination

This activity consists of decontaminating drilling and sampling equipment.

Hazard/Risks

- minimal contact with potentially contaminated water and soils.

Hazard Prevention

- wear appropriate personnel protective equipment as specified under SOPs.

SOPs

- Level D protection required,
- Air monitoring is not anticipated for this activity.

F.6 DECONTAMINATION/PROCEDURES

F.6.1 EQUIPMENT DECONTAMINATION

Equipment decontamination (Decon) areas for decontamination of equipment which may come into contact with potentially contaminated material will be made available on site during drilling. A separate decontamination area will be made available on each side of the river to minimize inadvertent cross-contamination. The areas will be classified as an Exclusion Zone with all EZ requirements as presented in Section F.4. A wash tank will be placed within the Decon area and equipment cleaning will be conducted in and/or over this tank. Disposal of decontamination fluids is discussed in detail in Section E.3.2.2 of Appendix E of the RD/RA Work Plan. Personnel performing equipment decontamination will be required to wear Level D protective equipment.

Prior to mobilization, the drilling rig and all associated equipment will be thoroughly cleaned using a pressurized low volume water wash or steam cleaner to remove oil, grease, mud and other foreign matter. Subsequently, before initiating drilling at each location, the augers, cutting bits, samplers, drill steel and associated equipment will be thoroughly cleaned, at the Decon area, to prevent potential cross-contamination from the previous drilling location. The equipment will be inspected by the Site Representative after cleaning, prior to initiation of drilling. Cleaning will be accomplished by flushing and wiping the components to remove all visible sediments followed by a thorough steam cleaning. Special attention will be given to the threaded sections of the drill rods and split spoon samplers.

Prior to leaving the Site, the drilling rig and all associated equipment which may have contacted potentially contaminated material will be thoroughly cleaned using a pressurized low volume water wash or steam cleaner. The equipment will be inspected by the Site Representative after cleaning, prior to leaving the site.

All equipment used for the collection of samples for chemical analysis will be cleaned according to the protocols outlined in Section E.3.2.2 of Appendix E of the RD/RA Work Plan.

F.6.2 PERSONNEL DECONTAMINATION

A potable water supply will be provided adjacent to the Decon area for drinking water and personnel cleaning during drilling activities.

Hands must be washed with soap and water before eating, drinking or using toilet facilities upon finishing a field activity.

F.7 AIR MONITORING

F.7.1 EQUIPMENT AND FREQUENCY

F.7.1.1 Borehole Installation/Soil Sample Collection

Periodic measurements will be taken by the Site Representative and/or designee to monitor levels of organic vapors resulting from drilling operations. An HNu photoionization detector (organic vapors) equipped with an 11.7 eV light source will be used for this purpose.

Measurements will be taken immediately adjacent to the borehole, in the breathing zone and at the downwind boundary of the Exclusion Zone. Measurements will be taken on an hourly basis during active drilling at each boring location. Background measurements immediately upwind of the drilling site will be taken before drilling commences.

F.7.1.2 Soil Gas Sampling

Potential inhalation exposures during soil gas sampling will be mitigated by having the soil gas sampling personnel stand at least 10 feet from the soil gas sampling pump exhaust during the purge cycle. Therefore, air monitoring is not anticipated for this activity.

F.7.1.3 Groundwater Sampling

Based on air monitoring conducted over a six month period for the operable unit extraction well, air monitoring is not anticipated for this activity. Air monitoring conducted using an HNu meter (11.7 eV probe) did not detect any organic vapors at any monitoring well above 1 ppm. The conservative action level set that would require respiratory usage is 2 ppm.

F.7.2 RESPIRATOR PROGRAM AND ACTION LEVELS

All on-site drilling personnel will receive training in the use of, and be fit tested for both half- and full-facepiece respirators. Documentation of personnel successfully completing the fit testing will be maintained on site throughout the duration of the drilling activities.

Personnel protective equipment (PPE) to be utilized for the various activities will be as specified in Table F.1. The PPE is mandatory throughout the entire compliance monitoring program with the exception of respiratory protection during borehole completion and soil sample collection. The levels of respiratory protection required during drilling and soil sample collection are discussed below.

The action level criteria presented in this plan are based on the historical data base developed for the Wausau site areas. Identified chemical compounds of concern and respiratory criteria are summarized on

Table F.2. The ACGIH has defined the TLV as the time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. Because the lower TLV for the contaminants of concern is 50 ppm, the basis of upgrade from level D to level C may be placed at 50 ppm. Because field photoionization detectors (PID) typically measure chlorinated ethylene at about 50 percent efficiency compared to their calibration standard (HNU Systems, Inc. literature), a reading of 25 ppm greater than background level on a field PID would represent the TLV. CRA has selected a level of about one tenth this meter reading, 2 ppm, as its action level for upgrade of respiratory protection to full face air purifying respirators with organic vapor cartridge.

The action level for upgrade to a supplied air system is developed on the same basis. Because the maximum use concentration (MUC) is based on the TLV of the known contaminant and the protection factor (PF) of the selected respirator by the relationship:

$$\text{MUC} = \text{TLV} \times \text{PF}$$

an action level based on site conditions can be developed. With a PF of 100 for a full face purifying respirator (ANSI 288.2-1980), the MUC would be 5000 ppm. However, NIOSH approval of the purifying respirators used, limits their use to 1000 ppm organic vapors. With a 50 percent efficiency of PID air monitor, the MUC would read 500 ppm. CRA's action level of 200 ppm is well below this value. The action level is also less than the IDLH values for the chlorinated ethylenes of concern.

TABLE F.2

IDENTIFIED CHEMICAL COMPOUNDS AND RESPIRATORY CRITERIA

The following summarizes chemical hazard information.

Chemical Properties

Name	*Specific Gravity*	*Flash Point*	*Flam. Limits*	*Vapor Pressure*	*Vapor Density*	*Ionization Potential*	*Solubility*
Perchloroethylene	1.63	Not Combustible		14 mmHg	5.83	9.32 eV	0.015%
Trichloroethylene	1.46	89.6°F	11-41%	58 mmHg	4.53	9.47 eV	0.1%
1,2-Dichloroethylene	1.27	37.0°F	9.7-12.8%	180-265 mmHg	3.34	9.65 eV	0.35 - 0.63%

Health Properties

Name	*Odor Characteristic*	*Odor Threshold*	*TLV*	*IDLH*	*Dermal Toxicity*	*Approved Cartridge*
Perchloroethylene	chloroform-like	4.7 ppm	50 ppm	500 ppm[1]	moderate	organic vapor
Trichloroethylene	chloroform-like	21.4 ppm	50 ppm	1000 ppm[1]	skin irritant	organic vapor
1,2-Dichloroethylene	chloroform-like	0.085 ppm	200 ppm	4000 ppm	moderate	organic vapor

<u>Notes</u>:

1. Classified as occupational carcinogen in 29 CFR 1990.102

The action levels for respiratory protection were developed for known chemical contaminants unique to the Wausau project area. Their determination was made on a conservative basis, not only from the hazard of chemical exposure, but also to avoid unnecessary exposure to the physical hazards of restricted vision and mobility inherent in the use of respiratory protection equipment.

F.7.3 EQUIPMENT CALIBRATION

HNu Calibration checks will be done daily in the field prior to the commencement of field activities.

Calibration Checks of the HNu

Calibration checks will be performed in accordance with the following procedures:

1. Connect the analyzer to the regulator and cylinder with a short piece (butt connection) of tubing. The calibration gas in the cylinder consists of a mixture of isobutylene and zero air. Isobutylene is non-toxic and safe to use in confined areas. There are no listed exposure levels at any concentration.

   It is important that the tubing be clean since contaminated tubing will effect the calibration reading. Do not use cylinder below about 30 psig as reading below that level can deviate up to ten percent from the rated value.

Safely discard the disposable cylinder when empty. Do not refill this cylinder.

2. With the SPAN setting and the function switch at the same positions as listed in the Application Data Sheet or Calibration Report, open the valve on the cylinder until a steady reading is obtained.

3. If the reading is the same as the recorded data, the analyzer calibration for the original species of interest is still correct.

4. If the reading has changed, adjust the SPAN setting until the reading is the same.

5. Shut off the cylinder as soon as the reading is established.

6. Record and maintain this new SPAN setting.

7. If the calibration reading for the specific gas and span setting is not within 10% of the required range, disconnect probe and tubing and check for any potential foreign materials. Also check the energy path and source surface for foreign materials. Reassemble the probe unit and repeat steps 1 through 6. If the instrument is still outside the 10% acceptable range, use an alternate instrument until the instrument is corrected.

Additional manufacturer SOPs are included in Attachment F-2 of this HSP.

F.8 MEDICAL SURVEILLANCE

Pre and post physical examinations, conducted in accordance with 40 CFR §1910.120, will be required for all persons working in the EZ during drilling activities with the exception of persons who are already receiving suitable medical examinations on a regular basis. All subcontractors will assume responsibility for ensuring that their employees have received appropriate examinations. All contractors/subcontractors will provide certification that appropriate medical exams have been performed. This certification will be provided to the Site Representative prior to work commencing. All on-site personnel, regardless of the length of employment, will be entitled to a follow up medical examination up to one year after such individual is no longer working at the site. The results of the medical examination will be retained by the physician or physician group performing the examinations. The physician or physician group is required to make a report to the Site Representative if an individual has increased risks.

Employers will comply with OSHA regulations regarding the retention of medical or other records. Upon request to the examining physician or physician group, each on-site personnel shall be furnished with a copy of such individual's examinations.

Records that all employee's have completed the required physical examination shall be maintained on site throughout the duration of the field activities.

F.9 EMERGENCY AND FIRST AID EQUIPMENT AND SUPPLIES

The safety equipment listed below will be supplied for use by EZ personnel and will be located in close proximity to the work zone (i.e. in the CRZ).

i) 20 pound ABC type dry chemical fire extinguishers (one per drill rig).

ii) OSHA approved first aid kit sized for a minimum of five people.

iii) Portable emergency eyewash.

F.10.0 SITE EMERGENCY CONTINGENCY PLAN

F.10.1 CHEMICAL EXPOSURE SYMPTOMS

Vapors of chlorinated organic solvents are irritating to the eyes, nose, and throat. If inhaled in high concentration they can cause difficult breathing, nausea or dizziness.

Liquids containing these solvents can be irritating to the eyes and skin. If swallowed, they may produce nausea.

F.10.2 FIRST AID TREATMENT

For vapor exposure, remove victim to fresh air. If breathing has stopped, begin artificial respiration.

For liquid exposure, remove contaminated clothing and flush affected skin with plenty of water. If in eyes, hold eye lids open and flush with plenty of water. If swallowed and the victim is conscious, have him drink water or milk and induce vomiting. If swallowed and the victim is unconscious, do nothing except keep him warm and contact emergency medical help.

F.10.3 RESOURCES

Service or Organization	*Location*	*Phone Number*
Hospital: Wausau Hospital Center	Wausau, WI 333 Pine Ridge Blvd.	715-847-2121
Fire Department	Wausau, WI	715-845-1111
Poison Control Center	Green Bay, WI	414-433-8100
Police	Wausau, WI	715-842-2055
Rescue/Ambulance	Wausau, WI	715-845-1111

F.10.4 HOSPITAL ROUTE

Following is the route from the two source areas to the Wausau Hospital. An emergency route map is provided as Figure F3.

Wausau Hospital Center Route

From Marathon Electric:

i) From main parking lot, turn right (north) onto Cherry Street,

ii) Go 0.15 miles north to Randolph Street, turn left (west),

iii) Go 0.2 miles west on Randolph Street to Third Avenue, turn left (south),

iv) Go 0.75 miles south on Third Avenue to Bridge Street, turn right (west),

v) Go 0.9 miles west on Bridge Street, to Westwood Drive, turn left (south) to Westwood Drive, following blue "Hospital" signs,

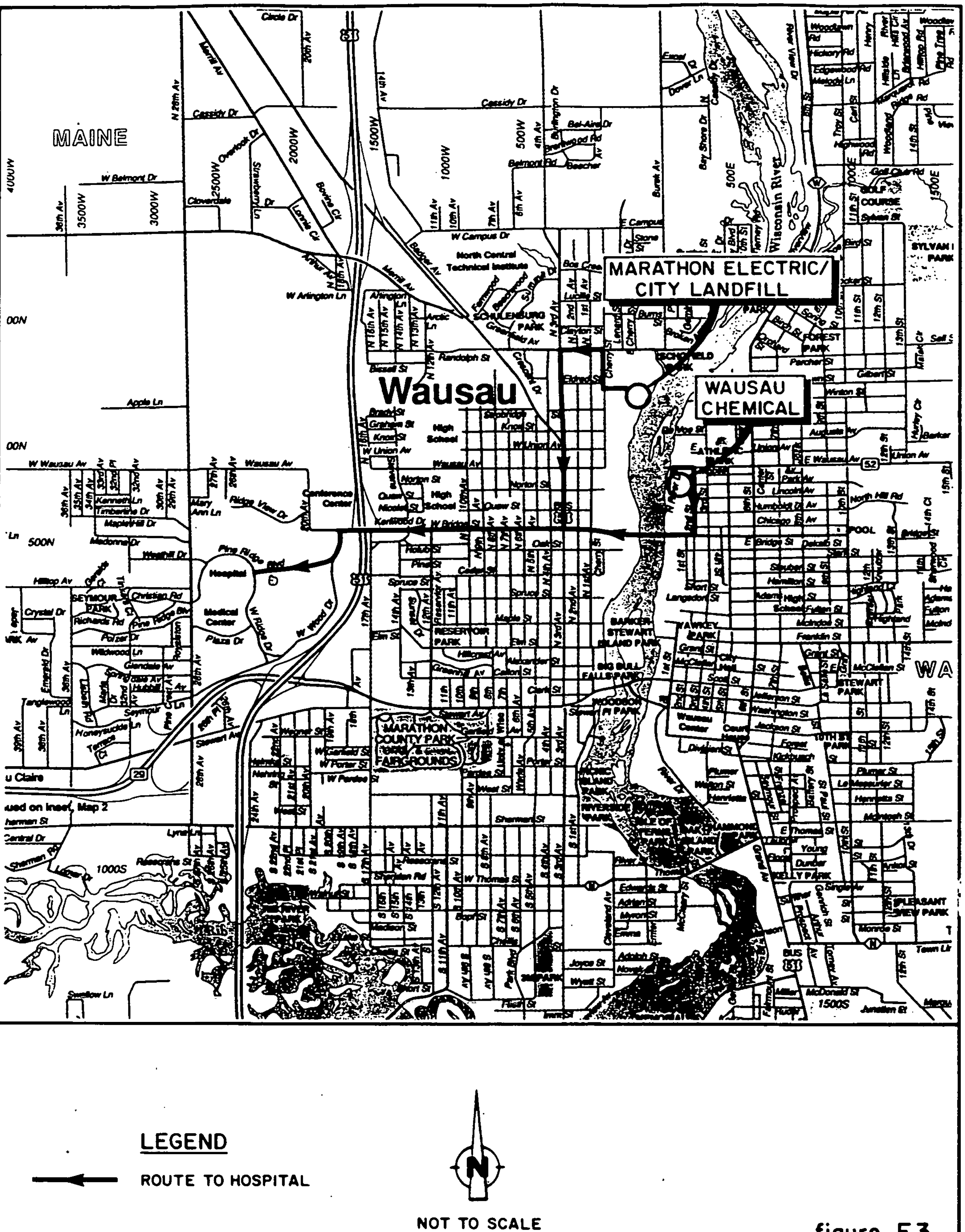

figure F.3

HOSPITAL EMERGENCY ROUTE

Wausau Superfund Site

CRA

3978-15/10/91-2-0

vi) Go 0.15 miles south of Westwood Drive to Pine Ridge Blvd., turn right (west),

vii) Go 0.4 miles on Pine Ridge Blvd. to Wausau Hospital Center. Follow signs to Emergency Entrance.

<u>From Wausau Chemical:</u>

i) Go north on either North River Drive or Filtration Road to Wausau Avenue, turn right (east),

ii) Go one block east on Wausau Avenue, turn right (south) on Second Street,

iii) Go 0.2 miles south on Second Street to Bridge Street, turn right (west),

iv) Go 1.4 miles west on Bridge Street to Westwood Drive, turn left (south) at "Hospital" sign,

v) Go 0.15 miles south on Westwood Drive to Pine Ridge Blvd., turn right (west),

vi) Go 0.4 miles on Pine Ridge Blvd., to Wausau Hospital Center. Follow signs to Emergency Entrance.

Personnel should ascertain that the routes are available prior to the start of field activities.

ATTACHMENT F-1

HEAT STRESS AND COLD EXPOSURE

HEAT STRESS

STANDARD OPERATING PROCEDURES FOR EMERGENCIES DUE TO HEAT AND HEAT STRESS MONITORING

Field operations during the summer months can create a variety of hazards to the employee. Heat cramps, heat exhaustion, and heat stroke can be experienced and, if not remedied, can threaten life or health. Therefore, it is important that all employees be able to recognize symptoms of these conditions and be capable of arresting the problem as quickly as possible.

THE EFFECTS OF HEAT

As the result of normal oxidation processes within the body, a predictable amount of heat is generated. If the heat is liberated as it is formed, there is no change in body temperature. If the heat is liberated more rapidly, the body cools to a point at which the production of heat is accelerated and the excess is available to bring the body temperature back to normal.

Interference with the elimination of heat leads to its accumulation and thus to the elevation of body temperature. As a result, the person is said to have a fever. When such a condition exists, it produces a vicious cycle in which certain body processes speed up and generate additional heat. Then the body must eliminate not only the normal but also the additional quantities of heat.

Heat produced within the body is brought to the surface largely by the bloodstream and escapes to the cooler surroundings by conduction and radiation. If air movement or a breeze strikes the body, additional heat is lost by convection. However, when the temperature of the surrounding air becomes equal to or rises above that of the body, all of the heat must be lost by vaporization of the moisture or sweat from the skin surface. As the air becomes more humid (contains more moisture), vaporization from the skin slows down. Thus, on a day when the temperature is 95 to 100°F, with high humidity and little or no breeze, conditions are ideal for the retention of heat within the body. It is on such a day or, more commonly, a succession of such days (a heat wave) that medical emergencies due to heat are likely to occur. Such emergencies are classified in three categories: heat cramps, heat exhaustion, and heat stroke.

HEAT CRAMPS

Heat cramps usually affect people who work in hot environments and perspire a great deal. Loss of salt from the body causes very painful cramps of the leg and abdominal muscles. Heat cramps also may result from drinking iced water or other drinks either too quickly or in too large a quantity.

<u>Heat Cramp Symptoms</u>. The symptoms of heat cramp are:

- Muscle cramps in legs and abdomen,
- Pain accompanying the cramps,
- Faintness, and
- Profuse perspiration.

Heat Cramp Emergency Care. Remove the patient to a cool place. Give him sips of liquids such as "Gatorade" or its equivalent. Apply manual pressure to the cramped muscle. Remove the patient to a hospital if there is any indication of a more serious problem.

HEAT EXHAUSTION

Heat exhaustion occurs in individuals working in hot environments, and may be associated with heat cramps. Heat exhaustion is caused by the pooling of blood in the vessels of the skin. The heat is transported from the interior of the body to the surface by the blood. The blood vessels in the skin become dilated and a large amount of blood is pooled in the skin. This condition, plus the blood pooled in the lower extremities when an individual is in an upright position, may lead to an inadequate return of blood to the heart and eventually to physical collapse.

Heat Exhaustion Symptoms. The symptoms of heat exhaustion are:

- Weak pulse;
- Rapid and usually shallow breathing;
- Generalized weakness;
- Pale, clammy skin;
- Profuse perspiration;
- Dizziness;
- Unconsciousness; and
- Appearance of having fainted (the patient responds to the same treatment administered in cases of fainting).

Heat Exhaustion Emergency Care. Remove the patient to a cool place and remove as much clothing as possible. Administer cool water, "Gatorade," or its equivalent. If possible, fan the patient continually to remove heat by convection, but do not allow chilling or overcooling. Treat the patient for shock, and remove him to a medical facility if there is any indication of a more serious problem.

HEAT STROKE

Heat stroke is a profound disturbance of the heat-regulating mechanism, associated with high fever and collapse. Sometimes this condition results in convulsions, unconsciousness, and even death. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age (over 40) bear directly on the tendency to heat stroke. It is a serious threat to life and carries a 20% mortality rate. Alcoholics are extremely susceptible.

Heat Stroke Symptoms. The symptoms of heat stroke are:

- Sudden onset;
- Dry, hot, and flushed skin;
- Dilated pupils;
- Early loss of consciousness;
- Full and fast pulse;
- Breathing deep at first, later shallow and even almost absent;
- Muscle twitching, growing into convulsions; and
- Body temperature reaching 105 to 106°F or higher.

Heat Stroke Emergency Care. Remember that this is a true emergency. Transportation to a medical facility should not be delayed. Remove the patient to a cool environment if possible, and remove as much clothing as possible. Assure an open airway. Reduce body temperature promptly—preferably by wrapping in a wet sheet or else by dousing the body with water. If cold packs are available, place them under the arms, around the neck, at the ankles, or at any place where blood vessels that lie close to the skin can be cooled. Protect the patient from injury during convulsions, especially from tongue biting.

AVOIDANCE OF HEAT-RELATED EMERGENCIES

Please note that, in the case of heat cramps or heat exhaustion, "Gatorade" or its equivalent is suggested as part of the treatment regime. The reason for this type of liquid refreshment is that such beverages will return much-needed electrolytes to the system. Without these electrolytes, body systems cannot function properly, thereby increasing the represented health hazard. Therefore, when personnel are working in situations where the ambient temperatures and humidity are high—and especially in situations where protection Levels A, B, and C are required--the site safety officer must:

- Assure that all employees drink plenty of fluids ("Gatorade" or its equivalent);
- Assure that frequent breaks are scheduled so overheating does not occur; and
- Revise work schedules, when necessary, to take advantage of the cooler parts of the day (i.e., 5:00 a.m. to 1:00 p.m., and 6:00 p.m. to nightfall).

If protective clothing must be worn, especially Levels A and B, the suggested guidelines for ambient temperature and maximum wearing time per excursion are:

Ambient Temperature (°F)	Maximum Wearing Time per Excursion (Minutes)
Above 90	15
85 to 90	30
80 to 85	60
70 to 80	90
60 to 70	120
50 to 60	180

One method of measuring the effectiveness of employees' rest-recovery regime is by monitoring the heart rate. The "Brouha guideline" is one such method:

- During a three-minute period, count the pulse rate for the last 30 seconds of the first minute, the last 30 seconds of the second minute, and the last 30 seconds of the third minute.

- Double the count.

If the recovery pulse rate during the last 30 seconds of the first minute is at 110 beats/minute or less and the deceleration between the first, second, and third minutes is at least 10 beats/minute, the work-recovery regime is acceptable. If the employee's rate is above that specified, a longer rest period is required, accompanied by an increased intake of fluids.

COLD EXPOSURE

FIRST AID FOR HYPOTHERMIA VICTIMS

Incorrect treatment of hypothermia victims may induce a condition known as "after-drop." This is caused by improper rewarming, allowing cold, stagnant blood from the extremities to return to the core of the body. This may cause the core temperature to drop below the level which will sustain life.

(1) Move the victim to shelter and warmth. *Do not allow victim to walk.*

(2) Remove all wet clothing, but handle the victim gently.

(3) Apply heat to the victim's *trunk* by using a warm bath, shower, hot water bottles or *heated* blankets. Do not wrap a hypothermic in a blanket *without* an auxiliary source of heat unless it is to protect him against further heat loss before treatment. An effective field treatment is for one or more of the rescuers to remove their own clothing, using their bodies to warm the victim's naked body. If the victim appears dead, heart massage and mouth-to-mouth resuscitation should be administered.

(4) In cases of mild hypothermia, shelter and dry clothing may be all that is needed. If the victim is conscious and can swallow without difficulty, he may be given a hot sugary drink. Care must be taken to ensure that the victim does not take the liquid into the lungs. Do *not* give the victim alcohol.

NEVER put an unconscious victim in a bathtub.

ALL hypothermia victims should be seen by a doctor.

Some of the information in this brochure has been taken from "Man in Cold Water" with permission of Dr. Martin Collis, University of Victoria, British Columbia, Canada; and from the U.S. Coast Guard publication, "Hypothermia and Cold Water Survival."

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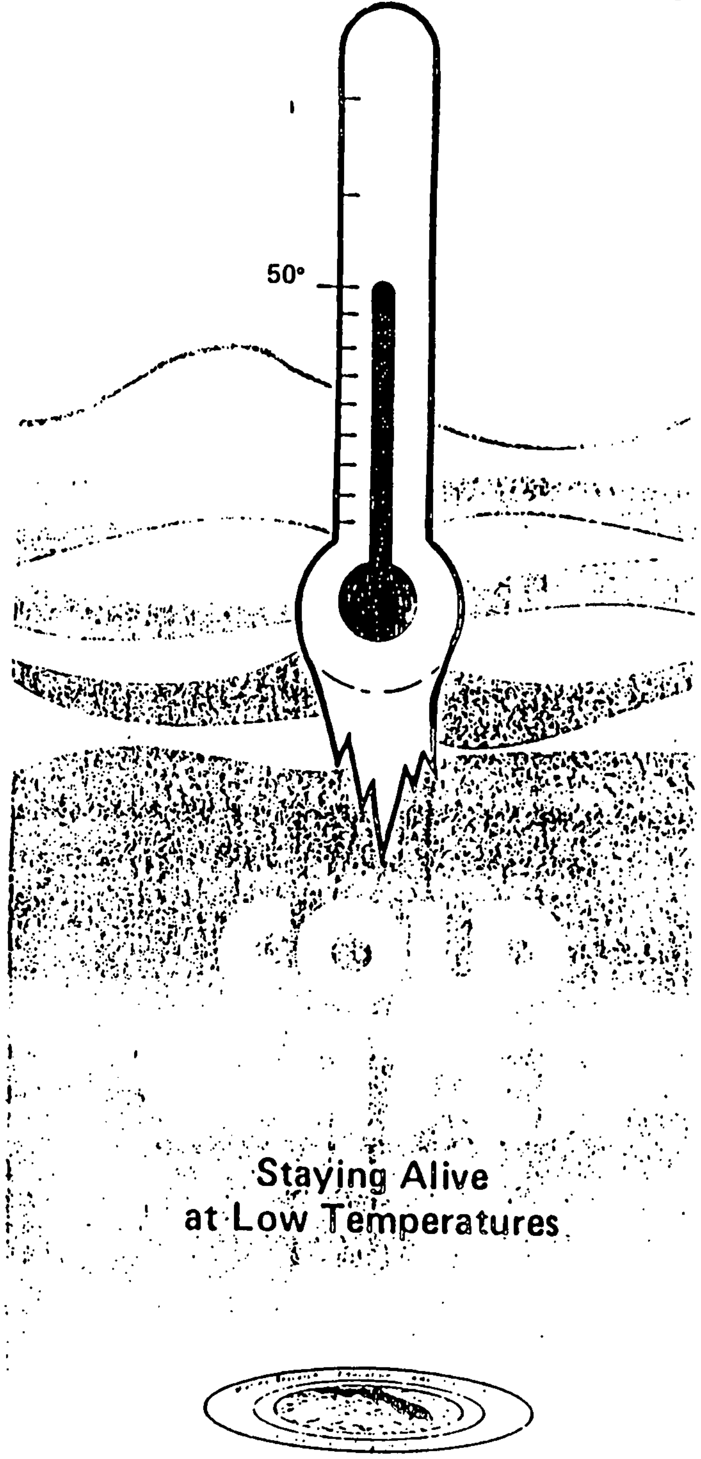


Staying Alive at Low Temperatures

INTRODUCTION

Even in the Sunshine State, cold water can be a menace.

All boaters and others in danger of accidental immersion in cold water should be aware of the factors that determine body cooling rate and eventual death from hypothermia as well as survival techniques.

The following information focuses on the major problems of cold water immersion and provides recommendations for survival.

HYPOTHERMIA - Lowered Deep Body Temperature

In cold water, the skin and nearby tissues become cooled very rapidly, but it takes 10-15 minutes before the temperature of the heart and brain begin to cool. Intensive shivering occurs in an attempt to counteract large heat loss.

COLD WATER SHOCK

Immersion in cold water causes immediate major changes in body functions, occasionally resulting in heart attacks or ruptured blood vessels. However, this is unlikely to occur in someone with a healthy heart and circulatory system. Also, cold water shock causes immediate hyperventilation (overbreathing) which could lead to uncontrolled inhalation of water and drowning.

IF AN ACCIDENT HAPPENS

Remember that water conducts heat many times faster than air. Most boats will float even when capsized or swamped. Therefore, get in or on the boat to get as far out of the water as possible. Wearing a personal flotation device (PFD) is a must. It will keep you afloat even if you are unconscious.

SURVIVAL FACTORS

Temperature of the water is not the only factor to be considered in cold water survival. Activity in the water, body size and fat have an effect. Small, thin people cool faster than large, fat people. Children cool faster than adults. The following table shows predicted survival times for the "average" person in 50°F water.

SITUATION	Predicted Survival Time (Hours)
NO FLOTATION	
Drownproofing	1.5
Treading Water	2.0
WITH FLOTATION	
Swimming	2.0
Holding-still	2.7
H.E.L.P.	4.0
Huddle	4.0

Treading water and drownproofing are anti-drowning techniques used when the person is without a PFD. Treading water is the continuous movement of arms and legs in certain patterns which keeps the head out of the water. Body cooling rate is 34% faster when treading water than while holding still in a life jacket.

Drownproofing, which involves restful floating with lungs full of air and raising the head out of the water every 10-15 seconds to breathe causes a person to cool 82% faster than while holding still in a life jacket. This is mostly due to putting the head, a high heat loss area, into the water along with the rest of the body. Drownproofing appears to be the *fastest way to die* from hypothermia.

Swimming is not recommended unless the individual is absolutely certain of reaching safety. Some good swimmers have been able to swim 8/10 of a mile in 50°F water before being overcome by hypothermia. Others have not been able to swim 100 yards.

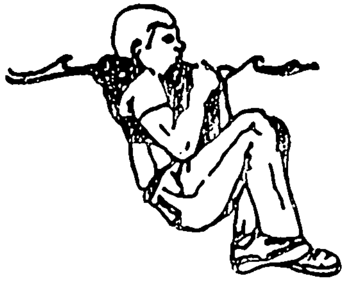
Although the body produces almost three times as much heat when swimming slowly and steadily in cold water compared to holding-still, this extra heat (and more) is lost to the cold water due to more blood circulation to the arms, legs and skin. The average person swimming in a life jacket cools 35% faster than when holding still.

CRITICAL BODY HEAT LOSS AREAS

In addition to the head (which is normally out of the water) certain other body regions have high rates of heat loss while a person is holding-still in cold water. The sides of the chest, where there is little muscle or fat, is a major route for heat loss from the warm chest cavity. Also, the groin region loses much heat due to large blood and lymph vessels near the surface. The following survival techniques focus on these areas.

TECHNIQUES THAT INCREASE SURVIVAL TIME APPROXIMATELY 50%

H.E.L.P. (Heat Escape Lessening Posture) - Hold the inner side of the arms tight against the side of the chest over the warm chest cavity and raise the thighs to close off the groin region - similar to the fetal position.



HUDDLE - If there are several people in the water, form a huddle so that the sides of the chests of different persons are held close together.

ATTACHMENT F-2

HNu SOP

HNU 1 of 7
P.I.D.

2.1 INTRODUCTION/UNPACKING

Unpack the instrument carefully. The carton will contain the housing, straps, battery charger, additional probes, regulator and cylinder if ordered, spare parts, supplies and a manual. Be sure all items are removed before discarding the carton.

Attached to the instrument is a warranty card which should be filled out completely and returned to HNU Systems.

2.2 CONTROLS AND INDICATORS

The controls and indicators are located on the front panel of the readout assembly (see Figure 2-1) and are listed and described in Tables 2-1 and 2-2.

2.3 OPERATING PROCEDURES

The following procedures are to be used in operating the analyzer:

a. Unclamp the cover from the main readout assembly.

b. Remove the inner lid from the cover by pulling out the two fasteners.

c. Remove the probe, handle and cable from the cover. Attach the handle to the front part of the probe.

d. Connect the probe cable plug to the 12 pin keyed socket on the readout assembly panel. Carefully match the alignment slot in the plug to the key in the connector. Screw down the probe connector until a distinct snap and lock is felt.

e. Screw the probe extension into the probe end cap. The probe may be used without the extension if desired.

f. Set the SPAN control for the probe being used (10.2, 9.5, or 11.7 eV) as specified by the initial factory calibration or by subsequent calibrations.

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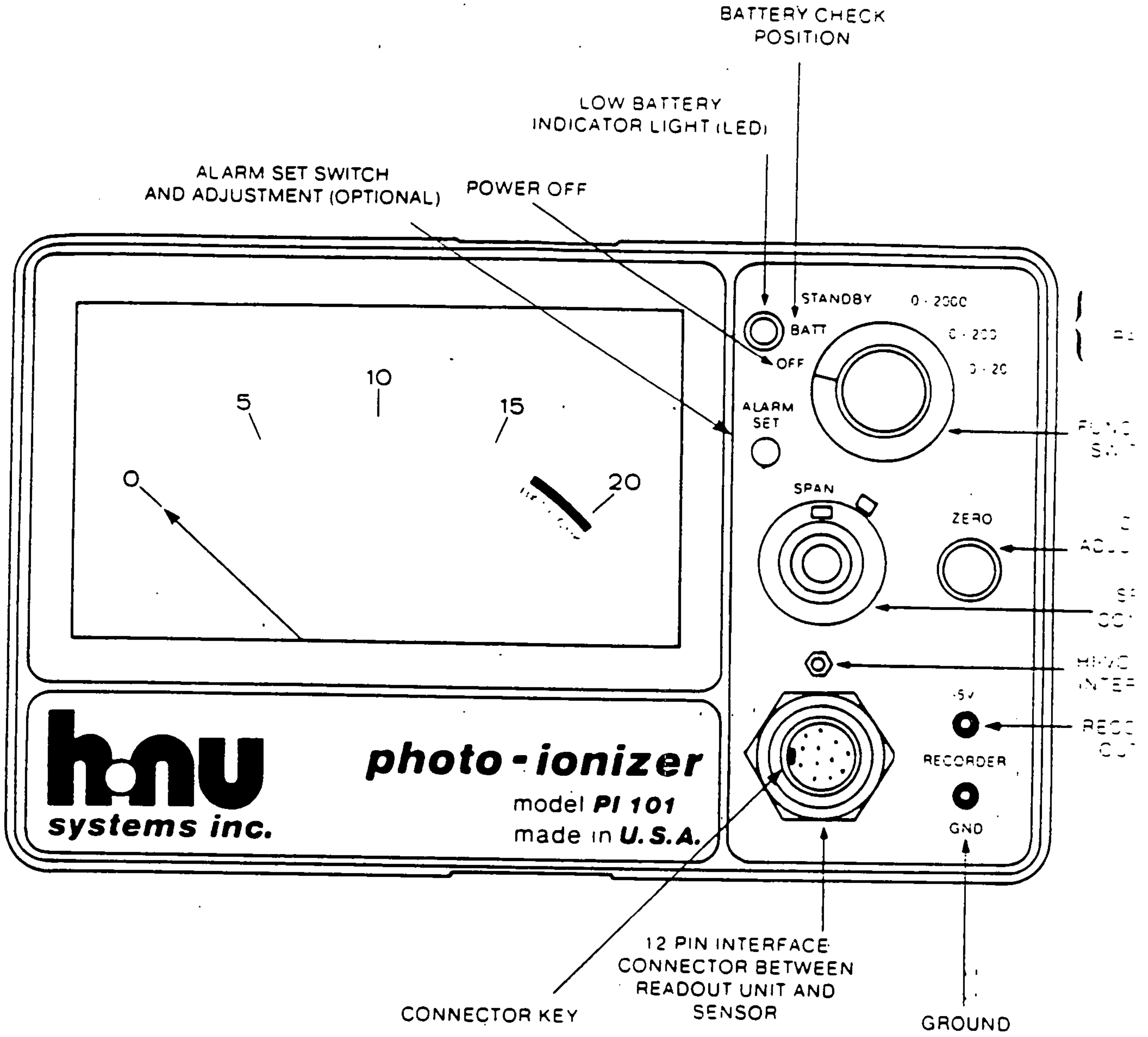

FIGURE 2-1
CONTROLS AND INDICATORS

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TABLE 2-1

CONTROLS

Name	Position	Function
Function Switch	---	Controls the operation of the analyzer
	OFF	All operations OFF
	BATT (battery check)	Checks the condition of the battery. If the meter needle is in the green arc, the battery is charged. If not the battery should be recharged. Charging can be done in any position, best in OFF; see directions on charger.
	STANDBY	All electronics ON, ultraviolet (UV) light source OFF. This position conserves power and extends battery life. This position is used to set the analyzer zero position. (i.e. no UV light, no signal)
	0-2000	Sets range of meter at 0-2000 ppm.
	0-200	Sets range of meter at 0-200 ppm.
	0-20	Sets range of meter at 0-20 ppm.
ZERO	---	With the function switch in STANDBY position, this potentiometer is used to adjust the reading to zero.

NOTE: See Figure 2-1 for locations.

TABLE 2-1 cont.

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SPAN	---	This vernier potentiometer is used to set the gain of the amplifier to give direct readings of the trace gas concentrations in ppm. The whole number of the setting appears in the window of the control, decimal appears on the dial. A lock secures it at a specific setting.
HI-VOLTAGE	---	This is a normally open microswitch.
	Open	Switch is open when cable not connected, disconnecting high voltage for the UV lamp from the 12 pin connector as a safety precaution.
	Closed	Switch is automatically closed when the cable is attached. This switch may also be closed manually during maintenance checks of the readout assembly without the probe cable attached.
ALARM SET (optional)	---	Potentiometer with screwdriver adjustment. Turns the audible alarm ON or OFF and sets the ppm level at which the alarm sounds. If alarm is low limit, it sounds when measured ppm falls below this value. If alarm is high limit it sounds when measured ppm exceeds this value.

NOTE: See Figure 2-1 for locations.

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TABLE 2-2

INDICATORS AND DISPLAYS

Name	Function
Low Battery Indicator Light (red light) (see NOTE)	Illuminates when battery is discharged, indicates need for recharge. Do not use unit when this light is ON. Readings may be taken while battery is being recharged.
Meter (see NOTE)	Indicates concentration of measured gas.
Recorder (optional) (see Figures 2-1 And 8-3)	Provides a record of readings while analyzer operates unattended. Recorder inputs 0 to -5 V DC.

NOTE: See Figure 2-1 for locations.

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g. Turn the function switch to the BATT (battery check) position. The needle on the meter will go to the green zone if the battery is fully charged. If the needle is below the green arc or if the Low Battery Indicator comes on, the battery must be recharged before the analyzer is used.

h. Set SPAN pot to the desired value based on the gas to be used.

i. Turn the function switch to the STANDBY position. Turn the zero adjustment until the meter needle is at zero.

j. Calibrate the instrument daily as described in the manual. Calibration on the selected operating range is desirable.

k. If equipped with optional alarm, set or check the alarm setting at the level desired. Turn the function switch to the desired range, turn the zero adjustment control so the meter needle moves upscale thru the desired value. This simulates real conditions. Observe the reading when the alarm sounds. Adjust the ALARM SET, if required, with a screw driver. Turn the function switch to the STANDBY position and reset the zero position (para. h. above). If the range is to be changed, the alarm must be reset on that range.

l. To operate with optional recorder, add the recorder bracket (see Figure 8-3). Remove the plug in the analyzer case and insert power cord into the recorder. Then connect the signal leads to the appropriate jacks in the control module. The recorder is now operational.

NOTE: Ranges must be marked on the chart as the recorder prints the meter display as % of Full Scale.

m. Turn the function switch to the appropriate operating position. Start with the 0-2000 position and then switch to the more sensitive ranges. The UV light source should be on, confirmed by briefly looking into the probe to observe a purple glow from the lamp.

WARNING

Do not look at the light source closer than 6 inches with unprotected eyes. Observe only if necessary, then only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight.

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n. The analyzer is now operational.

o. Hold the probe so that the extension is at the point where the measurement is to be made. The instrument measures the concentration by drawing the gas in at the end of the extension, through the ionization chamber, and out the handle end of the probe.

WARNING

The instrument measures gases in the vicinity of the operator and a high reading when measuring toxic or explosive gases should be cause for action for operator safety.

p. Take the reading or readings as desired taking into account that air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings. Change the ranges as required.

q. Check battery condition as required. If the Low Battery Indicator comes on, turn analyzer off and recharge.

CAUTION

Use only in an emergency with a low battery when on battery charge.