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Final
Quality Assurance Project Plan Addendum (QAPP)
13076

Remedial Investigation/ Feasibility Study
Wausau Water Supply NPL Site
Wausau, Wisconsin

Prepared for:

United States Environmental Protection Agency
Region V
Chicago, Illinois

Prepared by:

Warzyn Engineering Inc.
Madison, Wisconsin

QUALITY ASSURANCE BRANCH
JUN 17 1988
ENVIRONMENT SERVICES DIVISION

June 1988

ADDENDUM
QUALITY ASSURANCE PROJECT PLAN (QAPP) FOR THE WAUSAU WATER SUPPLY NPL SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY

Prepared By:

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June 15, 1988
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Mr. Kevin Adler, RPM
Region V U.S. EPA
5-HR-11
230 South Dearborn
Chicago, IL 60604

Re: Revised QAPP Addendum
Wausau Water Supply NPL Site

Dear Mr. Adler:

Warzyn is pleased to forward four copies of the Final Quality Assurance Project Plan for the Wausau NPL Site. Revisions were made based on review comments received from the EPA Quality Assurance Section and the Project Management Section, on June 13, 1988. Additional clarification of the Quality Assurance Project Plan Addendum Revision are provided as follows:

Section I Project Description

- Paragraph A, items d, e, f have been incorporated into Table 7 as requested since they represent field measurements which are supplementing sample collection.
- Paragraph A, items a, b, c have not been incorporated into Table 7 because they are field measurements which are independent of sample collection. These field measurements are briefly described in Table 10.
- Paragraph C, fast turnaround RAS/SAS analysis of groundwater and soil/residue samples have been requested so the data can be incorporated into the Remedial Investigation Report. Contract 68-01-7401 stipulates that this report must be submitted within 240 days of the contract authorization date. The fast turnaround data is also necessary for source characterization which directly influences the assessment of remedial alternatives in the feasibility study. Contract 68-01-7401 stipulates that the Feasibility Study must be completed within 18 months of contract initiation.

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As previously discussed, Warzyn will begin conducting stream flow measurements and drawdown measurements at selection site monitoring wells on Monday, June 20, 1988. This monitoring is necessary to establish background hydraulic conditions prior to Production Well CW6 being placed into service. The other Phase II investigation activities are scheduled to begin on Monday, June 27, 1988 with the test pit investigation to be conducted during the Marathon Electric holiday period (Week of July 5, 1988). Rapid review and approval of the QAPP is imperative to maintain the project schedule.

Please contact us if you have any questions or comments regarding the QAPP.

Sincerely,

WARZYN ENGINEERING INC.

Craig S. Rawlinson

Craig S. Rawlinson
Project Hydrogeologist

Dennis L. Iverson

Dennis L. Iverson
Project Manager

CSR/jpl/DLI
[jpl-106-90]

cc: Elissa Speizman

WARZYN

Remedial Investigation/ Feasibility Study Wausau Water Supply NPL Site Wausau, Wisconsin

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JUN 17 1988

ENVIRONMENT SERVICES DIVISION

June 1988

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APPENDICES

SECTION 1.0 - INTRODUCTION

This document describes supplements to the Quality Assurance Project Plan (QAPP) for the Wausau Water Supply Remedial Investigation/Feasibility Study (RI/FS) in Wausau, Wisconsin. The changes in the QAPP are presented as an addendum to the approved QAPP, dated September, 1987. The need for modification of the Phase II investigation, as presented in the original QAPP, results from data gaps identified during the Phase I Investigation.

Reference will be made to the previous QAPP document through citation of subtask, as applicable. Unless changes are noted in this document, the description of activities in the original QAPP remain applicable.

QAPP elements including 3.0 - Project Description, 3.1 - Background and 3.5 Project Objectives remain unchanged. Additional information obtained during the Phase I investigation has indicated probable volatile halogenated hydrocarbon (VHHs) source areas, plume migration routes, etc. (see Phase I Technical Memorandum for details). The Phase II investigation will emphasize characterization of suspected source areas and provide further definition of groundwater flow hydraulics between suspected source areas and municipal production wells CW3 and CW6.

SECTION 2.0 - PHASE II INVESTIGATION ACTIVITIES

Based on data gaps identified during the Phase I investigation, the following Phase II activities are planned:

2.1.0 TASK 1 - CONTINUED GROUNDWATER FLOW AND TRANSPORT MODELING

Groundwater flow and contaminant transport modeling will be continued during the Phase II investigation. The objectives of the continued groundwater flow and contaminant transport modeling include:

- Evaluation of contaminant transport from suspected VHH source areas through time;
- Evaluation of factors affecting groundwater flow and contaminant transport (i.e. influence of Bos Creek recharge on contaminant transport from the former City landfill);
- Calibrate groundwater flow and transport models for use in evaluating the remedial action alternatives during the feasibility study;
- Assessment of existing remedial actions (i.e. Wausau Chemical extraction system); and
- Provide enforcement support.

To achieve the modeling objectives, the following subtasks are anticipated:

Subtask 2.1.1 Groundwater Flow Model Adjustments

Based on preliminary model results, additional flow model calibration is required. At least three areas requiring modifications have been identified. The observed groundwater levels at Monitoring Wells GM4D, GM4S and the Plum Drive Test Well are generally higher than model simulated levels at these wells. A possible explanation for this discordance may be increased groundwater recharge due to sand and gravel excavations north of Campus Drive. In order to improve model calibration, groundwater recharge rates will be increased in the vicinity of the excavations.

Further flow model calibration is also required in the vicinity of Monitoring Well R2D. Bos Creek flow measurements (see Task 2.2.6) will be used to estimate the induced recharge from the creek into the aquifer. This information may indicate model adjustments which will improve the model calibration in the vicinity of Monitoring Well R2D.

Finally, the groundwater flow model south of Production Well CW4 requires that stream bed leakance (River Bed Hydraulic Conductivity) be adjusted. Comparison of observed and simulated water levels at monitoring wells WGS9 and WGS10 indicate simulated water levels are generally greater than the observed levels. Adjustment of parameters used in the Phase I Technical Memorandum simulation will be conducted within measured ranges to improve the calibration in this area.

Subtask 2.1.2 Contaminant Transport Model Calibration

The contaminant transport model will be calibrated, in general, to observed conditions. The contaminant mass per unit area will be computed from VHH concentrations observed in groundwater samples collected during Round 2 sampling (December, 1987). The source particle release rate and particle mass will be adjusted over one memory period (the residence time of a tracked particle from source to sink) until the distribution of particles in the system approximately matches the mass per unit area distribution determined from the Round 2 groundwater sampling. The groundwater flow field will be defined from the transient groundwater flow model run for the memory period prior to the Round 2 sampling. Values for contaminant dispersion and release rates will be determined through calibration of the model to existing conditions utilizing general information where available. Given the state-of-the-art in contaminant transport modeling, and unknown release rates, calibration of the contaminant transport model may be very general in nature.

Before the contaminant transport model can be calibrated, the groundwater flow model will have to be extended to include time steps through December, 1987. If preliminary modeling indicates that the system memory period exceeds the current model start date (January 1976) the model will be extended back to include pumping records prior to January 1976.

Subtask 2.1.3 Contaminant Transport Modeling

Once the contaminant transport model is calibrated, probable source areas, including Wausau Chemical and the former City landfill, will be evaluated to determine the fate of VHH contamination through time. This will be used in the endangerment assessment to evaluate future potential exposure risks. The contaminant transport model will also be used to evaluate potential remedial alternatives in the Feasibility Study.

Remedial alternative evaluation may require substantial redesign of the finite difference model grid in order to obtain sufficient resolution in the vicinity of source areas. The redesigned grid would permit greater model accuracy for simulation of remedial actions limited to suspected source areas.

2.2.0 TASK 2 FIELD INVESTIGATIONS

Further characterization of probable source areas identified during the Phase I Investigation is needed to determine the distribution of contaminants within the source areas. The field investigation and tests will be used to assess potential remedial alternatives. The following field investigation activities are planned for Phase II.

Subtask 2.2.1 Soil Gas Survey/Soil Boring Investigation

The Phase I soil gas survey, soil sampling and water quality sampling were used to identify potential source areas. The Phase II soil gas survey and soil boring investigation is designed to further characterize these potential source areas. The soil gas data will be used qualitatively as a field screening tool to determine which soil samples should be submitted for contract laboratory analysis and to identify locations where test pit excavations are required during Subtask 2.2.3.

The soil gas survey/soil borings will be conducted at the following thirty (30) locations:

- Wausau Chemical northwest loading dock - (3)
- Wausau Energy - (3)
- Wausau Chemical south side - (4)
- C. M. St. P. & P. Railroad right of way - (2)
- Former City of Wausau landfill - (12)
- Marathon Electric - (4)

An additional 2 soil boring locations will be determined based on results of the soil gas survey and analyses of soil samples. Refer to Figures 13 and 14 for proposed soil boring locations. Proposed soil boring depths, number of soil gas samples and boring rationale are presented in Table 6.

Soil gas samples will be collected through 4 1/4 inch hollow stem augers at selected depth increments. Drill rod fitted with lateral sampling ports will be driven two to three feet past the end of the augers. After the sampling probe has been driven to the desired depth, the drive head will be removed and a sampling adaptor will be threaded on to the drill rod. The soil gas sample will be collected in a 250 ml bomb, after purging a minimum of two sample device volumes using a portable air sampling pump. The sample bomb will be wrapped in aluminum foil, to minimize photoalteration and will be transported to the on-site GC. A sample blank and duplicate will be analyzed every 10 samples. Sample analysis will be conducted according to methods described in Appendix F of the approved QAPP (Dated September, 1987).

Decontamination will consist of purging more than 10 volumes of ambient air through the sampling device and brushing soil off the sampling probe and the lead auger. The split spoon will be cleaned between samples by washing with a laboratory wash solution (liquinox) and rinsing with clean water. The soil gas pumping probe and hollow stem auger will be steam cleaned prior to starting the investigation and between soil boring locations where residual materials are encountered.

East Study Area

Soil borings performed at Wausau Chemical, Wausau Energy, and the C.M. St. P.& P. Railroad right-of-way (Refer to Figure 13) will be approximately 15 feet deep. Soil samples will be collected according to ASTM D-1586 (standard penetration test). The samples will be obtained at 5 foot intervals using a 3 inch diameter split spoon. Samples undergoing VOC analyses will be transferred immediately to an 8 oz. VOC vial without compositing. Additional soil samples will be collected from locations where HNu screening of auger cuttings and/or visual observations indicate residual soil contamination. Soil samples will be screened for the presence of volatile organic compounds (VOCs) using a photoionization detector (PID). Selected samples will be submitted to the CLP laboratory for TCL Routine Analytical Service analysis, (CLP-RAS).

Approximately 4 groundwater samples (3 samples + 1 duplicate) will be collected from soil borings performed in the vicinity of Wausau Chemical northwest loading dock. The groundwater samples will be used to assess potential impact from the February 1983 PCE release. The groundwater samples will be collected at the water table through a screened lead auger. The samples will be obtained using either a stainless steel bailer or a Brainard Kilman hand pump. A minimum of three auger volumes will be purged prior to sample collection. Groundwater samples will be analyzed using an on-site GC according to the methods utilized during the Phase I investigation. As in the Phase I investigation, the GC analyses will provide fast turnaround field screening for target compounds. The analysis methods are described in Appendix F. The groundwater samples will also be submitted to the CLP for VOC analyses using

Soil gas samples will be collected from borings performed at Wausau Chemical, Wausau Energy, and the C.M. St. P.&P. railroad right-of-way. The soil gas samples collected during drilling will be used to assess the vertical soil gas concentration gradients within the soils. The soil gas sampling will also be used as a screening tool to aid in determining which soil samples should be submitted to the CLP for analyses. The soil gas results in combination with the soil analyses will be used to differentiate source areas from areas containing soils that have been impacted by the migration of contaminated groundwater. The soil gas samples will be collected at 5 foot intervals above the water table. Three (3) permanent gas monitoring probes will be installed at the former bulk solvent storage area (south side of Wausau Chemical). The probes will be screened from the water table (±12 feet) to approximately three feet below ground surface. The gas extraction well will be screened directly above the water table and will have a screen length of approximately 3 feet. The gas probes and extraction well will be used during the soil gas extraction test (Subtask 2.2.2).

West Study Area

The soil gas survey/soil boring investigation will also be performed at the former City landfill and at selected locations surrounding the Marathon Electric assembly building. The results of the boring/soil gas investigation at the former City landfill will be used to determine test pit locations (Subtask 2.2.3) and design a soil vapor extraction test (Subtask 2.2.2). A total of twelve soil gas survey/soil sampling borings are anticipated within the limits of fill of the former landfill. Four soil borings will be performed along the perimeter of the Marathon Electric assembly building. The boring locations at Marathon Electric were selected based on the soil gas survey results and on additional data obtained from the Marathon Electric Company. The soil borings at Marathon Electric will be used to characterize potential VHH contamination in the unsaturated zone. Additional borings maximum of [illegible] may be performed if the soil gas survey or the soil sample results indicate the need for further investigation. Proposed soil boring locations within the west study area are shown in Figure 14. Estimated boring depths, anticipated number of soil gas samples and boring rationale are presented in Table 6.

Soil samples will be collected at 5 foot intervals from ground surface to the completion depth. Soil samples will be collected according to procedures specified for the East Study Area. If soil samples cannot be collected due to split spoon obstruction, samples may be obtained from the auger cuttings. The soil samples will be screened for VOCs using a PID. Approximately twenty (20) soil samples collected from both east and west study area soil borings will be submitted to the CLP for RAS-VOC, RAS-BNA, RAS-PEST/PCB's, RAS-Metals/cyanide using Routine Analytical Services. Approximately two (2) groundwater samples will be collected through screened hollow stem augers at borings performed in the former City Landfill. An additional four (4) groundwater samples will be collected from borings performed along the perimeter of the Marathon Electric assembly building. The groundwater samples will be analyzed for target VOCs using the field GC. The groundwater samples will also be submitted to the CLP for verification of VOC results using fast-turnaround, low detection GC/MS SAS methods. Refer to Table 7 for a summary of proposed sample numbers and analysis parameters.

The soil gas samples will be collected at five foot intervals from the ground surface to a depth of 10 foot, and at 10 foot intervals from 10 foot to boring completion (i.e., 5 ft, 10 ft, 20 ft, 30 ft). Soil gas samples will be collected according to the methods described in Subtask 2.2.1. Soil gas results will be used for field screening. Results will be presented in the remedial investigation report as estimated values and tentatively identified compounds. The results will not be used to formulate final conclusions concerning possible source areas. Approximately twelve (12) permanent gas monitoring probes will be installed at six locations (Refer to Subtask 2.2.2 for gas probe installation descriptions). Approximate gas probe installation locations at the former landfill are presented in Figure 14.

Subtask 2.2.2 Soil Gas Extraction Treatability Study

Soil gas extraction tests will be conducted at the south side of Wausau Chemical and at the former City landfill located south of the Marathon Electric Assembly building. The gas extraction tests will be used to evaluate the effectiveness of in-situ enhanced volatilization (soil venting) as a potential remedial alternative. The technique is based on the principal that volatile organic compounds (VOCs) will vaporize to a state approaching equilibrium in the air space between soil particles. If the soil gas is static (not influenced by pumping), the vapors will diffuse slowly outward to lower concentration areas. Soil venting actively draws relatively clean air through the soil. VOCs in the soil moisture or adsorbed onto solids can then volatilize and be removed by the soil venting system.

Based on the presence of relatively high VOC concentrations in soil gas samples (Refer to Phase I Technical Memorandum), enhanced volatilization appears to be a potential remedial alternative for the treatment of unsaturated zone contamination at Wausau Chemical and the former City landfill. The gas extraction tests at these locations will be used to determine the radius of influence of the extraction system and to estimate the potential rate of removal of volatile halogenated hydrocarbon (VHH) compounds from contaminated soils. The data acquired from the extraction test will be used to support development and evaluation of remedial alternatives.

The gas extraction tests will require the installation of several gas monitoring probes at the former City landfill and at the former Wausau Chemical bulk solvent storage area. Based on Phase I soil gas results, tentative gas probe locations have been identified (Refer to Figures 13 and 14). The exact probe locations and depths will be determined from Phase II soil gas results. The soil gas probes will be installed in the borings performed during the soil boring/soil gas sampling investigation (Subtask 2.2.1).

The installation of approximately sixteen (16) gas probes is anticipated (12 at the former City landfill and 4 at Wausau Chemical). Due to greater unsaturated zone thickness at the former City landfill (approximately 30 ft), the twelve (12) gas monitoring wells will be nested at approximately six (6) locations. The gas monitoring probes will be installed through a 4-1/4 inch hollow stem auger. *If necessary, the shallow soil borings (≲ 20 ft) will be* left open until field GC data is available to select the screen position. Soil gas monitoring probe installation diagrams for single probe and multiple probe nests are shown in Figures 3 and 4, respectively. The probes will consist of 3/4-inch Schedule 40 PVC with threaded couplings. The screened interval will be determined in the field and pipes will be either perforated using a power drill or slotted using a hack saw. The screened interval will be backfilled with 3/8-inch washed stone and a granular bentonite seal will be placed over the gravel pack. A protective flush mount surface casing will be placed over the completed gas probes which are located in high traffic areas (i.e. Marathon Electric parking lot).

Gas extraction wells will be installed at the former City landfill and Wausau Chemical (Refer to Figures 13 and 14 for approximate locations). The exact extraction well locations, depths and screen length will be determined based on soil gas and soil analyses results. The extraction wells will be installed using a 4-1/4 inch hollow stem auger. The extraction wells will be constructed of 2-inch ID Schedule 40 PVC with threaded couplings. The screen will be backfilled with 3/8-inch washed stone and a granular bentonite seal will be placed above the gravel pack. The remainder of the annular space will be backfilled with granular bentonite. The conceptual extraction well design is presented in Figure 17.

The gas extraction tests will require approximately four (4) days to complete (2 days at each location). Prior to each test the gas probes and extraction wells will be monitored for static pressure, VOC levels, methane levels and oxygen levels. The samples will be collected from a sampling port located on the PVC riser. The VOC samples will be collected in a 250 ml bomb according to methods described in the soil gas investigation (Refer to Section 2.1.5 Final Work Plan). The VOC samples will be analyzed using the on-site GC. The oxygen and methane levels will be measured at the gas probe using a Gastech Model 1939 OX gas analyzer. The operations manual for the Gastech is presented in Appendix K. The pressure measurements will be conducted using Dwyer Magnehelic pressure gages. A description of and specifications for the pressure gages are presented in Appendix K. The static (non-pumping) pressure measurements will be assumed to be indicative of background conditions and will be used to determine relative pressure deviations at the extraction well and gas probes during the extraction tests. Barometric pressure, ambient air temperature and gas temperature will be recorded before and during the extraction test so that appropriate corrections can be made if necessary.

The gas extraction tests will be conducted by inducing a negative pressure at the test well using a 600 Watt, 2.6 Amp EG&G Rotron regenerative blower (Model #DR353BT72). The extraction tests will be used to determine the minimum gas flow rate and well head pressure required at the gas extraction well to influence the desired area or to influence the maximum area possible without inducing excessive air intrusion into the soils. The extraction tests will be initiated at predetermined test well valve settings and extraction gas flow velocities. The oxygen, methane, VOC levels and wellhead pressure will be recorded periodically until an apparent equilibrium is established at the test well (ie., constant wellhead pressure). Once equilibrium is established at the test well, pressure measurements will be conducted at adjacent gas probes to determine if the negative pressure induced at the test well is also influencing the adjacent monitoring points. This is shown by an observed decrease in static pressure relative to background pressures. If the desired area of influence is not obtained by the initial extraction well settings, the valve apertures and velocities will be adjusted. Wellhead pressure, oxygen, methane, and VOC levels will be monitored to determine if excessive induced air intrusion into the soils is occurring. The extraction tests will be terminated when either the desired area has been influenced or the apparent maximum zone of influence has been obtained. Gas velocities will be measured during the test using an Alnor Model 5016AP velometer. The operations manual for velometer is presented in Appendix K. The gas flow rate for the test wells will be calculated from the gas velocity measurements. The flow rate and VHH concentrations will be used to estimate the mass of contaminants removed from the unsaturated zone during the test.

Subtask 2.2.3 Former City Landfill Test Pit Investigation

Backhoe test pit excavations will be conducted at a maximum of eight (8) locations within the former City landfill. Five of the test pit excavation locations are shown in Figure 14. The proposed test pit locations are approximate, based on data obtained during Phase I including: soil gas survey results, presence of VHHs in unsaturated zone soils obtained from the landfill and interviews conducted with former landfill employees. The exact test pit locations will be determined based on review of the Phase II soil gas survey results and PID screening of soil samples obtained during the Phase II boring program. If needed, an additional three test pit locations will be selected based on the Phase II soil borings, soil gas sampling (Subtask 2.2.2) and based on materials encountered in the first five test pits.

The test pit excavations will be used to characterize the source of VHH contamination within the former City landfill. Source characterization will include field classification of the landfill cover materials, waste materials and fill materials. Approximately, fifty (50) soil samples will be collected from the test pit excavations. The soil samples will be screened using a photoionization detector (PID). Twenty (20) duplicate soil samples will be submitted to the CLP for Routine Analytical Services analysis of the USEPA Target Compound List (TCL) parameters, (CLP-RAS). Refer to Table 7 for a summary of the sampling and analysis program. The CLP VOC analyses of soil samples will be used to quantify field PID screening results. The TCL parameter analyses will be used to identify additional compounds which may be present at the source area.

The test pit excavations will be performed with a backhoe to an approximate depth of 15 feet. Test pit excavations are anticipated to be approximately 15 feet long and 5 feet wide. However, the excavation may be enlarged to characterize residual materials encountered. Fill and waste materials removed during the excavation will be stockpiled and used to refill the excavation following sampling. If drummed wastes are encountered during the excavations, the wastes will be sampled and arrangements will be made to submit the samples for CLP analysis of TCL organics and inorganics. Drummed residual materials will be considered high hazard samples and will be transported and analyzed according to High Hazard Protocols (Refer to Table 9). If possible the containerized wastes will be sampled in place without removal from the excavation. However, if the containerized waste cannot be sampled in-situ, without endangering field personnel, the waste will be excavated and sampled. Containerized (drummed) wastes will be placed back in the test pits unless the integrity of the container has been compromised. Containers which become breached during the excavation will be overpacked and stored in a secured location. Each test pit excavation will be documented using photographs and video/audio recording.

Samples of excavated fill materials will be collected out of the backhoe bucket using stainless steel spatulas or trowels. Samples submitted for VOC analyses will be placed directly into the sampling bottle without compositing. Base neutral and acid extractable samples will be composited in a stainless steel mixing bowl before being placed in sample jars. If containerized wastes are encountered in the excavations, the contents will be sampled using a glass pipe (liquid) or a sediment sampler (sludge). The residue samples will be shipped according to high hazard protocols (Refer to Table 9).

The test pit investigation area will be returned to its approximate previous state (bituminous pavement or vegetated) following completion of the test pit excavation program.

Subtask 2.2.4 Round 3 Groundwater Sampling

Round 3 groundwater samples will be collected at ninety (90) locations in order to augment sample analysis results obtained from Round 1 (Subtask 2.1.4 and Round 2 (Subtask 2.1.8) sampling. The primary purpose for this round is to obtain a second sample and analysis from wells installed during Phase I to confirm the observations of contaminant distribution from Phase I sampling. The samples will also provide additional information pertaining to source area characterization, extent of contamination, temporal groundwater quality variations and mass of contaminants present. Samples of Wausau Chemical and City of Wausau air stripper influent and effluent will be collected in order to provide performance data of documentable quality. This information will aid in the evaluation of remedial alternatives. The samples will be collected from the following locations:

- Five (5) City production wells;
- Thirty (30) monitoring wells installed during Subtask (2.1.6);
- Five (5) Wausau Chemical Extraction wells (preferably pumping);
- Wausau Chemical treatment system influent and effluent (2 samples of each, 4 total);
- City of Wausau air stripper influent and effluent (2 samples of each from both strippers, 8 total);
- Thirty-five (35) previously existing monitoring wells; and
- Three (3) recently installed Marathon Electric monitoring wells which were not sampled during the Phase I investigation.

The groundwater sampling methods, equipment and decontamination procedures are the same as those summarized in Section 2.1.8 of the approved work plan (dated September 1987). The ninety (90) groundwater samples will be analyzed for VOCs according to SAS methods specified in Appendix D, (Low Detection Limits).

An additional twenty-three (23) groundwater samples collected from potential source areas and impacted production wells (CW3, CW4, CW6) will be submitted to the CLP for TCL analyses by RAS. Refer to Table 7 for a summary of the sampling and analysis program. Sample locations are presented in Figure 18.

Subtask 2.2.5 Surface Water and Sediment Sampling

Based on VOC analyses of surface water and sediment samples obtained during Subtask 2.1.6, Bos Creek was identified as a probable source of VHHs to the shallow aquifer. This impact may vary seasonally, depending on the rate of volatilization from the creek. Therefore, an additional round of surface water and sediment sampling is proposed. The samples will be collected from four locations on Bos Creek (Refer to Figure 18 for sample locations). The surface water and sediment samples will be collected according to procedures described in Subtask 2.1.7 of the approved Work Plan dated September, 1987. The surface water samples will be analyzed for VOCs by low detection, GC/MS through SAS. Sediment samples will be analyzed for VOCs according to RAS methods. Refer to Table 7 for a summary of the surface water and sediment sampling and analysis program.

Subtask 2.2.6 Bos Creek Discharge Measurements

In order to refine the groundwater flow model calibration and determine the relationship of Bos Creek to the existing and previous groundwater flow regimes, surface water discharge and elevation measurements at Bos Creek will be required. These data will also be used to assess risks due to contact with VHH contaminated surface water.

This task will require continuous monitoring of creek elevation and intermittent measurement of stream discharge. An electronic data logger with attached pressure transducer will be located on Bos Creek in the pool above Randolph Street. The creek elevations will be monitored continuously for approximately 3 months (through the end of August). Stream discharge measurements will be made by Warzyn personnel at both Burns Street and

Randolph Street. The discharge measurements will be conducted approximately every two weeks throughout the three month monitoring period. The flow measurements will be made using both a pygmy flow meter and a price current meter (Refer to Appendix L for stream gaging procedures). Stream discharge measuring frequency will be increased during the week that Production Well CW6 is put back on line and is no longer pumped to waste into Bos Creek.

The stream elevation and flow velocity monitoring will be used to create flow versus elevation curves which will be used to assess variations in stream discharge rates. The difference between the average upstream and downstream discharge rates will be used to estimate the induced recharge into the aquifer.

Subtask 2.2.7 Groundwater Level Monitoring

Due to the critical need to define the affects of induced surface water recharge on groundwater flow in the vicinity of Bos Creek, four additional rounds of water level data should be obtained from site monitoring wells. The data will be used to assess changes in groundwater flow resulting from variations in production well pumping rates, river stages and groundwater recharge. The water levels will be measured using a fiberglass tape and sounding device or an electronic water level indicator. The water level measuring devices will be calibrated prior to use so that readings from the various devices are consistent to within ± 0.01 feet (accuracy of the elevation survey).

Subtask 2.2.8 Drawdown Testing

Continuous water level measurements will be conducted during the period when production well CW6 is put back into service (discontinue pumping to Bos Creek). The drawdown test will be conducted in cooperation with the City of Wausau. The water levels will be recorded at ten monitoring well locations (W55, W55A, R3S, R3D, W52, R4D, C2S, W53, E21, E21A) using a network of pressure transducer and data loggers. A transducer and data logger will also be installed at Bos Creek, to record surface water fluctuations (Refer to

Subtask 2.2.6). The data loggers will be programmed to record water level measurements at 10 minute intervals. The water level measurements will commence several days prior to production well CW6 being put in service. If possible, production well CW6 will remain unpumped for approximately one week while water levels are recorded. The non-pumping water level measurements will be used to assess antecedent conditions (aquifer recovery) and to evaluate the aquifer response in the vicinity of Bos Creek. Water level measurements will be collected at each of the above mentioned monitoring points for approximately two weeks following production well CW6 being placed back in service. Production well CW3 will be pumped at a constant rate throughout the initial portion of the test so that drawdown due to pumpage of this well does not interfere with determination of the capture zone of production well CW6. After the zone of influence from production well CW6 has reached the maximum extent and water level measurements in the monitoring wells have stabilized production well CW3 will be turned off. Water level measurements will be continued until the recovery from production Well CW3 is no longer observable and water levels appear to have stabilized.

During the course of the test no effort will be made to regulate the pumpage of Production Wells CW7, CW9, CW4. However, the pumping schedule and approximate drawdown at these wells will be recorded several times a day during the test. Continuous record of river levels during the course of the test will be obtained from Wisconsin Valley Improvement Company (WVIC). Record of precipitation and barometric pressure will be obtained from the weather station in Wausau.

The drawdown data will be used to assess the extent of the capture zones from Production Wells CW6 and CW3. The test data will be evaluated in order to determine if hydraulic connection exists between apparent source areas and the municipal production wells.

3.7 - SAMPLING SUMMARY

Table 7 provides a summary of the anticipated sampling that will occur in conjunction with the Phase II investigation at the Wausau NPL site. The table is compiled by subtask and matrix type. The table lists parameters, numbers of samples anticipated, the analyzing lab and the estimated number of QC samples. Fast data turnaround is requested for soil (Subtask 2.2.1 and 2.2.3) and groundwater (Subtask 2.2.1) analyses, in order to fulfill contractual obligations with the U.S. EPA (Refer to Attachment C, Contract 68-01-7401).

3.8 SCHEDULE

The Phase II investigation can be separated into two major tasks; continued groundwater flow and contaminant transport modeling and field investigation. Several of the groundwater flow model alterations are presently being instituted. Additional modifications will be made when preliminary Bos Creek flow measurements have been completed. The contaminant transport calibration process will begin as soon as validated Round II VOC analysis results are received, QA completed, and the data evaluated. The flow and contaminant transport modeling activities will continue throughout the Feasibility Study (FS) and will be used to develop and evaluate remedial alternatives.

With the exception of the Bos Creek flow measurements and the additional rounds of groundwater level monitoring, the Phase II field investigation tasks will require approximately one month to complete. The soil gas survey and soil boring investigation will require approximately 8 days. Gas extraction test well and monitoring probes will also be installed during this time. The soil gas extraction test and test pit excavations will be conducted the following week. The soil gas extraction test at the former City Landfill will require approximately 2 days and will be completed prior to test pit excavations (Subtask 2.2.3). Test pit excavations at the former landfill will be performed while the soil gas extraction test is conducted at Wausau Chemical. Groundwater and surface water sampling will require approximately two weeks to complete and will be conducted before the other Phase II tasks have been completed. The drawdown test will require approximately 1 month to complete and will be conducted concurrently with the soil boring, test pit and sampling programs. The Bos Creek flow measurements will be conducted over a three month period and will begin as soon as practical. The stream elevation monitoring interval will be increased during the drawdown test (Subtask 2.2.8). The Phase II investigation schedule is summarized in Figure 9.

Fast data turnaround of soil and groundwater analyses have been requested so that results of the Phase II investigation can be incorporated into the RI report.

4.0 PROJECT ORGANIZATION

With the exception of the following, Section 4.0 of the QAPP (Project Organization) remains unchanged.

4.1 Overall Responsibility

Mark Giesfeldt will represent the WDNR as State Project Manager. Kevin Adler will temporarily replace Margaret Guerriero as U.S. EPA Project Officer.

4.3 Laboratory Analysis and QC

Alkalinity, chloride, sulfate, nitrate+nitrite-nitrogen, TKN, TOC, calcium, magnesium, sodium, potassium, and iron will not be sampled or analyzed during the Phase II investigation.

QAPP ELEMENT 5.0 - QUALITY ASSURANCE OBJECTIVES

Quality assurance objectives for Sections 5.0 through 5.3 generally remain unchanged. The level of quality control effort for field sampling, analysis and field measurements will be maintained according to guidelines in the approved QAPP (dated September, 1987). The majority of groundwater surface water, sediment and soil samples collected during Subtasks 2.2.1, 2.2.3, 2.2.4 and 2.2.5 will be submitted for analysis by the Contract Laboratory Program (CLP). The QA goals of routine analyses (RAS) are established under guidelines stated in IFB WA-87-K236/K237/K238 for organics and WA-87-K025/K026/K027 for inorganics (Refer to Appendix B for contract required detection limits). Goals for CLP Special Analytical Services (SAS) requests are listed with methods descriptions in Appendix D. The QA goals of the analytical measurements conducted by Warzyn in the field are summarized in Section 5.1.C of the original QAPP. Procedures for the operation and maintenance of the field GC have been modified and are presented in Appendix F.

5.4 Field Measurements (for which samples are not collected)

Several tasks which were not included in the original QAPP have been added to the Phase II investigation. These tasks will result in the acquisition of data through field measurements. The field data will be utilized for a variety of purposes (summarized in Table 10). The general QC objectives for such measurements are to obtain reproducible and comparable measurements to a degree of accuracy consistent with the intended use of data through the documented use of standardized procedures. The additional tasks and specific level of QC include, but are not limited to, the following:

Soil Gas Extraction Testing

The level of QA effort for gas extraction testing will consist of calibration as needed for the gas tech combustible gas/oxygen meter. The Alnor velometer and Dwyer magnetic pressure gages are internally calibrated by the manufacturer. These equipment will be operated according to manufacturers specifications (Appendix K). The level of QA effort in determining soil gas VOC concentrations will consist of collecting 1 soil gas blank and 1 duplicate for every 10 investigative samples.

Test Pit Excavations

The level of QA effort for test pit excavations will consist of daily HNu calibration. The test pit excavations will also be video taped so that field logs may be cross checked at a later date to assure completeness.

Bos Creek Discharge Measurements

Current meters (Price, pygmy) used to determine surface water flow velocity are individually calibrated in the rating flume at the National Bureau of Standards. Stream elevation data obtained from the transducer and data logger will be cross checked against a staff gage located adjacent to the transducer. Data collected during a period in which the transducer values vary by more than 2 percent from observed levels will be considered unusable.

Drawdown Testing

The QA of data obtained from pressure transducers and data loggers installed at site monitoring wells will be maintained by cross checking observed water level data against the pressure transducer record values. If observed values differ by more than 1% of the data logger recorded value, the system will be recalibrated and the data collected during that interval will be considered unusable.

QAPP Element 6.0 - Sampling Procedure is changed to the following: Procedures to sample soil, sediment, surface water, groundwater are described in the original Sampling Plan and as subsequently revised for the Phase II Field Investigation (Appendix A). Containers, preservatives, holding times, transport and storage methods are summarized in Table 3 (Phase I) and in Table 9 (Phase II). Additional sample volumes (3x) will be taken for matrix spike/matrix duplicate analysis at a frequency of 1 per 20 samples. Trip blanks will be collected at (2x) the sample volume for each shipment container of liquid samples targeted for VOC analyses.

QAPP Element 7.0 - Sample and Document Custody Procedures remains unchanged.

QAPP Element 8.0 - Calibration Procedures, Frequency and Preventative maintenance for Field Instruments text remains unchanged. Appendix F Field Analysis of volatile organics has been modified according to methods used in the Phase I investigation.

QAPP Element 9.0 - Analytical Services, Subelement 9.2 - CLP SAS, A. Analytical and Calibration Procedures
Soil samples collected during Phase II subtasks 2.2.1 and 2.2.3 will be analyzed for the complete CLP HSL target compound list (Tables A-1 and A-2) using Routine Analytical Services methods with fast turnaround. Groundwater and surface water samples collected during Subtasks 2.2.1, 2.2.4 and 2.2.5 will be submitted to the CLP for VOC analyses using low detection GC/MS with fast turnaround. An additional twenty-three (23) groundwater samples collected from potential source areas and impacted production wells will be submitted to the CLP for TCL analyses using RAS methods with fast turnaround.

Analytical procedures for samples analyzed by SAS are specified in SAS-Regional Request Forms found in Appendix D. Calibration of instruments will follow procedures specified in analysis methods on the SAS requests. The remainder of QAPP Element 9.0 remains unchanged.

QAPP Element 10.0 - Quality Assurance Reports remains unchanged.
The following tables are added to the QAPP specifically for performance of the Phase II investigation.

Table 6 - Proposed soil boring and soil gas survey location rationale.

Table 7 - Summary of Sampling and Analysis Program Wausau NPL Site, Phase II Investigation.

Table 8 - Proposed Round 3 Sample Locations Wausau Water Supply NPL site

Table 9 - Sample Quantities, Bottles, Preservatives and Packaging for Soil and Water Samples collected during Phase II, Wausau Water Supply NPL Site

Table 10- Phase II Site Investigation Activity Summary

Appendices B and C remain unchanged. Appendix A - Sampling Plan has been revised to address Phase II field activities.

Appendix D - SAS requests for Phase II have been modified to reflect changes in sample numbers and in the requested analytical methods.

Appendix F has been revised to reflect modifications of field GC methods.

Appendix I - Health and Safety Addendum has been added in order to address potential health concerns associated with the test pit investigation. The original health and safety plan remains unchanged for site drilling and sampling activities.

CSR/jpl
[jpl-602-88]

TABLE 6
PROPOSED SOIL BORING DEPTH AND RATIONALE
WAUSAU NPL SITE
PHASE II INVESTIGATION

Boring Number	Anticipated Number of Soil Gas Samples	Estimated Depth (feet)	Rationale
West Study Area			
B1	2	15	Investigate potential sources of VHHs within the former landfill.
B2	2	15	Investigate potential sources of VHHs within the former landfill
B3	4	30	Investigate potential sources of VHHs within the former landfill
B4	2	10	Investigate potential sources of VHHs within the former landfill
B5	4	25	Investigate potential sources of VHHs within the former landfill
B6	4	30	Investigate potential sources of VHHs within the landfill and install gas monitoring probes
B7	3	20	Investigate potential sources of VHHs within the landfill and install gas monitoring probes
B8	3	20	Investigate potential sources of VHHs within the landfill and install gas monitoring probes
B9	2	10	Investigate potential sources of VHHs within the former landfill
B10	4	25	Investigate potential sources of VHHs within the former landfill and install gas extraction test well.

TABLE 6
PROPOSED SOIL BORING DEPTH AND RATIONALE
WAUSAU NPL SITE
PHASE II INVESTIGATION

Boring Number	Anticipated Number of Soil Gas Samples	Estimated Depth (feet)	Rationale
B11	2	15	Investigate potential sources of VHHs within the landfill and install gas monitoring probes
B12	2	15	Investigate potential sources of VHHs within the landfill and install gas monitoring probes
B13-B16	4(EA)	30(EA)	Investigate potential sources of VHHs at the Marathon Electric facility.
East Study Area			
B17	2	15	Determine extent of elevated soil gas concentrations at Wausau Chemical, in the vicinity of the February 1983 PCE release.
B18	2	15	
B19	2	15	
B20	2	15	Delineate PCE soil contamination discovered at Boring E34 during the Phase I investigation
B21	2	15	
B22	2	15	Characterize residual PCE in unsaturated zone at the former Wausau Chemical bulk tank farm and install soil gas monitoring probe.
B23	2	15	
B24	2	15	
B25	2	15	Install gas extraction well.
B26	2	15	Discretionary soil borings location to be determined on-site.
B27	2	15	
B28	2	15	Investigate VHHs and petroleum related VOCs present in the unsaturated zone at the Wausau Energy facility.
B29	2	15	
B30	2	15	
	78	560 feet	

CSR/jpl/DFK
[jpl-402-24]

TABLE 7
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM (WAUSAU, PHASE II)

Matrix	Field Parameters	Lab	No. of Samples	No. of Duplicates	No. of Blanks	No. of MS/MSD	Matrix Total	Test Parameters
Groundwater (new and existing wells, Subtask 2.2.4)	pH, specific conductivity, temp, water level	CLP(SAS)	90	9	9	5	108	VOC
		CLP(RAS)	23	3	3	2	29	VOC
		CLP(RAS)	23	3	3	2	29	BNA
		CLP(RAS)	23	3	3	2	29	PEST/PCB's
		CLP(RAS)	23	3	3	2	29	metals
		CLP(RAS)	23	3	3	2	29	cyanide
Surface Water (Subtask 2.2.5)	pH, specific conductivity, creek elevation, flow velocity	CLP(SAS)	4	1	1	1	6	VOC
Soil Gas (Subtsk 2.2.1)	On-site GC VOC screen	Field GC	78	9*	8*	*	94	VOC
Soil Gas Extraction Test (Subtask 2.2.2)	VOC screen On-site GC Oxygen, methane pressure, temp gas flow velocity	Field GC	24	3	3	*	28	VOC
Groundwater (during drilling, Subtask 2.2.1)	On-site GC	Field GC	9	1*	1*	*	11	VOC
		CLP(SAS)	9	1	1	1	11	VOC
Soil (soil borings) Subtask 2.2.1 Phase II	VOC screen using PID	CLP(RAS)	25	3	2	2	30	VOC
		CLP(RAS)	25	3	2	2	30	BNA
		CLP(RAS)	25	3	2	2	30	metals/CN
Soil (Test Pits) (Subtask 2.2.3)	VOC screen using PID	CLP(RAS)	18	2	2	1	22	VOC
		CLP(RAS)	18	2	2	1	22	BNA
		CLP(RAS)	18	2	2	1	22	PEST/PCB's
		CLP(RAS)	18	2	2	1	22	metals/CN
Waste (Test Pits) (Subtask 2.2.3)	VOC screen using PID	CLP(RAS)						VOC
		CLP(RAS)						BNA
		CLP(RAS)		To be determined in the field				PEST/PCB's
		CLP(RAS)						metals
		CLP(RAS)						cyanide
Sediment (Subtask 2.2.5)	VOC screen using PID	CLP(RAS)	4	1	0	1	5	VOC

*Duplicates, blanks and spikes will be analyzed on a per day basis for on-site GC analyses as outlined in Appendix F.

***The matrix total column does not include matrix spike/matrix spike duplicates.

TABLE 7 (Cont)
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
WAUSAU NPL SITE
[illegible]

1) Samples are to be considered low concentration

2) Field parameters run by Warzyn sampling personnel.

3) Contract Laboratory Program, RAS, SAS

4) Triple the sample volume will be collected for matrix spike/matrix spike duplicate analysis samples. (Liquid organic samples)

5) The matrix spike/matrix spike duplicate samples are at a frequency of one per twenty or fewer investigative samples.

6) Field blank numbers are estimated. Actual numbers may vary based on field conditions.

7) Groundwater samples targeted for Target Compound list (TCL) metals analysis will be field filtered immediately after collection, prior to preservation.

8) Two trip blanks (*one* analyzed) will be submitted with each shipment of samples targeted for liquid VOC analyses.

SGW/jpl/CSR
[jpl-402-23]

TABLE 8
PROPOSED ROUND 3 SAMPLE LOCATIONS
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

City Production Wells (5)
CW3
CW4
CW6
CW7
CW9

U.S. EPA RI/FS Installed Monitoring Wells (30)

E20
E21, E21A
E22, E22A
E23A
E24, E24A
E25, E25A
E26, E26A
E27
E28A
E29A
E30
E31
E37A
W50
W51
W52, W52A
W53, W53A
W54
W55, W55A
W56, W56A
W57

Previously Existing Monitoring Wells (38)

East

WC1 (to be repaired)
WC2
WC3, WC3A, WC3B, WC3C
WC5, WC5A
MW10A, MW10B
MW11
MW13
FVD2
FVD7
GM9S

TABLE 8, Continued
PROPOSED ROUND 3 SAMPLE LOCATIONS
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

MW14
GM6D
GM5D
GM8D
WERGIN
MW7A
WW2
TCT40

<u>West</u>

C6S
C4S, C4D
C3S
C2S
C7S
R4D
R3S
R3D
R2S, R2D
R5S (Marathon Electric Wells
R6S installed January, 1987)
R7S
MW7

Wausau Chemical Extraction Wells

Five (5) pumping extraction wells located on south side of Wausau Chemical.

CSR/jpl/DFK
[jpl-402-22]

TABLE 9

SAMPLE QUANTITIES, BOTTLES, PRESERVATIVES AND PACKAGING FOR SOIL, SEDIMENT AND WATER SAMLES FROM WAUSAU NPL SITE

Analysis	Bottles and Jars	Preservation	Holding time	Volume of Samples	Shipping	Normal Packaging
WATER AND LIQUIDS						
Routine Analytical Services (RAS) Low or Med Concentration (Organics)						
Acid Extractables, base/neutral extractables, pesticides/PCBs	Two 1/2-gallon amber bottles (teflon-lined caps)	Iced to 4°C	5 days until extraction	Fill bottle to neck	Federal Express Priority I (Med w/attached shipper's certificate for restricted articles)	No. 1 foam liner or vermiculite (Med in Cans/ vermiculite
Low or Med Concentration (Inorganics)						
Metals	**One 1-liter high density polyethylene bottle**	**Filter through 0.45 um filter 1:1 HNO_3 to pH<2 Iced to 4°C**	**6 months (Hg 26 days)**	**Fill to shoulder of bottle**	**Federal Express Priority I (Med w/attached shipper's certificate for restricted articles)**	**No. 2 foam liner or vermiculite (Med in Cans/ vermiculite**
Cyanide	One 1-liter high density polyethylene bottle	6N NaOH to pH>12 Iced to 4°C	14 days	Fill to shoulder of bottle	Federal Express Priority I (Med w/attached shipper's certificate for restricted articles)	No. 2 foam liner or vermiculate (Med in Cans/ vermiculite)
High Hazard Samples						
Liquid Samples Organic and Inorganic	**One 8 oz Wide Mouth Jar**	**None**		3/4 Full	Federal Express Priority I (w/attached shipper's certificate for restricted articles)	No. 2 foam liner or vermiculate (in Cans/ vermiculite)

TABLE 9 (cont.)

SAMPLE QUANTITIES, BOTTLES, PRESERVATIVES AND PACKAGING FOR SOIL, SEDIMENT AND WATER SAMPLES FROM WAUSAU NPL SITE

Analysis	Bottles and Jars	Preservation	Holding time	Volume of Samples	Shipping	Normal Packaging
Special Analytical Services (SAS) Water Low Concentration (Organics)						
Volatiles	Two 40-ml volatile organic analysis (VOA vials)	Iced to 4°C	7 days	Fill completely no headspace	Delivered daily to performing laboratory	No. 1 foam liner or vermiculite
Low Concentration (Inorganics)						
TKN, TOC, Nitrate + Nitrite-N NH_3	One 1-liter high density polyethylene bottle	1 ml/l 1:1 H_2SO_4 Iced to 4°C	28 days	Fill to shoulder of bottle	Federal Express Priority I	Vermiculite
Sulfate, Chlorides, Alkalinity	One 1-liter high density polyethylene	Iced to 4°C	28 days (14 days for alkalinity)	Fill to shoulder of bottle	Federal Express Priority I	No. 2 foam liner or vermiculite
Metals	One 1-liter high density ployethylene	Filtered through 0.45 um filter, 1:1 HNO_3 to pH<2 Iced to 4°C	16 months Hg 30 days	Fill to shoulder of bottle	Deliver daily to performing Laboratory	Vermiculite
SOILS AND SOLIDS						
Routine Analytical Services (RAS) Low or Med Concentration (Organics)						
Volatiles	Two 120-ml VOA vials	Iced to 4°C	7 days	Fill completely no headspace	Federal Express Priority I (Med w/attached shipper's certificate for restricted articles)	Vermiculite (Med in cans/ vermiculite)
High Hazard Samples						
Solid or Sludge Samples Organic and Inorganic	One 8 oz Wide Mouth Jar	None		3/4 Full	Federal Express Priority I (w/attached shipper's certificate for restricted articles)	No. 2 foam liner or vermiculate (in Cans/ vermiculite)

TABLE 10
PHASE II SITE INVESTIGATION ACTIVITY SUMMARY
WAUSAU WATER SUPPLY, NPL SITE
WAUSAU, WISCONSIN

Activity	Subtask No.	Type*	Anticipated No. of Investigative Samples	Description	Results	Utilization Of Data
Soil Gas Survey	2.2.1	FA	94 soil gas	Soil gas samples will be collected through soil borings performed at suspected source areas. The soil gas survey will be conducted simultaneously with the soil boring program.	Vertical profile of soil gas VOC concentration variations with depth. Isoconcenttration contour maps of soil gas distribution in source areas.	1. Selection of soil samples for CLP analysis. 2. Determine test pit locations. 3. Determine locations and depth intervals for gas monitoring probes and extraction wells.
Soil Boring Investigation	2.2.1	FA, LA, IM	28 soil samples 11 Groundwater	Approximately 30 soil borings will be conducted at suspected source areas. Soil samples and soil gas samples will collected during boring advancement. Groundwater samples will be collected from approximately 9 of the borings. Gas monitoring probes and extraction wells will be installed in approximately 12 borings.	Soil boring logs, VOC analysis of soil samples, VOC analysis of groundwater samples, installation of gas monitoring probes and extraction wells.	1. Estimate vertical extent of unsaturated zone contamination. 2. Determine test pit locations. 3. Assess shallow groundwater impact beneath suspected source areas.
Soil Gas Extraction Treatability Study	2.2.2	FA, IM	±28 soil samples	Soil gas extraction tests will be conducted at the former City landfill and at Wausau Chemical to evaluate the effectiveness of enhanced volatilization as a potential remedial alternative.	Wellhead gas velocities, wellhead and probe pressures soil gas contaminant concentrations.	1. Determine maximum possible extraction rate and radius of influence. 2. Determine contaminant removal rate.
Test Pit Investigation	2.2.3	FA, IM, LA	20 soil samples Possible High Hazard Residue Samples	The test pit investigation will be conducted at the former City landfill to characterize waste materials and to identify the source of VHH contamination found in soil gas and soil samples collected during the Phase I investigation.	Visual description of waste materials, VOC analysis of soil/residue samples. Determination of the limits of fill.	1. Characterize potential source area in order to determine health risks and to assess potential remedial alternatives.
Round 3 Groundwater Sampling	2.2.4	IM, LA, FA	108 groundwater samples (GC/MS) 29 TCL groundwater samples	Groundwater samples will be collected from approximately 90 locations. Samples will be submitted to the CLP for analysis of VOCs by GC/MS (SAS), 23 samples will be submitted to the CLP for analysis of Target Compound List parameters.	Groundwater concentrations of VOCs and and TCL parameters at selected monitoring wells.	1. Verify analytical results obtained during Phase I samplings. 2. Supply data for the Endangerment Assessment (EA)

TABLE 10
PHASE II SITE INVESTIGATION ACTIVITY SUMMARY
(Continued)

	Subtask No.	Type	Anticipated No. No. of Investigative samples	Description	Results	Utilization of Data
Surface Water and Sediment Sampling	2.2.5	LA	6 sediment & (RAS) surface water (SAS) samples analyzed for VOCs	Surface water and sediment samples will be collected from 4 locations on Bos Creek in order to determine the effect of CW6 discharge on surface water quality.	Surface water VOC concentrations, sediment VOC concentrations.	1. Determine effect of Production Well CW6 discharge on Bos Creek water quality. 2. Determine temporal variation of VOC concentrations in surface water.
Bos Creek Flow Measurements	2.2.6	IM		Stream elevation and flow velocity measurements will be conducted at two locations on Bos Creek in order to estimate induced surface water recharge of the aquifer.	Continuous record of creek elevation, intermittent measurement of flow velocity, estimate of surface water discharge at two locations.	1. Estimate induced surface water recharge from Bos Creek into the aquifer. 2. Quantify the effect of CW6 discharge on surface water VOC concentrations. 3. Monitor surface water levels during drawdown tests (Subtask 2.2.8).
Water Level Measurements	2.2.7	IM		Four rounds of groundwater and surface water levels will be measured at site monitoring wells, production wells and staff gages.	Groundwater elevations, potentiometric maps and cross-sections.	1. Evaluate the effect of of municipal well pumpage and river stage fluctuations on groundwater flow.
Drawdown Testing	2.2.8	IM		Continuous water level measurements will be conducted at ten (10) monitoring wells in order to assess drawdown resulting from the pumpage of production wells CW6 and CW3.	Time vs. drawdown plots of site monitoring and production wells.	2. The data will also be used to assess the influence of induced surface water recharge on groundwater flow in the vicinity of Box Creek.

Type FA = Field Analysis
LA = Lab Analysis
IM = In Situ Measurement

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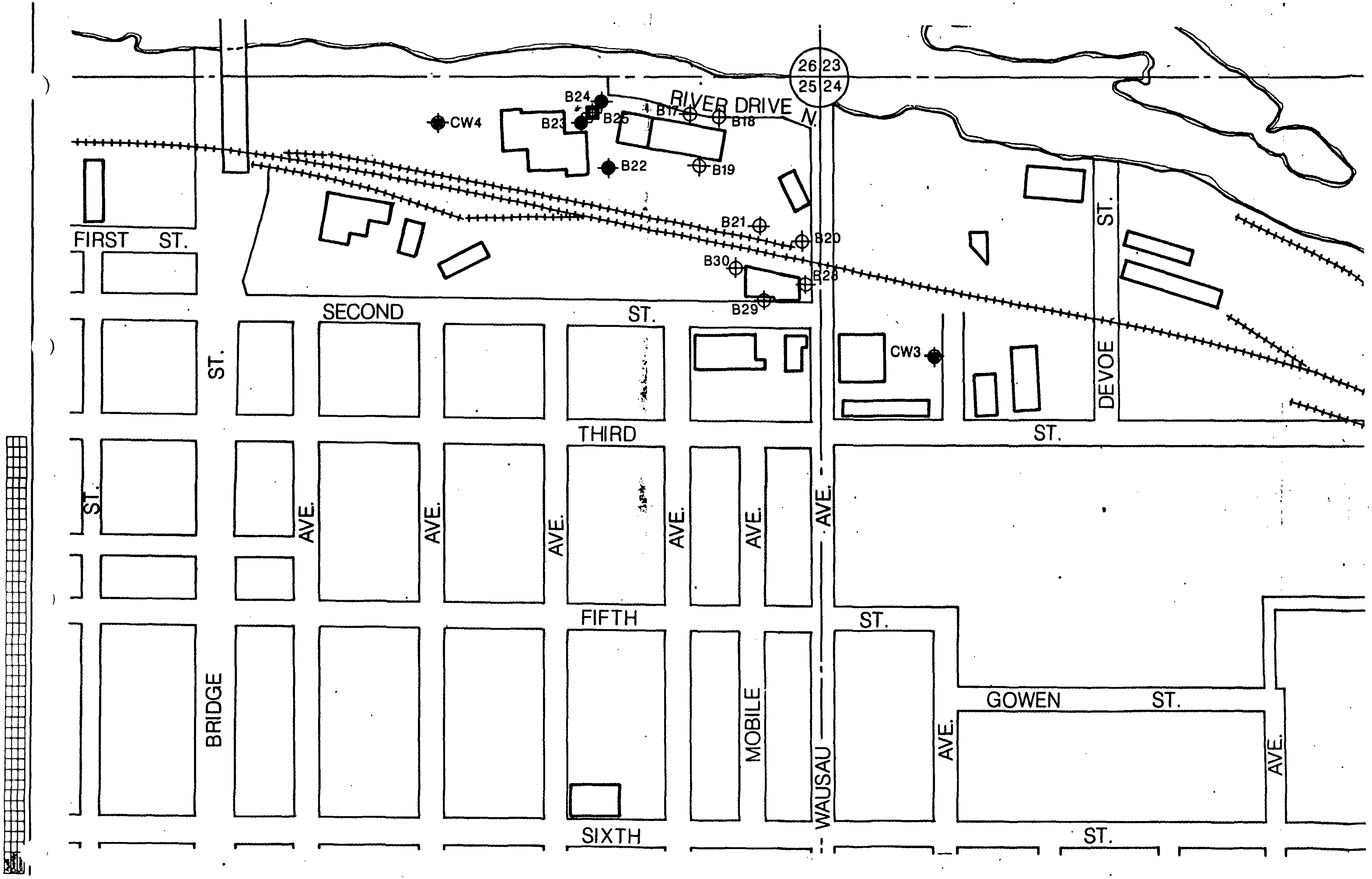


LEGEND

B17 ⊕ PROPOSED SOIL B

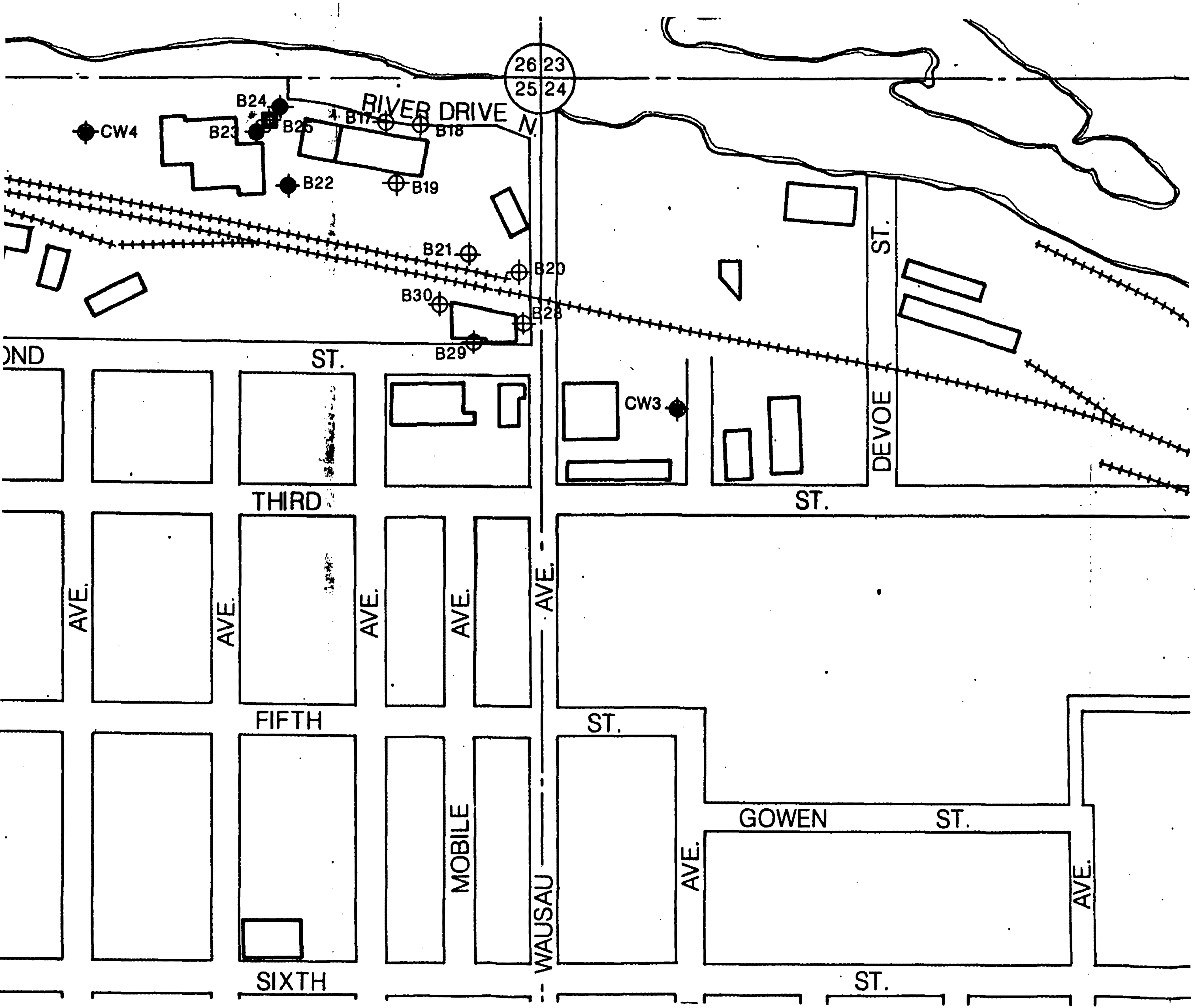
CW3 ● PRODUCTION WELL

B14 ● PROPOSED SOIL B
PROBE LOCATION

B21 ▪ PROPOSED GAS EX

NOTES

1. REFER TO TABLE 6 FOR A
SOIL BORING DEPTHS AND
THE BORINGS.
2. TWO ADDITIONAL BORING L
IN THE FIELD BASED ON T
AND FIELD GAS CHROMATOG
3. SOIL GAS SAMPLES WILL B
AND 10 FEET.



LEGEND

B17 ⊕	PROPOSED SOIL BORING LOCATION AND NUMBER
CW3 ●	PRODUCTION WELL LOCATION AND NUMBER
B14 ●	PROPOSED SOIL BORING WITH PERMANENT GAS MONITORING PROBE LOCATION AND NUMBER
B21 ■	PROPOSED GAS EXTRACTION WELL LOCATION AND NUMBER

NOTES

1. REFER TO TABLE 6 FOR A SUMMARY OF ANTICIPATED SOIL BORING DEPTHS AND RATIONALE FOR CONDUCTING THE BORINGS.
2. TWO ADDITIONAL BORING LOCATIONS WILL BE DETERMINED IN THE FIELD BASED ON THE SOIL GAS SURVEY RESULTS AND FIELD GAS CHROMATOGRAPH ANALYSIS OF SOIL SAMPLES.
3. SOIL GAS SAMPLES WILL BE COLLECTED AT DEPTHS OF 5 AND 10 FEET.

PROPOSED SOIL BORING LOCATIONS
EAST STUDY AREA
QUALITY ASSURANCE PROJECT PLAN ADDENDUM
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

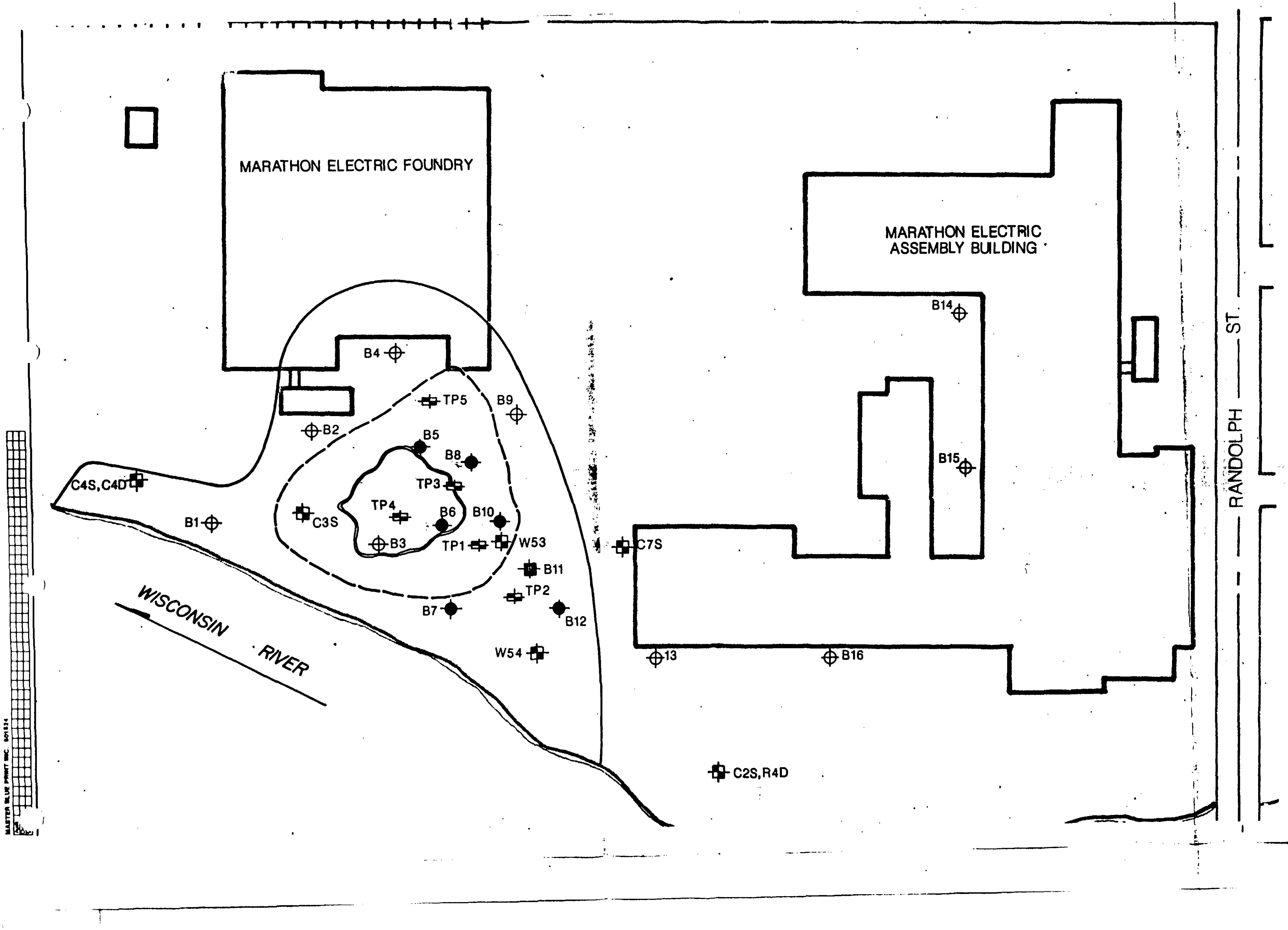
WARZYN
WARZYN ENGINEERING INC
Madison · Milwaukee
Minneapolis · Chicago
Detroit

Designed by
Approved by Ken Quinn
Drawn by JC
Checked by DBC
Date 6/15/88
Scale 1" = 200' (APPROXIMATE)
Reference

Sheet Number 1 OF 3
Project Number 13076 B31

WARZYN

FIGURE 13

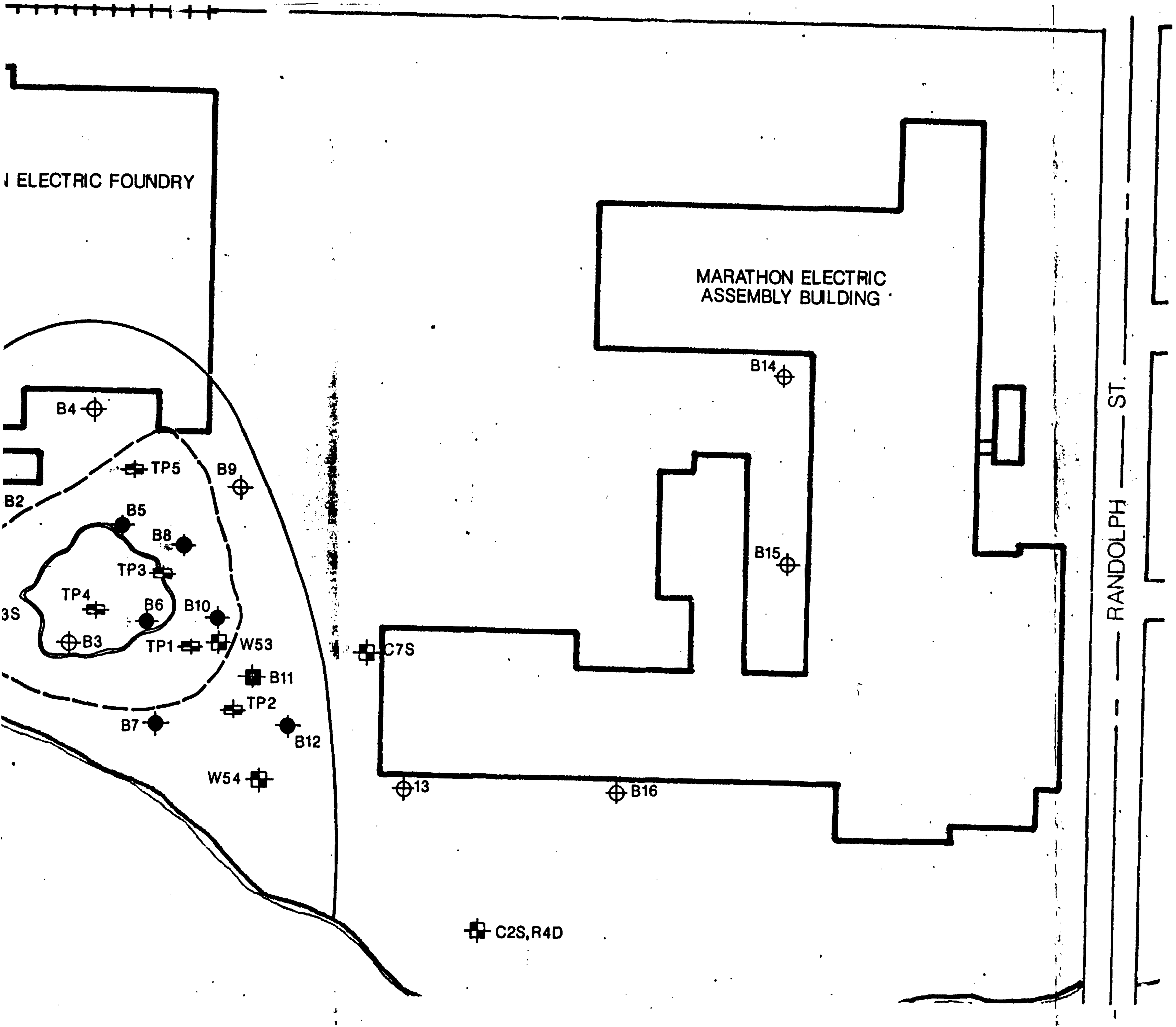


LEGEND

W53	MONITORING
B1	PROPOSED SO
B10	PROPOSED SO PROBE LOCAT
B11	PROPOSED GA
TP1	PROPOSED TE
———	LIMITS OF 9/28/48)
— —	FORMER SAND BASED ON A
∼	MAXIMUM LA THE SAND A WATER TABLE 9/28/48

NOTES

1. SOIL BORING DEPTHS
BASED ON THE LANDF
2. TEST PIT EXCAVATIO
15 TO 20 FEET.
3. AN ADDITIONAL 3 TE
BASED ON RESULTS O
4. TWO ADDITIONAL BOR
AREAS) DETERMINED
SURVEY RESULTS AND
SOIL SAMPLES.
5. SOIL GAS SAMPLES W
DURING DRILLING.



LEGEND

W53 ⊞	MONITORING WELL LOCATION AND NUMBER
B1 ⊕	PROPOSED SOIL BORING LOCATION AND NUMBER
B10 ●	PROPOSED SOIL BORING WITH PERMANENT GAS MONITORING PROBE PROBE LOCATION AND NUMBER
B11 ■	PROPOSED GAS EXTRACTION WELL LOCATION AND NUMBER
TP1 ⊟	PROPOSED TEST PIT LOCATION AND NUMBER
———	LIMITS OF FILL (BASED ON AERIAL PHOTOGRAPHY DATED 9/28/48)
— —	FORMER SAND AND GRAVEL PIT EXCAVATION ESCARPMENT BASED ON AERIAL PHOTOGRAPHY DATED 9/28/48
〰	MAXIMUM LANDFILL THICKNESS BASED ON LOCATIONS WHERE THE SAND AND GRAVEL OPERATIONS HAD EXCAVATED INTO WATER TABLE (BASED ON AERIAL PHOTOGRAPHY DATED 9/28/48

NOTES

1. SOIL BORING DEPTHS WILL BE DETERMINED IN THE FIELD BASED ON THE LANDFILL THICKNESS.
2. TEST PIT EXCAVATION DEPTHS ARE PLANNED TO BE BETWEEN 15 TO 20 FEET.
3. AN ADDITIONAL 3 TEST PIT LOCATIONS WILL BE SELECTED BASED ON RESULTS OF THE SOIL BORING/SOIL GAS SURVEY.
4. TWO ADDITIONAL BORING LOCATIONS (EAST AND/OR WEST STUDY AREAS) DETERMINED IN THE FIELD BASED ON THE SOIL GAS SURVEY RESULTS AND FIELD GAS CHROMATOGRAPH ANALYSIS OF SOIL SAMPLES.
5. SOIL GAS SAMPLES WILL BE COLLECTED ON 10 FOOT INCREMENTS DURING DRILLING.

PROPOSED SOIL BORING AND TEST PIT LOCATIONS WEST OF STUDY AREA

QUALITY ASSURANCE PROJECT PLAN ADDENDUM
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

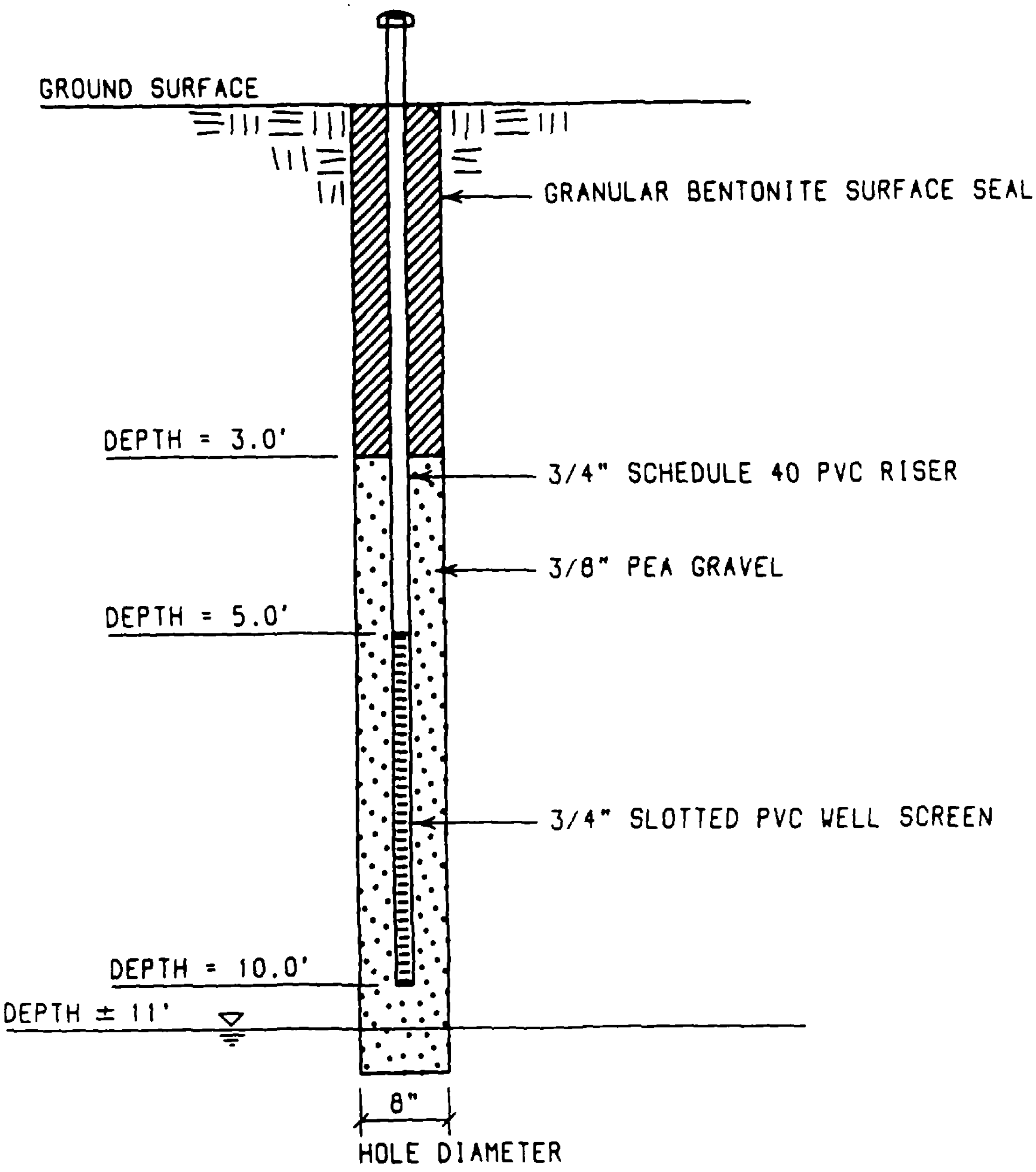
WARZYN
WARZYN ENGINEERING INC.
Madison · Milwaukee
Minneapolis · Chicago
Detroit

Designed By
Drawn By JC
Checked By CSC
Approved By Ken Quinn
Date 6/15/88
Scale 1" = 100' (APPROXIMATE)
Reference

Sheet Number
2 OF 3
Project Number
13076 B32

WARZYN

FIGURE 14



NOT TO SCALE

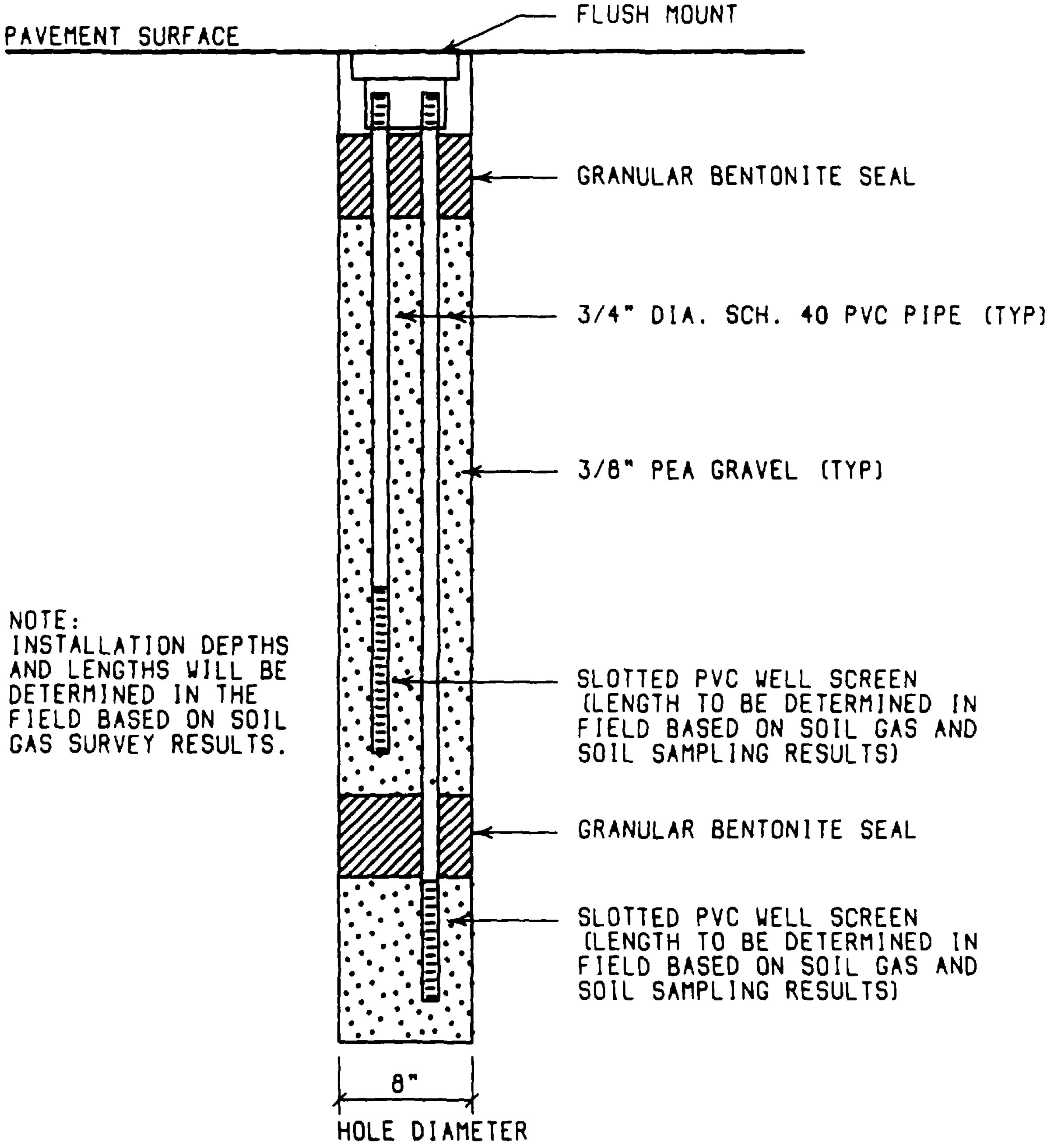
FIGURE 15

PROPOSED GAS MONITORING PROBE INSTALLATION DIAGRAM-E. STUDY AREA

QUALITY ASSURANCE PROJECT PLAN ADDENDU
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WARZYN

DWN ALH	APP'D	DATE 6/15/88	13076	A17



NOTE:
INSTALLATION DEPTHS AND LENGTHS WILL BE DETERMINED IN THE FIELD BASED ON SOIL GAS SURVEY RESULTS.

NOT TO SCALE

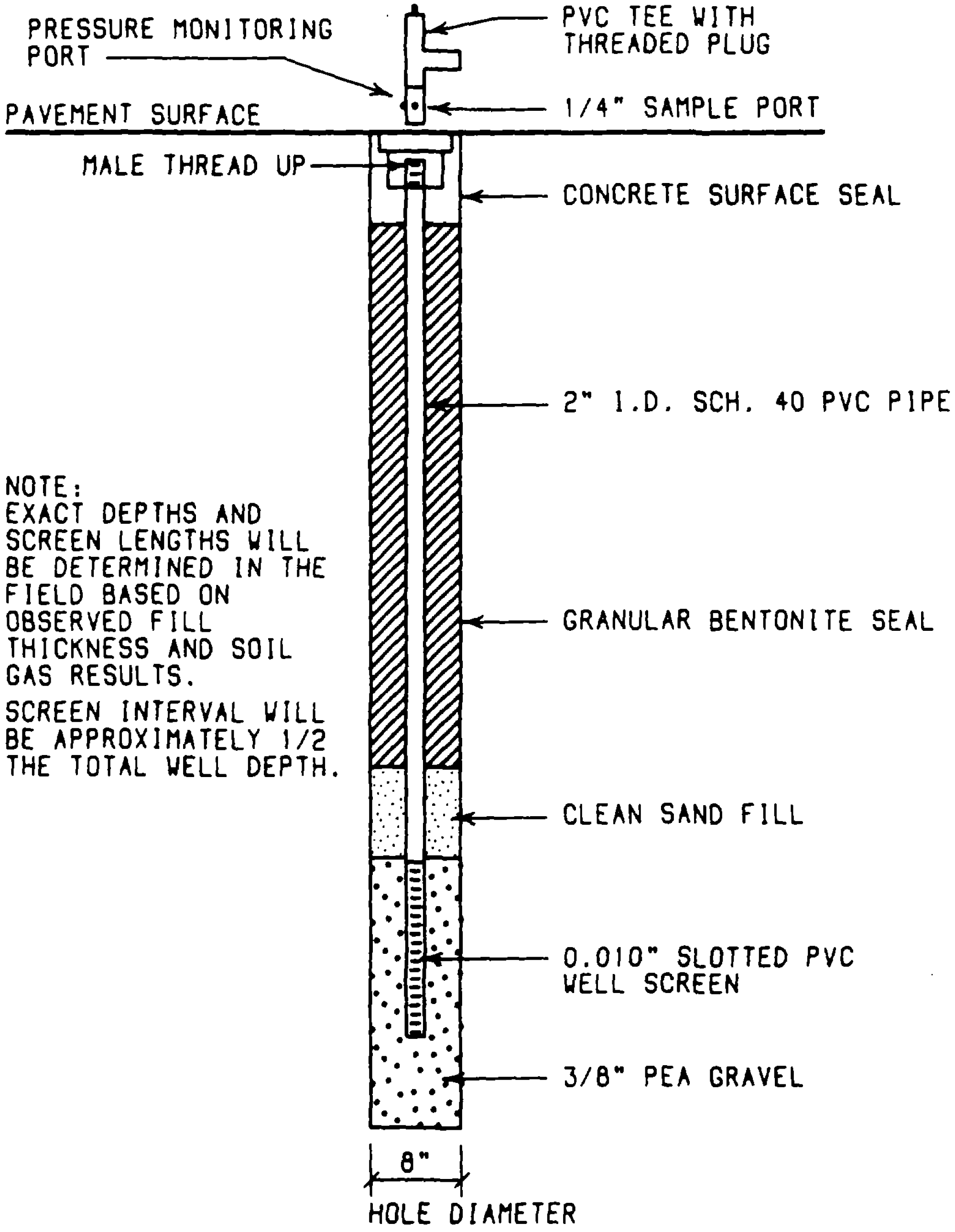
FIGURE 16

WARZYN

PROPOSED GAS PROBE NEST DETAIL

QUALITY ASSURANCE PROJECT PLAN ADDENDU
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

DWN ALH	APP'D	DATE 6/15/88	13076	A18



NOTE:
EXACT DEPTHS AND SCREEN LENGTHS WILL BE DETERMINED IN THE FIELD BASED ON OBSERVED FILL THICKNESS AND SOIL GAS RESULTS.

SCREEN INTERVAL WILL BE APPROXIMATELY 1/2 THE TOTAL WELL DEPTH.

NOT TO SCALE

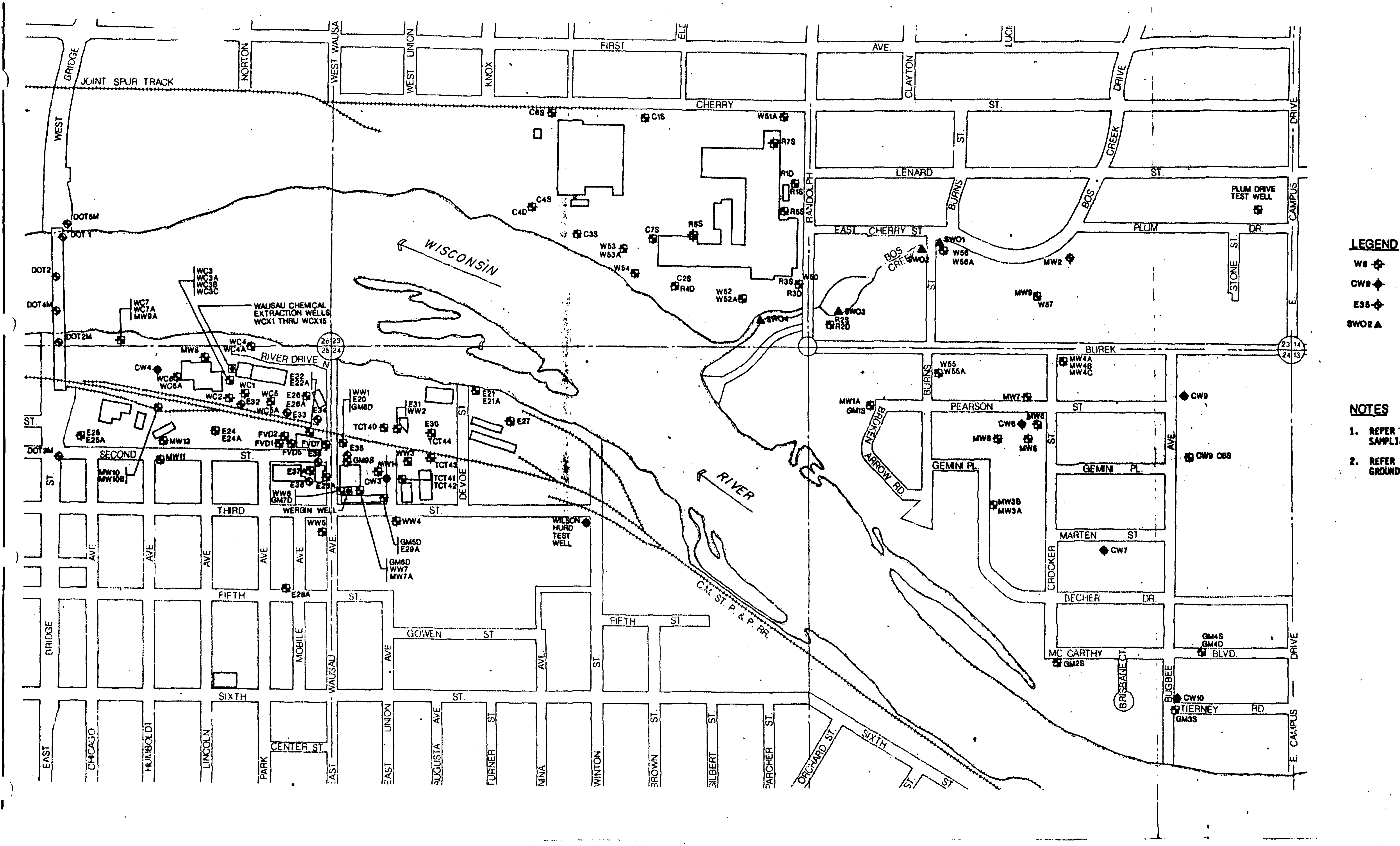
FIGURE 17

CONCEPTUAL GAS EXTRACTION TEST WELL

QUALITY ASSURANCE PROJECT PLAN ADDENDUM
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WARZYN

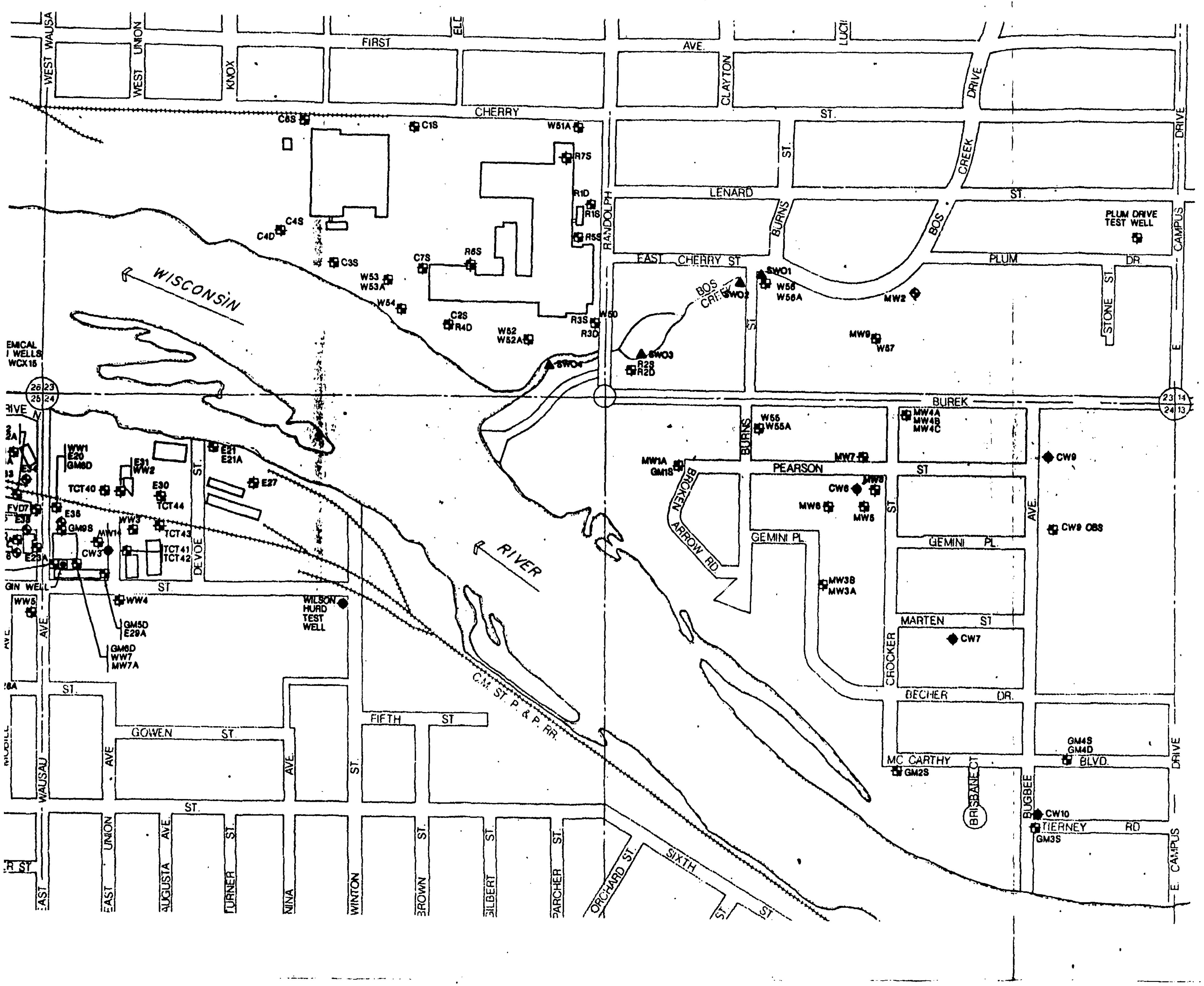
DWN ALH | APP'D | DATE 6/15/88 | 13076 | A19



NOTES

1. REFER
SAMPLI

2. REFER
GROUND



LEGEND

W6 ⊕	MONITORING WELL LOCATION AND NUMBER
CW9 ◆	PUMPING MUNICIPAL WELL LOCATION AND NUMBER
E35 ⊕	SOIL BORING LOCATION AND NUMBER
SWO2 ▲	SURFACE WATER SAMPLING LOCATION AND NUMBER

NOTES

1. REFER TO TABLE 7 FOR A SUMMARY OF PROPOSED SAMPLING AND ANALYSIS.
2. REFER TO TABLE 8 FOR A SUMMARY OF ROUND 3 GROUNDWATER SAMPLE LOCATIONS.

FIGURE 18

PROPOSED ROUND 3 SAMPLING LOCATIONS

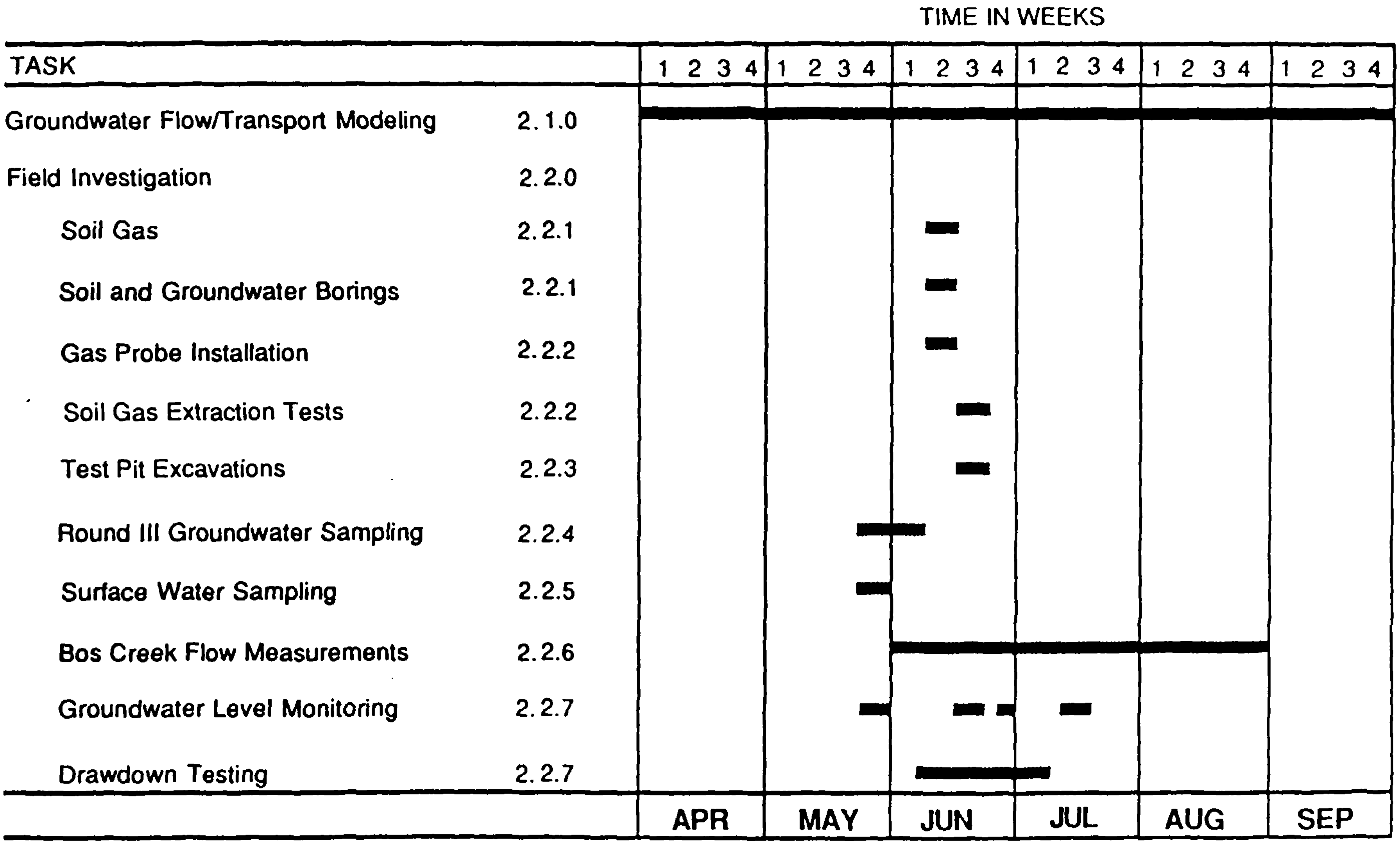
QUALITY ASSURANCE PROJECT PLAN ADDENDUM
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN

WARZYN
WARZYN ENGINEERING INC
Madison · Milwaukee
Minneapolis · Chicago
Detroit

Drawn by JC
Checked by CSR
Approved by Ken Quinn
Date 6/15/88
Scale 1" = 400' (APPROXIMATE)

Sheet Number 3 OF 3
Project Number 13076 B33
WARZYN

FIGURE 19
PROPOSED SCHEDULE PHASE II WORK PLAN
WAUSAU WATER SUPPLY NPL SITE
WAUSAU, WISCONSIN



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APPENDIX A
SAMPLING PLAN
WAUSAU WATER SUPPLY
NPL SITE
13070.16

I. OBJECTIVE

This document describes the procedures and practices to be used in obtaining groundwater, soil and soil gas samples for the Phase II investigation of the Wausau Water Supply, NPL Site, RI/FS. This document is an addendum to the original Sampling Plan document dated September, 1987.

II. SAMPLING LOCATIONS AND NUMBER OF SAMPLES

A. SAMPLING LOCATIONS

Groundwater, soil and soil gas samples will be collected at various locations in the vicinity of the Wausau Well Field. Specific locations and numbers of samples to be obtained are listed in the Phase II Work Plan. A summary of sample numbers and required numbers of quality control samples are presented in Table 7 of the supplemental QAPP.

B. SOIL SAMPLING (SUBTASKS 2.2.1 AND 2.2.4)

A total of approximately 48 soil/residue samples will be collected and submitted to the CLP for analysis of Target Compound List (TCL) parameters including: VOCs, metals, cyanides and base neutral and acid extractables. The analyses will be conducted by RAS methods .

Approximately 28 of the samples will be collected from soil borings conducted during subtask 2.2.1. The remaining 20 soil samples will be collected during the test pit investigation at the former City of Wausau Landfill. Duplicate samples will be submitted once every 10 samples. The quality control samples (duplicates) are included in the total sample quantity estimate.

C. SOIL GAS SAMPLING (SUBTASK 2.2.1 AND 2.2.2)

Approximately 100 soil gas samples will be collected and analyzed by field GC during the Phase II investigation. Up to seventy-eight (78) of the samples will be collected during the soil boring investigation (Subtask 2.2.1) from the following facilities:

Wausau Chemical (14)
C.M St. P. & P. Railroad (4)
Wausau Energy (6)
Marathon Electric (16)
Former City of Wausau Landfill (34)
Additional Contingency Soil Borings (4)

The soil gas samples will be collected according to methods outlined in the Phase II Work Plan. The samples will be obtained at discrete depth intervals from the soil borings. Duplicate and field blanks will be collected once every ten samples. The soil gas survey will be used qualitatively as a field screening tool to determine which soil samples should be submitted to the CLP. The soil gas results will also be used to determine the gas extraction well screen intervals and test pit locations.

Additional soil gas samples (Approximately 28) will be obtained during the gas extraction treatability study (Former City Landfill and Wausau Chemical). The samples will be obtained from both monitoring probes and from the extraction test well. The soil gas samples obtained from the monitoring probes will be used to determine the area of influence of the test well. Concentrations recorded at the extraction test well will be used to determine the mass of contaminates removed during the test.

D. GROUNDWATER SAMPLES (SUBTASK 2.2.1 AND 2.2.4)

Groundwater sampling will be conducted both during drilling (Subtask 2.2.1) and from completed monitoring wells (Subtask 2.2.4) installed prior to the Phase II Investigation. Approximately 11 groundwater samples (9 samples, 1 duplicate and/blank) will be collected from borings conducted at the former City of Wausau Landfill, Marathon Electric and from the northwest loading dock and at Wausau Chemical. The samples will be used to supplement the round 3 groundwater sampling (Section 2.2.4) in order to determine the contaminant distribution at the water table in the vicinity of suspected source areas.

Groundwater samples will be collected during Round 3 at approximately 90 locations. A total of 108 samples are anticipated during round 3 sampling (90 locations, 9 duplicate, 9 blanks). The sample locations are outlined in the (Table 8 of the QAPP). Samples will be collected from the following locations:

- 5 City Production Wells
- 30 U.S. EPA RI/FS Installed Monitoring Wells
- 38 Previously Existing Monitoring Wells
- 5 Wausau Chemical Extraction Wells
- 4 Wausau Chemical Treatment System Influent and Effluent
- 8 City of Wausau Treatment System Influent and Effluent.

The samples will be submitted to the CLP for low detection GC/MS VOC analyses using SAS methods described in Appendix D.
Approximately twenty-three (23) samples collected from potential source areas and impacted production wells (CW3, CW4, CW6) will be submitted to the CLP for TCL, VOC, metals, cyanide, Base neutral and acid extractable analyses using Routine Analytical Services (RAS).

III. SAMPLE DESIGNATION

A. PROJECT IDENTIFIER CODE

A 2-letter designation will be implemented to identify the sampling site. The project identifier will include "W" for Wausau Water Supply NPL Site followed by "E" for U.S. EPA lead project.

B. SAMPLE TYPE AND LOCATIONS CODE

Each sample collected will be identified by a 2-digit sample code corresponding to the sample type. The locations code or sample description will follow the sample type code. The location code consists of a 2 to 5 digit number or alpha-numeric code that indicates the sample location. Field blanks, [illegible] and soil gas samples will use a consecutive numbering system start[illegible] assigned in the field. [illegible] industrial water supply well sample descriptions are listed in Table 8 of the QAPP. For groundwater samples collected during drilling and soil boring samples, the location code assigned in the Phase II Work Plan (Figures 1 and 2) will be followed by the sample depth. The sample type codes are:

GD - groundwater sample collected during monitoring well installation
GW - groundwater sample form a completed monitoring well
PW - groundwater sample from a private residential well
MW - groundwater sample from a municipal or industrial water supply well
SS - soil sample
SG - soil gas sample
FB - field blank (water quality sampling)
TB - trip blank
FD - field blank (during drilling)

C. SAMPLING ROUND CODE/DUPLICATE CODE

Groundwater samples obtained from completed monitoring wells, groundwater extraction wells, municipal production wells, from the City and Wausau Chemical treatment systems, field blanks and trip blanks will have a numeric identifier (03) to signify the third sampling episode. Groundwater and soil samples collected during drilling, surface water and soil gas samples will not have episode codes because they represent a one-time sampling at a unique location. Duplicate samples will be designated by the episode codes preceded by a 9. A D is not to be used because it is too easily confused with the location code.

D. EXAMPLES OF SAMPLE IDENTIFICATION CODES

Examples of sample identification codes are as follows:

- WE-GDB13-30 Wausau, U.S. EPA lead project, groundwater sample collected during drilling of boring B13 at a depth of 30 ft.
- WE-GWFVD5-03 Wausau, U.S. EPA lead project, groundwater sample collected from Monitoring Well FVD5, Episode 3.
- WE-GWFVD5-93 Duplicate of groundwater sample collected from Monitoring Well FVD5, Episode 3.
- WE-FB04-03 Wausau, U.S. EPA lead, field blank number 4, episode 3.
- WE-SGB12-10 Wausau, U.S. EPA lead, soil gas sample collected from boring 12 at a depth of 10 feet.

- WE-TP08-04 Wausau, U.S. EPA lead, soil/residual sample obtained from Test Pit 08 at a depth of 4 foot.
- WE-TP08-04-DVP Wausau, U.S. EPA lead, soil/residual sample obtained from Test Pit 08 at a depth of 4 foot, duplicate.

IV. GENERAL SAMPLING EQUIPMENT AND PROCEDURES

A. SOIL GAS SURVEY/SOIL AND GROUNDWATER BORING INVESTIGATION (SUBTASK 2.2.1)

1. Objective

The combined soil gas survey/soil and groundwater boring investigation will be conducted as an initial source characterization screening. The soil gas data will be used qualitatively to select soil samples for CLP analyses and to determine test pit and gas extraction well locations and screen intervals. The soil sampling will provide depth integrated characterization of unsaturated zone soils in potential source areas. The groundwtaer sampling during drilling will be used to assess shallow aquifer impact at suspected source areas.

2. Personnel and Responsibilities

Drilling and Sampling Supervision - Drilling and sampling (soil gas, groundwater and soil) activities at each drilling rig will be supervised by a geologist or hydrogeologist. The rig supervisor will oversee the collection of soil, groundwater and soil gas samples, field classify and log samples, prepare sample documentation, and act as rig safety officer.

Site Safety Officer - The site safety officer (SSO) will be responsible for overseeing safety aspects of the drilling and sampling program. The site safety officer in conjunction with the drilling rig supervisor will determine appropriate levels of personnel protection. The SSO will also function as a sample transfer technician and will transfer samples from the drilling rigs to the on-site GC.

Laboratory Technician - The laboratory technician will be responsible for analysis of soil gas, groundwtaer and soil samples collected during Subtask 2.2.1. The laboratory technician will also be responsible for maintaining all sample analysis documentation.

3. Methods

a. Soil Gas Sample Collection

- A drill rig will auger a bore hole to the desired sample depth.
- The steel sampling probe will be driven into the ground an additional depth of 2.5 ft.
- The drive head will be removed from the probe and the sampling head attached with teflon tubing connected to the sample bottle in line with the pump upstream of the sample bottle. Sample bottle will be a 250 ml bottle with a septum and 2 stop cocks. The probe and tubing will be purged to remove a minimum of one volume of air from the probe, tubing and sample bottle, not exceeding 20 centibars of vacuum.
- Sample will be collected following purging by closing the stop cocks on the sample bottle. The sample will be immediately wrapped in aluminum foil and put in a dark area. The sample will not be cooled so as not to cause condensation of moisture within the sample bottle. The soil gas samples will be transferred to the on-site GC as soon as practical after sampling.

Decontamination

- The sample probe and sampling tubes will be decontaminated by drawing a minimum of 10 volumes of ambient air through the probe and tubing. If ambient air results in contaminated blanks, decontamination will be completed using the GC carrier gas.
- Sample bottles will be decontaminated by flushing a minimum of 10 volumes of helium through the sample bottles.

Sample Analysis

Sample analysis and QC will be conducted as described in the QAPP (Appendix G).

b. Soil Sample Collection Methods

The soil boring will be advanced using 4 1/4-inch I.D. hollow-stem augers with a screened lead auger. Soil sampling will be conducted in general accordance with ASTM D1586 using a 3-inch split-spoon sampler. Soil samples will be collected on five foot intervals from ground surface to the boring completion depth. The soil samples will be screened for the presence of VOCs using an HNu photoionization detector. Samples indicating the presence of VOCs (above background of HNu readings, visually greasy appearance or odor) will be transferred to 8 oz VOA vials without compositing. Twenty-eight (28) selected soil samples will be composited and submitted to the CLP for analysis of Target Compound List (TCL) parameters. The soil samples will be selected based on results of soil gas analyses and HNu screening.

Decontamination

- The split spoon sampler and soil spatulas will be cleaned between samples by washing with a laboratory wash solution (liquinox) and rinsing with clean water.
- The hollow stem auger will be steam cleaned prior to entering the site and between boring locations where residual materials are encountered.
- The hollow stem auger will also be steam cleaned after the collection of groundwater samples.

c. Groundwater Quality Sampling While Drilling Methods

Groundwater samples will be collected at approximately nine (9) locations. The groundwater sample locations are presented in Table 6 and are shown on Drawings 13076-B28 and B29. The groundwater quality samples will be used to assess potential impact at suspected contaminant source areas.

The groundwater samples will be collected through a screened hollow stem auger which has been advanced approximately 3 feet into the water table. Prior to sample collection, a minimum of three casing (auger volumes) will be purged using a Brainard Kilman 1.7 pump or a stainless steel bailer. Four 40 ml VOA vials will be collected, two for on-site GC analysis and two for CLP GC/MS analysis. All samples will be collected with no head space. Samples for on-site analysis will be analyzed according to methods in Appendix G of the QAPP.

Decontamination

- The sampling pump and/or stainless steel bailer will be steam cleaned after each use.
- The hollow stem auger will be steam cleaned after each boring extended into the water table.

d. Waste Disposal

Cuttings from the soil borings will be contained if they are found to be contaminated by screening with a PID (HNu readings above background). If on-site disposal of cuttings creates an aesthetic problem, the cuttings will be removed and disposed of at an off-site location predetermined by the City of Wausau.

B. SOIL GAS EXTRACTION TREATABILITY STUDY (SUBTASK 2.2.2)

1. Objective

The soil gas extraction tests will be used to evaluate the effectiveness of in-situ enhanced volatilization (soil venting) as a potential remedial alternative for the treatment of unsaturated zone contamination at the Wausau Chemical Company and the Former City of Wausau Landfill.

2. Personnel and Responsibilities

Field Geologist - the field geologist will supervise the installation of gas monitoring probes and extraction wells. The gas monitoring probes and extraction wells will be installed in borings performed during Subtask 2.2.1 The field geologist will document monitoring probe and extraction well installation.

Test Supervisor - The gas extraction test will be conducted under the supervision of a geologist or engineer. The test supervisor will coordinate test activities including; pressure measurements, gas sample collection and flow velocity measurements. The test supervisor will determine initial flow velocity and valve apertures prior to initiation of the test. If necessary, the field supervisor will determine appropriate modification of test parameters. The field supervisor will also maintain appropriate documentation of sample collection and test procedures.

Field Technician - The field technician will assist the field supervisor in setting up the test and in collection of samples. The field technician may also transfer samples to the on-site laboratory as necessary.

3. Gas Extraction Test Methods

1) Install gas monitoring probes and extraction wells according to Figures 3, 4 and 5;
2) Obtain static (non-pumping) measurements of oxygen, methane and VOC concentrations;
3) Obtain static pressure measurements using the Dwyer Magnehelic pressure gage;
4) Initiate gas extraction test by setting test well valve apertures and commencing pumping;
5) Measure gas flow rate at test well using velometer;
6) Obtain well head and monitoring probe pressure readings;
7) Obtain gas discharge samples from blower at set intervals;
8) Obtain methane, oxygen and VOC concentration measurements at gas monitoring probes located within radius of influence of the pumping well (Determine radius of influence from step 6).
9) Adjust extraction well valve settings and blower rates, repeat steps 5 through 8; and
10) Conclude test when desired area of influence has been obtained or the apparent maximum area has been influenced.

C. TEST PIT INVESTIGATION (SUBTASK 2.2.3)

1. Objective

The test pit investigation will be conducted in order to characterize possible VHH source areas within the former city landfill. The source characterization will be used to assess potential health risks and will be used to determine potential remedial actions during the feasibility study.

2. Personnel

Geologist/Team Leader - The team leader/geologist will coordinate test pit activities with the subcontractor, U.S. EPA and Marathon Electric. The team leader and U.S. EPA project officer will determine test pit locations based on the soil boring/soil gas survey results and the location of underground and above ground utilities. The team leader will assist the U.S. EPA Project

Officer in obtaining access to test pit locations. During excavation activities the team leader will be responsible for soil screening and segregation, soil sampling, waste sampling, test pit documentation, subcontractor direction and site restoration.

Site Safety Officer (SSO) - The site safety officer will monitor air quality during the excavation and will determine appropriate personnel protection levels. The site safety officer will conduct field decontamination of sampling utensils and will supervise personnel and equipment decontamination activities. The SSO will also document each test pit using a video recorder.

Backhoe Subcontractor - The backhoe subcontractor will perform the test pit excavations under the direction of the team leader. The backhoe operator will be responsible for removal and segregation of soils and materials as designated by the team leader. The backhoe operator will be responsible for transport of any containers breached during excavation activities. The containers will be transported to an on-site secured location designated by Warzyn in cooperation with the U.S. EPA and the City of Wausau. The backhoe operator will also be responsible for the backfilling of the pit and the restoration of the excavation surface area. The backhoe subcontractor will be responsible for verifying that all on-site subcontractor personnel have completed 40 hours of health and safety training for hazardous waste site work and that all subcontractor personnel are on a medical monitoring program. The backhoe subcontractor will be responsible for providing personnel protective equipment for all on-site subcontractor employees.

Methods

Excavations by trenching will be performed with a backhoe to approximate depths of 15 feet. Uncontaminated excavation materials (HNu = background readings) will be stockpiled and used to recover the excavation at the end of sampling. Waste material removed from the test pits will be placed back in the pit at the end of sampling.

Approximately 50 soil/residue samples will be collected from a maximum of 8 test pit excavations. A minimum of 18 of the soil samples will be submitted to the CLP for analysis of (TCL) parameters. Refer to Table 7 for a summary of the sampling and analysis program. The samples will be collected out of the backhoe bucket with stainless steel spatulas or trowels, and composited in stainless steel buckets or stainless steel beakers to obtain a representative sample. Compositing will occur with a minimum stirring of the sample. The portion used for volatiles analysis will not be composited and will be collected first to minimize time for volatilization.

If containerized wastes are encountered during the excavation, an attempt will be made to sample the contents in-situ, without removal of the container from the test pit. The contents will be sampled using a glass tube (liquid) or sediment sampler (sludge). Containerized waste which cannot be sample from the surface of the trench will be excavated and sampled. Containerized wastes will be backfilled into the excavation, unless the container integrity has been breeched.

D. GROUNDWATER QUALITY SAMPLING (SUBTASK 2.2.4)

1. Objective

The objective of this activity is to collect groundwater quality samples from all recently installed monitoring wells and from selected previously installed monitoring wells which have indicated groundwater impact during previous sampling rounds. The sample locations are summarized in Table 8 and are shown in Drawing B30.

2. Personnel and Responsibilities

Sampling Teams - Two teams of two people each will be responsible for purging wells, collecting water quality samples, conducting the pH and conductivity measurements, providing site safety during sampling, decontamination of equipment and proper disposal of all purged water.

Chain-of-Custody Technician - This person will be responsible for all chain-of-custody records, preparing all sample bottles for the sampling teams, packaging and shipping samples with assistance from the sampling team members. This person will also assist in filtration and preservation of TCL metals samples.

3. Methods - Monitoring Wells

Monitoring well purging and sampling techniques to be utilized during Phase 2, groundwater sampling are summarized below.

Water Levels - A water level will be obtained using a weighted tape and sounding device or an electric water level meter, measuring to the nearest ±0.01 ft. If a floating oil layer is suspected to the present, based on drilling or previous sampling observations, an oil water interface probe will be used to measure both the depth to fluid and depth to water.

Purging

1. If floating product is observed, a stainless steel bailer will be used to collect a sample of the floating product without purging. The stainless steel bailer will then be used to purge the well of three volumes and to collect required samples (See Table 9 of the QAPP for required sample containers, preservatives and handling).
2. At deep wells (piezometers), a Johnson Keck sampling pump with packer will be used to purge and collect the samples.
3. The pump will be set within the screened interval and the packer inflated above the pump within the stainless steel riser section above the screen.
4. The pump will be used to purge a minimum of three well volumes from the isolated zone of the well. Volume to be removed is 0.16 gallons/ft of the 2-inch well times the length of the isolated zone.
5. Water levels above the isolated zone will be monitored regularly to determine whether any leakage past the packer is occurring. If more than 10% of the purged volume comes from leakage past the packer (0.1 ft of head drop above the isolated zone per foot of isolated zone), the packer will be deflated and reset. If a second attempt is unsuccessful, the entire volume of the well will be purged.

6. Purge water discharge will be collected in a tank.
7. When the purged water tank is full, it will be discharged to the City sanitary sewer at a point directed by the City of Wausau.

Sample Collection

1. Samples will be collected directly from the sampling pump discharge using the bottles listed in Table 9 of the QAPP.
2. All sample bottles will be labeled with the time of sample collection, in addition to the other chain-of-custody items prepared by the *Chain-of-Custody Technician.*
3. Samples collected from the bailer (those wells with floating product observed) will be collected with a minimum amount of water disturbance.

QC Samples

QC samples will be collected at the following rate:

- 1 duplicate/10 samples or 1/day, whichever is less
- 1 sample blank/10 samples; sample blanks will be collected by using the sampling device (the pump or bailer) and collecting a sample of deionized water immediately after decontamination
- 1 Trip blank submitted per sample shipment of VOCs
- 1 MS/MSD 20 investigative samples

Refer to Table 7 (QAPP) for a summary of Quality Control samples to be collected.

Sample Handling Preparation and Sample Analysis

- All samples will be iced immediately after collection
- Groundwater samples undergoing metals analyses will be filtered through a 0.45 μm pressure filtration device as soon as possible after sample collection
- Preservation will be conducted as specified in Table 9 of the QAPP
- pH and conductivity will be measured as specified in Appendices C1 through C4 of the original QAPP.

Decontamination

- Decontamination will be conducted by washing in TSP solution using City water followed by two rinses with deionized water
- The pump and with discharge tubing will be immersed in the wash water with a minimum of two volumes of water pumped through it, followed by two rinses. The first rinse will have water pumped into the wash tank until the TSP is substantially removed from the pump and discharge hose. The second rinse will follow a similar procedure
- Bailers used to sample oily groundwater will be decontaminated by rinsing with acetone followed by the same wash and rinse sequence.

E. SURFACE WATER AND SEDIMENT SAMPLING (2.2.5)

1. Objective

Surface water and sediment samples from four (4) different locations will be collected and submitted to the CLP for VOC parameter analyses. The results of these analyses will be used to determine temporal variations in the surface water impacts identified during the Phase I Investigation. GC/MS analyses of sediment samples will be used to evaluate residual VOC impact on surface water in Bos Creek.

2. Personnel and Responsibilities

Sampling Person - One team of two people will collect surface water and sediment samples and provide their own site safety monitoring.

Chain-of-Custody Technician - This person will prepare sample labels and provide chain-of-custody records and package and ship samples.

3. Methods

Surface Water Sampling - Samples will be collected in quiet water areas near the bank of the stream or river. Surface water samples will be collected prior to sediment samples at 4 locations shown on Figure 6. Surface water samples will be collected using stainless steel sampling equipment. Sampling equipment will be decontaminated using TSP wash followed by two, clean-water rinses. Sample handling, preservation, containers and packaging are summarized in Table 9 of the QAPP.

F. BOS CREEK DISCHARGE MEASUREMENTS (SUBTASK 2.2.6)

1. Objective

The surface water discharge measurement will be conducted in order to determine the hydraulic connection of Bos Creek with the groundwater flow regime in the vicinity of the municipal production wells. The flow measurement will be used to assess the potential recharge boundary effect that production Well CW6 pumpage to waste may have created.

2. Personnel and Responsibilities

Hydrologist - A hydrologist will be responsible for the initial test setup including: installation of pressure transducer and data logger. The hydrologist will conduct initial stream flow velocity measurements. After the initial site visit, the hydrologist will coordinate additional flow velocity measurements and data logger downloading. The hydrologist will interpret the flow versus elevation data in order to estimate surface water seepage into the aquifer.

Field Technician - The field technician will accompany the hydrologists and will assist in the initial test set up. The field technician will be responsible for subsequent site visits to record stream velocity and to download the data logger.

3. Methods

- Install pressure transducer and data logger on Bos Creek at the pool above Randolph Street.
- Measure flow velocity at Burns Street and at Randolph Street using both Pygmy and Price flow meters.
- Conduct 5 subsequent visits to download data logger, check pressure transducer calibration and conduct additional flow velocity measurements.
- Determine stream discharge at each location from the flow vs. elevation data.

Surface water samples will be analyzed for pH and conductivity using the methods in Appendices C1 through C4 of the original QAPP.

Sediment Sampling - Sediment samples will be collected following surface water samples using a hand-corer. The hand-corer will be driven to a depth of 6 inches and sediment samples will be collected in the sample bottles listed in Table 9 of the QAPP. The sample for VOCs analysis will be collected as soon as possible after sample removal. The hand-corer will be decontaminated in the same manner as the surface water sampling equipment.

QC Samples

- 1 duplicate of each media
- 1 sample blank for surface water by using the sampling device immediately after decontamination.
- 1 MS/MSD for surface water

SAMPLE DOCUMENTATION (Refers to Subtasks 2.2.1, 2.2.3, 2.2.4 and 2.2.5) Samples shipped to performing laboratories will be handled under chain-of-custody procedures. Standard forms including sample tags, traffic reports, chain-of-custody forms, and custody seals used for sample tracking will be recorded in the site log book maintained by the team leader and in logs maintained by each sampling crew. The information will include sampling time, location, tag numbers, designation and samplers. Pertinent PID readings, weather conditions, and field modifications of sampling strategy will be recorded. The log book will be maintained in indelible ink and will be in a bound volume unless weather conditions dictate otherwise. Sample documentation for analyses by field GC will be limited to labels and logbook entries by sampling crew and field analyst.

G. GROUNDWATER LEVEL MONITORING (SUBTASK 2.2.7)

Objective

Due to the critical need to define the affects of induced surface water recharge on groundwater flow in the vicinity of Bos Creek, four additional rounds of water level data will be obtained from site monitoring wells. The data will be used to assess changes in groundwater flow resulting from variations in production well pumping rates, river stages and groundwater recharge.

2. Personnel and Responsibilities

Water level monitoring will be conducted by a two-person team. The team will be responsible for measuring levels at all monitoring wells, production wells and extraction wells. The water level monitoring team is also responsible for inspecting and documenting the condition and/or need for repair of site monitoring wells.

3. Methods

The water levels will be measured using a fiberglass tape and sounding device or an electronic water level indicator. Water levels will be measured with respect to the top of the inner well riser. The water level measuring devices will be calibrated prior to use so that readings from the various devices are consistent to within 0.01 feet (accuracy of the elevation survey).

H. DRAWDOWN TESTING (SUBTASK 2.2.8)

1. Objective

The drawdown testing will be conducted in order to evaluate hydraulic connection between potential source areas and municipal production wells.

2. Personnel and Responsibilities

The drawdown test will be conducted in cooperation with the City of Wausau. A hydrogeologist and technical assistant will install and secure data loggers and transducers at site monitoring wells. The team will also be responsible for downloading the data to an on-site computer and periodically verifying the integrity of the test set up. The team leader/hydrogeologist will be responsible for coordinating production well operational schedules with the City of Wausau, Department of Water and Sewers.

3. Drawdown Test Methods

The drawdown test will be conducted as follows:

- Obtain water levels at designated monitoring wells (Refer to Work Plan Subtask 2.2.8) and install pressure transducers and data loggers.
- Set data logger to record in the linear mode at 10 minute intervals. Set data logger to start recording at a predetermine time during which existing conditions are recorded (CW6 pumping to waste into Bos Creek, CW3 pumping at a constant rate).
- After approximately 1 day, turn off production Well CW6 and record recovery (Production Well CW3 remains pumping at a constant rate).
- After recovery appears complete, initiate CW6 pumpage with water discharge to the treatment plant, (Production Well CW3 remains pumping at constant rate).
- Download data loggers and observe drawdown due to CW6 pumpage.
- Once drawdown has stabilized at all monitoring points, production well CW3 is turned off and recovery observed at the monitoring points.
- Test is completed when recovery appears to have stabilized and data loggers are downloaded to the computer.
- Record pumpage rate and schedule at municipal wells CW4, CW7 and CW9 during the test period.
- Obtain record of rivel levels and precipitation during the course of the test.

V. SCHEDULE

The Phase II investigation can be separated into two major tasks. Continued groundwater flow and contaminant transport modeling; and field investigations. Several of the groundwater flow model alterations are presently being instituted. Additional modifications will be made when preliminary Bos Creek flow measurements have been completed. The contaminant transport calibration process will begin as soon as validated Round II VOC analysis results are received, QA completed, and the data evaluated. The flow and contaminant transport modeling activities will continue throughout the Feasibility Study (FS) and will be used to develop and evaluate remedial alternatives. Refer to the Phase II Work Plan, Section 2.2.1 for the specific approach to the continued groundwater flow and contaminant transport modeling.

With the exception of the Bos Creek flow measurements and the additional rounds of groundwater level monitoring, the Phase II field investigation tasks will require approximately one month to complete. The soil gas survey and soil boring investigation will require approximately 8 days. Gas extraction test well and monitoring probes will also be installed during this time. The soil gas extraction test and test pit excavations will be conducted the following week. The soil gas extraction test at the former City Landfill will require approximately 2 days and will be completed prior to test pit excavations (Subtask 2.2.3). Test pit excavations at the former landfill will be performed while the soil gas extraction test is conducted at Wausau Chemical. Groundwater and surface water sampling will require approximately two weeks to complete and will be conducted after the other Phase II tasks have been completed. The drawdown test will require approximately 1 month to complete and will be conducted concurrently with the soil boring, test pit and sampling programs. The Bos Creek flow measurements will be conducted over a three month period and will begin as soon as practical. The stream elevation monitoring interval will be increased during the drawdown test (Subtask 2.2.8). The Phase II investigation schedule is summarized in Figure 7. Results of the Phase II investigation will be incorporated directly into the RI report.

CSR/jpl/RHW
[jpl-602-88a]

APPENDIX B

EPA CLP TARGET COMPOUND LIST - RAS ORGANIC AND INORGANICS

TABLE B-1

CLP TARGET COMPOUND LIST AND CONTRACT REQUIRED DETECTION LIMITS (CRDL)*

			Detection Limits(1)	
	Volatiles	CAS Number	Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
1.	Chloromethane	74-87-3	10	10
2.	Bromomethane	74-83-9	10	10
3.	Vinyl Chloride	75-01-4	10	10
4.	Chloroethane	75-00-3	10	10
5.	Methylene Chloride	75-09-2	5	5
6.	Acetone	67-64-1	10	10
7.	Carbon Disulfide	75-15-0	5	5
8.	1,1-Dichloroethene	75-35-4	5	5
9.	1,1-Dichloroethane	75-35-3	5	5
10.	1,2-Dichloroethene (Total)	156-60-5	5	5
11.	Chloroform	67-66-3	5	5
12.	1,2-Dichloroethane	107-06-2	5	5
13.	2-Butanone	78-93-3	10	10
14.	1,1,1-Trichloroethane	71-55-6	5	5
15.	Carbon Tetrachloride	56-23-5	5	5
16.	Vinyl Acetate	108-05-4	10	10
17.	Bromodichloromethane	75-27-4	5	5
18.	1,1,2,2-Tetrachloroethane	79-34-5	5	5
19.	1,2-Dichloropropane	78-87-5	5	5
20.	trans-1,3-Dichloropropene	10061-02-6	5	5
21.	Trichloroethene	79-01-6	5	5
22.	Dibromocloromethane	124-48-1	5	5
23.	1,1,2-Trichloroethane	79-00-5	5	5
24.	Benzene	71-43-2	5	5
25.	cis-1,3-Dichloropropene	10061-01-5	5	5
26.	Bromoform	75-25-2	5	5
27.	2-Hexanone	591-78-6	10	10
28.	4-Methyl-2-pentanone	108-10-1	10	10
29.	Tetrachloroethene	127-18-4	5	5
30.	Toluene	108-88-3	5	5
31.	Chlorobenzene	108-90-7	5	5
32.	Ethyl Benzene	100-41-4	5	5
33.	Styrene	100-41-4	5	5
34.	Total Xylenes	100-42-5	5	5
35.	Phenol	108-95-2	10	330

TABLE B-1, continued)

	Volatiles	CAS Number	Detection Limits(1) Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
36.	bis(2-Chloroethyl)ether	111-44-4	10	330
37.	2-Chlorophenol	95-57-8	10	330
38.	1,3-Dichlorobenzene	541-73-1	10	330
39.	1,4-Dichlorobenzene	106-46-7	10	330
40.	Benzyl Alcohol	100-51-6	10	330
41.	1,2-Dichlorobenzene	95-50-1	10	330
42.	2-Methylphenol	95-48-7	10	330
43.	bis(2-Chloroisopropyl)ether	39638-32-9	10	330
44.	4-Methylphenol	106-44-5	10	330
45.	N-Nitroso-Dipropylamine	621-64-7	10	330
46.	Hexachloroethane	67-72-1	10	330
47.	Nitrobenzene	98-95-3	10	330
48.	Isophorone	78-59-1	10	330
49.	2-Nitrophenol	88-75-5	10	330
50.	2,4-Dimethylphenol	105-67-9	10	330
51.	Benzoic Acid	65-85-0	50	1600
52.	bis(2-Chloroethoxy)methane	111-91-1	10	330
53.	2,4-Dichlorophenol	120-83-2	10	330
54.	1,2,4-Trichlorobenzene	120-82-1	10	330
55.	Naphthalene	91-20-3	10	330
56.	4-Chloroaniline	106-47-8	10	330
57.	Hexachlorobutadiene	87-68-3	10	330
58.	4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
59.	2-Methylnaphthalene	91-57-6	10	330
60.	Hexachlorocyclopentadiene	77-47-4	10	330
61.	2,4,6-Trichlorophenol	88-06-2	10	330
62.	2,4,5-Trichlorophenol	95-95-4	50	1600
63.	2-Chloronaphthalene	91-58-7	10	330
64.	2-Nitroaniline	88-74-4	50	1600
65.	Dimethyl Phthalate	131-11-3	10	330
66.	Acenaphthylene	208-96-8	10	330
67.	3-Nitroaniline	99-09-2	50	1600
68.	Acenaphthene	83-32-9	10	330
69.	2,4-Dinitrophenol	51-28-5	50	1600
70.	4-Nitrophenol	100-02-7	50	1600
71.	Dibenzofuran	132-64-9	10	330
72.	2,4-Dinitrotoluene	121-14-2	10	330
73.	2,6-Dinitrotoluene	606-20-2	10	330
74.	Diethylphthalate	84-66-2	10	330
75.	4-Chlorophenyl Phenyl ether	7005-72-3	10	330

TABLE B-1, continued)

			Detection Limits(1)	
	Volatiles	CAS Number	Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
76.	Fluorene	86-73-7	10	330
77.	4-Nitroaniline	100-01-6	50	1600
78.	4,6-Dinitro-2-methylphenol	534-52-1	50	1600
79.	N-nitrosodiphenylamine	86-30-6	10	330
80.	4-Bromophenyl Phenyl ether	101-55-3	10	330
81.	Hexachlorobenzene	118-74-1	10	330
82.	Pentachlorophenol	87-86-5	50	1600
83.	Phenanthrene	85-01-8	10	330
84.	ANTHRACENE	120-12-7	10	330
85.	Di-n-butylphthalate	84-74-2	10	330
86.	Fluoranthene	206-44-0	10	330
87.	Pyrene	129-00-0	10	330
88.	Butyl Benzyl Phthalate	85-68-7	10	330
89.	3,3'-Dichlorobenzidine	91-94-1	20	660
90.	Benzo(a)anthracene	56-55-3	10	330
91.	bis(2-ethylhexyl)phthalate	117-81-7	10	330
92.	Chrysene	218-01-9	10	330
93.	Di-n-octyl Phthalate	117-84-0	10	330
94.	Benzo(b)fluoranthene	205-99-2	10	330
95.	Benzo(k)fluoranthene	207-08-9	10	330
96.	Benzo(a)pyrene	50-32-8	10	330
97.	Indeno(1,2,3-cd)pyrene	193-39-5	10	330
98.	Dibenz(a,h)anthracene	53-70-3	19	330
99.	Benzo(g,h,i)perylene	191-24-2	10	330

TABLE B-1, continued)

			Detection Limits(1)	
	Volatiles	CAS Number	Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
100.	alpha-BHC	319-84-6	0.05	8.0
101.	beta-BHC	319-85-7	0.05	8.0
102.	delta-BHC	319-86-8	0.05	8.0
103.	gamma-BHC (Lindane)	58-89-9	0.05	8.0
104.	Heptachlor	76-44-8	0.05	8.0
105.	Aldrin	309-00-2	0.05	8.0
106.	Heptachlor Epoxide	1024-57-3	0.05	8.0
107.	Endosulfan I	959-98-8	0.05	8.0
108.	Dieldrin	60-57-1	0.10	16.0
109.	4,4'-DDE	75-55-9	0.10	16.0
110.	Endrin	72-20-8	0.10	16.0
111.	Endosulfan II	33213-65-9	0.10	16.0
112.	4,4-DDD	72-54-8	0.10	16.0
113.	Endosulfan Sulfate	1031-07-8	0.10	16.0
114.	4,4'-DDT	50-29-3	0.10	16.0
115.	Endrin Ketone	53494-70-5	0.10	16.0
116.	Methoxychlor	72-43-5	0.5	80.0
117.	alpha-chlrodane	5103-71-9	0.5	80.0
118.	gamma-Clordane	5103-74-2	0.5	80.0
119.	Toxaphene	8001-35-2	1.0	160.0
120.	AROCLOR-1016	12674-11-2	0.5	80.0
121.	AROCLOR-1221	11104-28-2	0.5	80.0
122.	AROCLOR-1232	11141-16-5	0.5	80.0
123.	AROCLOR-1242	53469-21-9	0.5	80.0
124.	AROCLOR-1248	12672-29-6	0.5	80.0
125.	AROCLOR-1254	11097-69-1	1.0	160.0
126.	AROCLOR-1260	11096-82-5	1.0	160.0

NOTES

(1) Detection limits listed for soil/sediment are based on net weight. The detection limits calculated by the laboratory for soil/sediments will be on dry weight basis and will be higher.

(2) Medium Water Contract Required Detection Limits (CRDL) for Volatile Hazardous Substances List (HSL) Compounds are 100 times the individual Low Water DL.

(3) Medium Soil/Sediment CRDL for Volatile HSL Compunds are 100 times the individual Low Water CRDL.

(4) Medium Water CRDL for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

(5) Meidum Soil/Sediment CRDL for Semi-Volatile HSL Compunds are 60 times the individual Low Soil/Sediment CRDL.

(6) Medium Water CRDL for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.

(7) Medium Soil/Sediment CRDL for Pesticide HSL Compunds are 15 times the individual Low Soil/Sediment CRDL.

* Specific detection limits are highly matrix dependent. The detection limit listed herein are provided for guidance and may not always be achievable.

[jpl-403-82]

TABLE B-2

ELEMENTS DETERMINED BY INDUCTIVELY COUPLED PLASMA EMISSION OR ATOMIC ABSORPTION SPECTROSCOPY

Metal	Required Detection Level(1) ug/l
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Other	
Cyanide	10

NOTES

(1) Any analytical method specified in Exhibit D of IFB WA 87-K025/K026/K027 may be utilized as long as the documented instrument or method detection limits meet the CRDL requirements. Higher detection levels may only be used in the following circumstances.

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the CRDL.

[jpl-403-83]

TAB
D

VCCS (Groundwater and Surfacewater)

U.S. Environmental Protection Agency
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: (703) 557-2490 - FTS/557-2490

SAS Number ________

SPECIAL ANALYTICAL SERVICES

Client Request

X Regional Transmittal ____ Telephone Request

A. EPA Region/Client: Region V, Wausau NPL Site

B. Regional Representative: Dennis Wesolowski

C. Telephone Number: (312) 886-1971

D. Date of Request: ____________

E. Site Name: Wausau Water Supply NPL Site

Please provide below description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in a delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for volatiles by GC/MS in 119 Groundwater and 6 Surface water samples using low detection limits.

2. Definition and number of work units involved (specify whether whole samples or fraction; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium or high concentration): 118 Groundwater and 6 Surfacewater samples.

3. Purpose of analysis (specify whether Superfund (enforcement or remedial action), RCRA, NPDES, etc.): U.S. EPA lead remedial investigation

4. Estimated date(s) of collection: June 27 - July 8, 1988

5. Estimated date(s) and method of shipment: Daily, overnight carrier

6. Number of days analysis and data required after laboratory receipt of samples: Analysis complete within 7 days of VTSR & deliverables within 14 days of VTSR, reviewed at Region V and data to contractor with 14 days of Region V receipt of data.

7. Analytical protocol required (attached copy if other than a protocol currently used in this program): As per current IFB

8. Special technical instructions (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.): ____________

   1. Exceptions to Organic IFB = Attachment 1
   2. Required low [illegible] limits - Table D-1
   3. Requirements for determining detection limits; using 1.5 ug L injected and easily recognizable mass spectra for all compounds
   4. Initial calibrations: RSD for RFs should be <30% for each VOA before beginning analysis.
   5. Continuing calibration: Run daily calibration standard before running analysis. %D should be <25 for all compounds in VOAs.
   6. If dilution of sample is required, results for both original and diluted sample should be reported.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.) If not completed, format of results will be left to program discretion.

   All deliverables included in the IFB are required including instrument sensitivity determination and if samples need dilutions, both sets (diluted and undiluted) results should be reported.

10. Other (use additional sheets or attached supplementary information, as needed): ____________

11. Name of sampling/shipping contact: Brian Hegge
    Phone: (608) 273-0440

12. Data Requirements

Parameter	Detection Limit	Precision Desired (+% or Concentration)
As per IFB		

13. QC Requirements

Audits Required	Frequency of Audits	Limits (Percent or Concentration)
As per IFB		

14. Action Required if Limits are Exceeded

Reanalyze, if reanalysis is outside limits contact Jan Pels @ (312)353-27[illegible]

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please contact your Regional representative at the Sample Management Office.

[jpl-602-88c]
[ncj-700-91]

Attachment I

[illegible] - Increase sample volume up to 20 ml to meet quantitation limits.
Initial Calibration: 5ug/L, 10ug/L, 20ug/L for all compounds except for acrolein and acrylonitrile, which should be run at 200ug/L, 300ug/L, 500ug/L; vinyl chloride, chloromethane, bromomethane, acetone, 2-butanone, 2-hexanone, and vinyl acetate, which should be run at 50ug/L, 100ug/L, 150ug/L.

Continuing Calibration: 10ug/L except all those compounds that have a detection limit > 3.0ug/L but <10ug/L which are to be run at 20ug/L. Acrolein and acrylonitrile should be run at 300ug/L. Vinyl chloride, chloromethane, bromomethane, acetone, 2-butanone, 2-hexanone, and vinyl acetate should be run at 50ug/L.

Surrogates: As in IFB but at 10 ug/L with percent recovery 80 - 120%.
Matrix spike: As in IFB but at 10 ug/L with percent recovery 80 - 120%.
All RFs must be >0.05.

OTE: The IFB limits for the RPDs for the matrix spike/matrix spike duplicate results apply for all of the organics analyses.
For corrective action when surrogates are outside the SAS required recovery limits, see the IFB for re-extraction/re-analysis requirements.
* The surrogate and matrix spike amounts listed are the concentrations in the liter of sample.

TABLE D-1

(All Units are Micrograms/Liter)

PARAMETER	CAS #	METHOD DETECTION LIMIT IN REAGENT WATER
Benzene	71-43-2	1.5
Bromodichloromethane	75-27-4	1.5
Bromoform	75-25-2	1.5
Bromomethane	74-83-9	10
Carbon Tetrachloride	56-23-5	1.5
Chlorobenzene	108-90-7	1.5
Chloroethane	75-00-3	1.5
2-Chloroethyl Vinyl Ether	110-75-8	1.5
Chloroform	67-66-3	1.5
Chloromethane	74-87-3	10
Dibromochloromethane	124-48-1	1.5
1,1-Dichloroethane	75-34-3	1.5
1,2-Dichloroethane	107-06-2	1.5
1,1-Dichloroethene	75-35-4	1.5
trans,1,2-Dichloroethene	156-60-5	1.5
1,2-Dichloropropane	78-87-5	1.5
cis-1,3-Dichloropropropene	10061-01-5	2
trans-1,3-Dichloropropene	10061-02-6	1
Ethyl Benzene	100-41-4	1.5
Methylene Chloride (*)	75-09-2	1
1,1,2,2-Tetrachloroethane	79-34-5	1.5
Tetrachloroethene	127-18-4	1.5
Toluene (*)	108-88-3	1.5
1,1,1-Trichloroethane	71-55-6	1.5
1,1,2-Trichloroethane	79-00-5	1.5
Trichloroethene	79-01-6	1.5
Vinyl Chloride	75-01-4	10
Acrylein	107-02-8	100
Acetone (*)	67-64-1	10
Acrylonitrile	107-13-1	50
Carbon Disulfide	75-15-0	3
2-Butanone	78-93-3	10
Vinyl Acetate	108-05-4	10
4-Methyl-2-Pentanone	108-10-1	(3)
2-Hexanone	519-78-6	10
Styrene	100-42-5	1
m-Xylene	108-38-3	2
o-Xylene**	95-47-6	
p-Xylene**	106-42-3	2.5

*Common Laboratory Solvent - Blank Limit is 5x Method Detection Limit
**The o-Xylene and p-Xylene are reported as a total of the two

APPENDIX F

FIELD ANALYSIS OF VOLATILE ORGANICS

FIELD ANALYSIS OF VOLATILE ORGANICS

Scope and Application: This method covers the determination of the following 15 organic compounds in water and soil gas.

Compounds:

Benzene
Bromomdichloromethane
Bromoform
Chloroform
Chlorodibromomethane
1,1-Dichloroethane
1,2-Dichloroethane
•1,1-Dichloroethene
•1,2-Dichloroethene
Ethyl benzene
Methylene chloride
•Tetrachloroethene
•Toluene
1,1,1-Trichloroethane
•Trichloroethene

• Target Compounds

Method: Headspace - Gas Chromatographic/Photoionization and Hall Electrolytic Conductivity Detection.

Reference: "EPA Test Methods for Evaluating Solid Waste," SW-846 Methods 3810, 8010 and 8020 with modifications.

Detection Limits: Headspace 1.0 - 50 ug/L, soil gas 5 - 10 ng (injected).

Quality Control:

1. Each analytical run should begin with a target headspace standard curve consisting of 50, 10, 5, 1 and a blank. Every eleventh analysis thereafter and the last sample analyzed should also be standards. Continuing calibration standards should be within 30% of the original standards or a new standard curve should be prepared and samples analyzed since the last check standard reanalyzed.

2. After the initial 3-point calibration with target headspace standards is done, the following 1-point calibrations will be performed:

    2.1 Run a 1-point, 50 ug/L headspace standard of the other non-targeted compounds.

    2.2 Direct inject 5 ul of a 5 ug/mL target standard (25 ng) for a 1-point soil gas curve.

    2.3 Direct inject 5 ul of a 5 ug/mL other VOC non-targeted standards (25 ng) for a 1-point soil gas curve.

3. A minimum of 10% duplicate samples should be analyzed. If less than 10 samples are analyzed, a duplicate sample should still be analyzed. Duplicates should be within 15%.

4. New stock standards should be prepared monthly in the laboratory. New secondary standards should be prepared weekly in the laboratory and brought to the field location while maintaining a temperature of approximately 4°C (iced).

Sample Collection of Handling:

Water samples are to be collected in 40 mL vials with open screw-caps and teflon faced silicone septa. They should be collected so that no headspace remains in the bottle. Soil gas samples are to be collected in 250 mL glass bulbs. Sample should be collected in a manner to ensure the complete purging of the bulb. All samples should be protected from sunlight and transported to the field lab as soon as possible.

Reagents and Apparatus:

1. Open screw cap 40 mL vial (Pierce #13075 or equivalent). Detergent washed, distilled water rinsed and dried at 105°C before use.
2. Septum - Teflon-faced silicone (Pierce #12722) or equivalent). Detergent washed, distilled water rinsed and dried at 105°C before use.
3. 250 mL gas sampling bulbs.
4. Gas chromatograph - Varian 3400 equipped with PID and Hall detectors in series.
5. Column 1 - 8 ft x 1/8 in. stainless steel, packed with 1% SP 1000 on Carbopack B (60/80 mesh).
6. Dual-channel Integrator/Recorder.
7. Syringes - 1 and 5 mL gas tight, fitted with shut-off valves and 22 gauge needle. 10, 100, and 1,000 mL gas tight.
8. Balance - ± 0.0001 g - (Cahn TA4200).
9. Balance - ± 0.01 g - (Sartorius, 1202 MP).
10. Reagent water - organic free water or cold tap water which has been shown to be organic-free at the method detection limit.
11. 25 mL TC graduated cylinders.
12. Constant temperature water bath - 55°C.
13. Volumetric flasks - assorted.
14. Pipettes - assorted.

Standard Preparation:

1. Stock standard solutions: Prepare a target VOC standard at 5000 ug/mL in methanol containing trichloroethene, tetrachloroethene, trans-1,2-dichloroethene, toluene, 1,1-dichloroethene. Prepare a second stock standard containing the other 10 compounds of interest in methanol also at 5000 ug/mL.

   1.1 Add about 20 mL of methanol to a 25 mL volumetric flask. Allow the flask to stand unstoppered until the methanol on the neck of the flask has dried.

   1.2 Tare the flask on the analytical balance.

   1.3 Using a 100 uL syringe, add 0.125 g (correct for % purity) of the reference material to the flask. Make sure the drops fall directly into the methanol without contacting the neck of the flask.

   1.4 Determine the amount of reference material added. Rinse the syringe with methanol, tare the flask, and add the next standard.

   1.5 After all the reference materials are added, fill to volume with methanol, cap and invert to mix.

2. Secondary Standard Solutions

   2.1 Target Standards: Prepare secondary target standards according to the following scheme:

Standard	mLs	Final Volume	Concentration
5000 ug/mL	1 mL	10 mL	500 ug/mL
500 ug/mL	1 mL	10 mL	50 ug/mL
50 ug/mL	2 mL	10 mL	10 ug/mL
10 ug/mL	5 mL	10 mL	5 ug/mL

Dilute to volume with methanol.

2.2 Other VOC Standards: Prepare secondary standards according to the following scheme:

Standard	mLs	Final Volume	Concentration
5000 ug/mL	1 mL	10 mL	500 ug/mL
500 ug/mL	1 mL	10 mL	50 ug/mL
50 ug/mL	1 mL	10 mL	5 ug/mL

Dilute to volume with methanol.

3.0 Working Target Headspace Calibration Standards: Prepare working target and non-target calibration standards according to the following scheme:

Secondary Standard	Amount	Final Volume	Concentration
500 ug/mL	20 uL	200 mL	50 ug/L
50 ug/mL	40 uL	200 mL	10 ug/L
50 ug/mL	20 uL	200 mL	5 ug/L
10 ug/mL	20 uL	200 mL	1 ug/L

Fill a 200 mL volumetric flask with reagent water to the mark. Directly inject the secondary standard into the water with an appropriate microliter syring.

Invert each standard 3 times, dicard the first 10 mL in the neck of the volumetric and transfer aliquots of the freshly prepared working standards to 40 mL VOC vials, (No headspace) and cap.

CALIBRATION

1.0 Target Headspace Standards

1.1 Remove and discard 10 mL from a freshly prepared standard and place the vial now having 10 mL of headspace in a 55°C water bath insuring the water level in the bath is sufficient to equal the water level in the vial.

1.2 Allow time for equilibratoin of temperature (10 minutes).

1.3 Remove 5 mL of headspace for injection onto the gas chromatograph.

1.4 Construct on external standard curve of peak area response versus concentration for each of the compounds of interest.

1.5 A continuing calibration check is performed after each set of 10 samples and as the last sample of the day. If the response for any of the target compounds varies from the expected response by more then ±30%, a new calibration curve should be prepared.

2.0 Non-Target Headspace Standards

2.1 Remove and discard 10 mL from a freshly prepared standard and place the vial now having 10 mL of headspace in a 55°C water bath insuring the water level in the bath is sufficient to equal the water level in the vial.

2.2 Allow time for equilibration of temperature (10 minutes).

2.3 Remove 5 mL of headspace and inject into the gas chromatograph.

2.4 Construct a 1-point standard curve of peak area response versus concentration for each of the compounds of interest.

3.0 Soil Gas (Total Nanograms):

3.1 Inject 5.0 uL of the 5 ug/mL target standard and 5.0 uL of the 5 ug/mL other VOC standard into the gas chromatograph.

3.2 Use a 1-point standard curve of peak area response versus total nanograms injected for each of the compounds of interest.

3.3 A continuing calibration check is performed after each set of 10 samples and as the last sample of the day. If the response for any of the compounds varies from the expected response by more than ±30%, the average response should be used.

Sample Analysis

1.0 Water Samples:

1.1 Water samples are received in 40 mL VOC vials. Uncap and decant 10 mL of the sample from the vial. Recap the vial containing 30 mL of sample.

1.2 The vials are placed in a 55°C water bath and allowed to equilibrate for 10 minutes.

1.3 Remove 5 mL of headspace and inject into the gas chromatograph.

1.4 If any target compound of interest is outside the calibration curve and an accurate concentration is required, a dilution of the sample is made using organic free water and the headspace analysis repeated.

2.0 Soil Gas Samples:

2.1 Soil gas samples will be received in 250 mL glass bulbs. When received, they are allowed to equilibrate to the ambient air temperature.

2.2 Remove 5 mL of sample through the sampling septum and inject into the gas chromatograph.

2.3 If any target compound of interest is outside the calibration curve and an accurate concentration is required, a smaller aliquot is taken from the same sample bulb.

Chromatographic Conditions:

Column

8 ft x 1/8 inch stainless steel, packed with 1% SP-1000 on Carbopack B (60/80 mesh).

Carrier Gas

Helium - Ultra High Purity Grade (Linde)
35 mL/min

Detectors (in series)

1. Photoionization 10.2eV

   Sensitivity - Range 11 x Attenuation 8
   Temperature - 240°C

2. Hall 700A

   Mode - Halogen
   Reactor Temperature - 1000°C
   Solvent Flow - 0.8 mL/min Methanol
   Hydrogen Flow - 60 mL/min

Injector

Temperature - 200°C

Oven*

Initial - 60° - 0 min
Rate 20°C/min
Final - 220°C - 7 min

*Conditions listed can be varied as needed for changing applications. Retention times are found on Table 4 using these conditions.

Target Headspace Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as incomplete data reports because of faulty integration.

2. Prepare external standard calibration curves for each compound using at least three data points and linear regression analysis.

3. Calculate the concentration found in the samples from the calibration curves using the following equations:

$$ug/L = A \times DF$$

where: A = Amount of compound found in the analysis in ug/L (from linear regression). DF = Dilution factor.

Other VOC Headspace Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as in complete data reports because of faulty integration.

2. Calculate the concentration of each parameter found in the samples using the following equation.

$$ug/L = \frac{R(samp)}{R(std)} \times C(std) \times DF$$

where: R(Samp) = Response of parameter in sample
R(Std) = Response of paramter in standard
C(Std) = Concentration of standard in ug/L
DF = Dilution factor

Soil Gas Bulb Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as incomplete data reports because of faulty integration.

2. Calculate the mass per liter of each parameter found in the samples using the following equation.

$$ug/L = \frac{R(samp) \times ug(std)}{R(std) \times VL}$$

where: R(samp) = Response of parameter in sample
R(std) = Response of parameter in standard
ug(std) = ug of standard injected
VL = Volume of aliquot taken from bulb (in L)

Data Reporting:

1. All results, standards conditions, and notes will be recorded in a bound field notebook.
2. All data generated by field G.C. will be considered as tentatively identified, with concentration being estimated.
3. All raw field data will be forwarded to Warzyn Engineering Inc., Analytical laboratory for final review and archiving.

[KAW-7-16]

TABLE 1

Volatile Retention Order

Photo Ionization Detector

Parameter	Retention Time
1,1-Dichloroethene	4.24
Trans-1,2-Dichloroethene	4.98
Trichloroethene	7.23
Benzene	7.39
Tetrachloroethene	9.86
Toluene	10.81
Ethyl Benzene	13.84

Hall Detector

Parameter	Retention Time
Methylene Chloride	3.26
1,1-Dichloroethene	4.29
1,1-Dichlorothane	4.77
Trans-1,2-Dichloroethene	5.04
Chloroform	5.21
1,2-Dichloroethane	5.49
1,1,1-Trichloroethane	6.12
Bromodichloromethane	6.40
Trichloroethene	7.29
Chlorodibromomethane	7.58
Bromoform	8.76
Tetrachloroethene	9.91

TABLE 2

Target VOC Detection Limits for Water Headspace

Compound	Replicates	Mean (1)	Standard Deviation	Method Detection Limit(2)
Toluene	7	2.49	0.208	0.65 ug/L
1,1-Dichloroethene	7	2.32	0.364	1.14 ug/L
Trans-1,2-Dichloroethene	7	2.08	0.332	1.04 ug/L
Trichloroethene	7	1.84	0.294	0.92 ug/L
Tetrachloroethene	7	2.38	0.310	0.97 ug/L

(1) Mean value for spike at 3 ug/L.

(2) Calculated D.L. according to Appendix A of EPA Test Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.

TABLE 3

Other VOC's Detection Limits for Water Headspace

Compound	Replicates	Detection Limit
Benzene	3	2.0 ug/L
Ethyl Benzene	3	2.0 ug/L
1,1,1-Trichloroethene	3	1.0 ug/L
1,1-Dichloroethane	3	2.0 ug/L
Chloroform	3	2.0 ug/L
Methylene Chloride	3	5.0 ug/L
1,2-Dichloroethane	3	5.0 ug/L
Bromodichloromethane	3	5.0 ug/L
Chlorodibromomethane	3	25 ug/L
Bromoform	3	50 ug/L

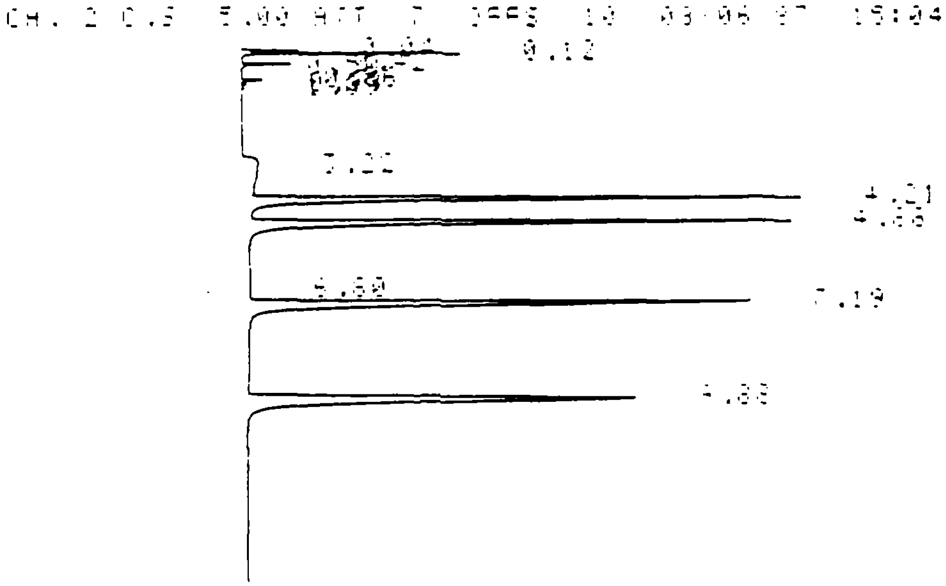
TABLE 4

Soil Gas Detection Limits

Compound	Replicates	Mean (ng)	Standard Deviation	Detection Limit (ng) (1)
Toluene	3	4.16	0.044	5.0
1,1-Dichloroethene	3	5.06	0.086	5.0
Trans-1,2-Dichloroethene	3	4.95	0.021	5.0
Trichloroethene	3	4.91	0.032	5.0
Tetrachloroethene	3	4.21	0.219	5.0
1,1,1-Trichloroethane	3	3.90	0.147	5.0
Benzene	3	7.57	0.085	5.0
Ethyl Benzene	3	6.08	0.301	5.0
1,1-Dichloroethane	3	3.99	0.216	5.0
Chloroform	3	4.02	0.132	5.0
Methylene Chloride	3	3.65	0.788	5.0
1,2-Dichloroethane	3	2.92	0.099	5.0
Bromodichloromethane	3	4.92	0.093	5.0
Chlorodibromomethane	3	8.77	0.180	10.0
Bromoform	3	8.95	0.118	10.0

(1) Detection limit is total nanograms injected into G.C. column.

Target compounds Hall detector



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C-2000                                                   08/06/87  15:04

METHOD: HALL            TAG:     57  CH: 2

FILE: 1  CALC-METHOD: EXT-STD  TABLE:    2  CONC: AREA

  NO.      RT   NAME          AREA       CONC  RC
    1    0.04                 11885      0.011  BV
    2    0.12                 56976      0.056  VB
    3    0.42                 11933      0.011  BV
    8    3.22 MECL2           92539      0.092  BV
    9    4.21 11DCE          391102      0.391  VV
   10    4.88 T12DCE         409407      0.409  VB
   12    7.19 TCE            443329      0.443  BB
   13    9.88 PCE            437092      0.437  BB
TOTAL
                            1854263      1.854
```

Target compounds PID detector

```
CH. 1 C.S 5.00 ATT  4  OFFS  10  08/06/87  15:04
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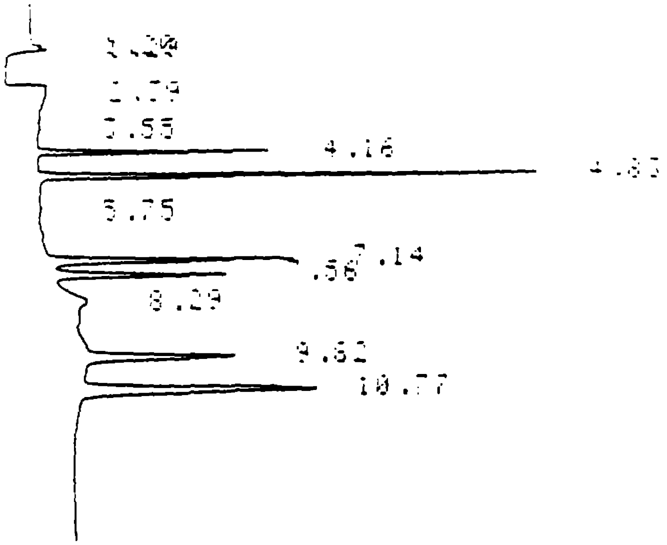

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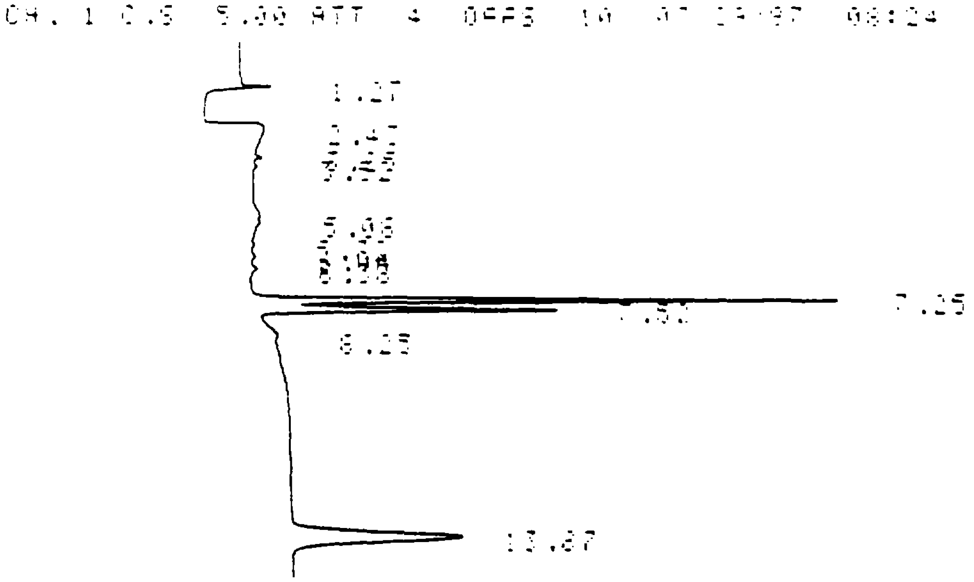
D-2000                                                    08/06/87  15:04

METHOD: PID             TAG:     57  CH: 1

FILE: 1  CALC-METHOD: EXT-STD  TABLE:    1  CONC: AREA

  NO.     RT    NAME          AREA       CONC   BC
   1    1.20                  1748      0.001   BV
   2    1.29                  1918      0.001   VB
   3    1.79                 23586      0.023   BV
   4    3.55                  1213      0.001   VB
   5    4.16 11DCE           14452      0.014   BB
   6    4.83 T12DCE          33524      0.033   BB
   7    5.75                   159      0.000   BB
   8    7.14 TCE             21629      0.021   BV
   9    7.56                 15877      0.015   VB
  10    8.29                  4345      0.004   BB
  11    9.82 PCE             18197      0.018   BB
  12   10.77 TOL             35826      0.035   BB
 TOTAL
                            172474      0.172
```

Non-targeted compounds PID detector



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D-2000                                                07/29/97  08:24

METHOD: PID              TAG:     34  CH: 1

FILE: 1  CALC-METHOD: EXT-STD  TABLE:   1  CONC: AREA

  NO.      RT    NAME         AREA       CONC  BC
   1     1.27                 2463      0.002  BB
   2     2.43                29535      0.029  BV
   3     3.25                 4080      0.004  VV
   4     3.52                 1398      0.001  VB
   5     5.08                 2370      0.002  BB
   6     5.72                  182      0.000  BB
   7     6.04                  335      0.000  BB
   8     6.38                  610      0.000  BB
   9     7.25  BENZENE       47354      0.047  BV
  10     7.52                30138      0.030  VB
  11     8.25                 1234      0.001  BB
  12    13.87  ETHBEN        40199      0.040  BB
TOTAL
                            159898      0.159
```

Non-targeted compounds   Hall detector

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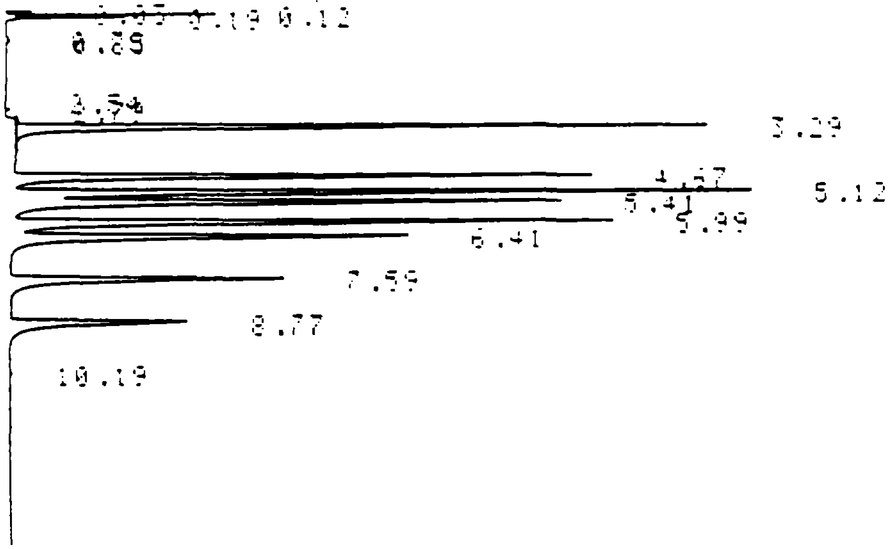

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D-2000                                                   07/29/87  08:24

METHOD: HALL              TAG:     39  CH: 2

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  NO.      RT    NAME          AREA       CONC  BC
    2    0.12                 38839      0.038  BU
    3    0.19                 29720      0.029  UB
    8    3.29 MECL2          489426      0.489  BB
    9    4.67 11DCA          390539      0.390  BU
   10    5.12 CHCL3          537809      0.537  UU
   11    5.41 12DCA          474194      0.474  UU
   12    5.99 111TCA         474926      0.474  UU
   13    6.41 BRCL2M         348516      0.348  UB
   14    7.59 CLBR2M         231536      0.231  BB
   15    8.77 BROMO          177886      0.177  BB
 TOTAL
                            3193351      3.193
```

APPENDIX I

HEALTH AND SAFETY ADDENDUM

APPENDIX I

HEALTH AND SAFETY ADDENDUM

TEST PITS

1.1 General Information

Five (5) test pit locations have been identified for Phase II remedial investigation of the former City landfill. An additional three (3) test pit locations will be determined based on the soil gas survey and on site analysis of soil samples. Prior to excavation, the area will be surveyed for soil gas at the depth of the anticipated test pits. The initial level of protection will be based on the soil gas results.

1.2 Test Pit Safety Concerns

The backhoe operator will exercises caution and maintain continual observation to avoid minimize damaging buried drums or tanks. Because of the importance of the operator's vision, work will be conducted during daylight hours and conditions of no precipitation. In the case of rain, the test pit excavation will be ceased by the On-Site Warzyn Safety Officer until such time the work can resume in a safe manner. No one will be permitted to enter a test pit. If necessary, materials will be removed from the excavation and inspected at the surface.

Air monitoring will be conducted during the test pit excavation using an HNu photoionization detector, and a methane combustible gas/O_2 meter. The excavation will be in level D personnel protection unless depth integrated soil gas sampling indicates need for higher levels of personnel protection. The following safety action limits will be observed during the test pit excavations:

Level D - Background
Level C - Above background below 5 ppm
Level B - Greater than 5 ppm

Note:

Action limits will be determined based on HNu concentrations within the breathing zone.

1.3 Excavated Soil Placement

The soil will be removed in shallow (six-inch to one-foot) passes. Each backhoe bucket of waste will be placed on visqueen (plastic sheeting). Excavated materials will be screened with an HNu photoionization detector and non contaminated materials (HNu=background) segregated from contaminated materials (HNu < Background). The plastic will be bermed such that liquids brought to the surface will be contained. When the sheet has been filled, another sheet should be layed atop the previous layer and continue the process. Soil/waste samples will be obtained directly from the backhoe buckets. The supervising professional may also inspect the pit for buried drums, etc. after each backhoe bucket has been removed. If drums or tanks are observed, the location will be noted and container markings and/or features will be noted. If possible the container will be removed from the excavation and its contents sampled.

1.3 Ruptured Drums

In the event a buried drum is accidentally ruptured, the drum will be removed from the test pit and overpacked (sludge). If the breached drum contains liquids, the contents will be removed using a bailer or and stored in a Federal Department of Transportation approved drum. In the case of leakage, sorbent material will be available to control 55 gallons of liquid waste.

1.4 Equipment Decontamination

Backhoe equipment will be decontaminated by steam cleaning before initial excavation activities and after the final test pit. Decon water will be collected and discharged to the city sanitary sewer system. Decontamination will be conducted in the level of protection that is designated for the test pit excavation.

1.5 Health and Safety Documentation Requirements

All personnel participating in the test pit excavation investigation will be required to present written verification of Health and Safety training and show that they were are presently enrolled in a medical monitoring program.

1.6 Utility Clearance

Prior to excavation activity, local sewer, electric and water utilities will be cleared by the on-site supervisor. City fire and police departments will also be notified of the scheduled excavation activities. Excavation work will not be authorized to proceed until these tasks have been completed.

KAS/jpl/CSR
[jpl-601-29]

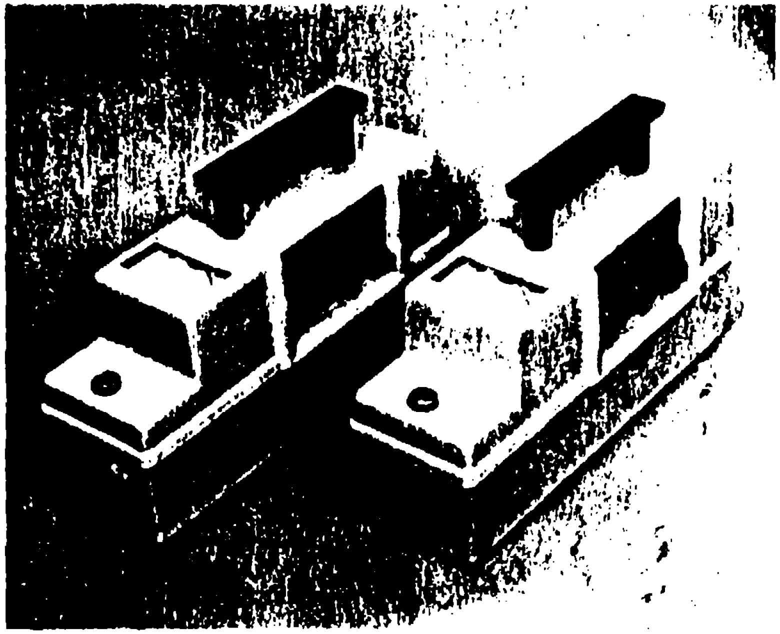
APPENDIX K

OPERATIONS MANUAL AND TECHNICAL SPECIFICATIONS GAS TECH, VELOMETER AND MAGNEHELIC GAGES

GASTECH

MODELS 1238 & 1314
GASTECHTOR

INSTRUCTION MANUAL



MADE BY

GASTECH INC

8445 CENTRAL AVE., NEWARK, CA 94560

WARNING

Explosive gas mixtures can maim, disfigure and kill, toxic vapors can cause impairment of health, and oxygen deficient atmospheres can cause instant death. It is essential that users of this instrument read, understand and follow the instructions for operation and maintenance, and the precautions contained in this manual to ensure that the instrument will warn of explosive or oxygen deficient atmospheres.

DO NOT USE FOR DETECTION OF TOXIC GASES OTHER THAN ORGANIC VAPORS IN THE TOXIC RANGE.

WARNING

INSTRUCTION MANUAL

GASTECHTOR HYDROCARBON SURVEYOR

MODEL 1939 OX PERCENT GAS AND OXYGEN INDICATOR

SERIAL NO. [illegible]

CALIBRATED FOR METHANE

Gastech

IF 5

CONTENTS

MADE BY:

GASTECH, INC.

8445 CENTRAL AVENUE

NEWARK, CALIFORNIA 94560

TELEPHONE: (415) 794 6200

1939-060586-S

SPECIAL INSTRUCTIONS

Model 1939 OX Triple Range GasTechtor
For 0-100% LEL/0-100% by Volume of Methane & 0-25% Oxygen

This instrument is a special version of the Model 1314 triple-range Hydrocarbon Surveyor as described in the accompanying manual pages. However, in place of the ppm range, a second range of 0-100% Methane by volume is provided. Refer to the accompanying manual for general information on the GasTechtor Model 1314, and refer to these supplementary pages for specific information relating to the Model 1939 OX version.

A. LEL and Oxygen Ranges

The LEL and Oxygen ranges are unchanged from the standard Model 1314, so the accompanying instructions apply.

B. 100% Gas Range

This range is obtained from a set of thermal conductivity filaments, which respond to the cooling effect of methane relative to air, and hence can be used over the full range of concentrations from 0 to 100%. The thermal conductivity section is activated by pressing the range switch in, to the GAS position. This simultaneously turns off the % LEL section.

The thermal conductivity Wheatstone bridge circuit is independent of the LEL circuit, with its own zero adjust and span controls. The zero adjust potentiometer is accessible only while the instrument is opened; the control, marked GAS ZERO, is a slotted-shaft miniature potentiometer found at the front of circuit board, close to terminal strip. It should require adjustment only rarely, and should be set only after circuit has warmed up for 10 minutes or more. (Zero on % GAS scale is however affected by turning the external (% LEL) ZERO potentiometer, so this knob position should not be changed while in the % GAS range.)

Calibration and alarm settings are adjustable, using the potentiometers marked PPM SPAN and PPM ALARM respectively. Span can be set to give a reading of 100% while undiluted propane is admitted to instrument. Alarm can be set as described on Page 13.

Thermal conductivity filaments are mounted in a metal block installed at the outlet of pump, so that total flow passes through it. A change in flow due to restriction of inlet tube will cause a zero shift which must be corrected for best accuracy. Therefore always adjust zero with the hose probe, and any other sampling components connected.

Thermal conductivity filaments connect to a set of terminals found at the end of the sensor block. To replace thermal sensors:

1) Disconnect wires at terminals noting wire color and location.

2) Remove retaining screws at each corner of the sensor plate.

3) Pull out sensor plate with sensors.

4) Install new sensor assembly in same position. Be sure gasket is in place.

5) Tighten screws snugly.

6) Reconnect wires to terminals as noted in 1) above. Turn on, and adjust zero and span.

Filaments will rarely if ever require replacement, as they operate at low temperature.

C. Sample System

1) Probe, consists of a 10" long 1/4" OD plastic tube with a dust filter chamber at the upper end, forming a handle. This filter chamber is of transparent acrylic plastic, so the filter condition can readily be inspected. To replace filter, unscrew filter chamber where it connects to the nickel-plated threaded base. Cotton may be used for filter material; pack cotton in firmly but not tight enough to restrict flow. Replace cotton when it becomes wet or dirty.

2) Hose, is attached by means of a knurled and threaded fitting on each end.

D. Replacement Parts

The only significant additions to the parts list in the accompanying Instruction Manual are:

Stock No.	Description
17-0491	Adapter, inlet
30-0500	Fitting, inlet
62-0106M	Filaments, thermal conductivity
80-0001	Hose, teflon-lined
80-0150	Probe, 10" plastic

When ordering any spares or replacement parts, always specify Model 1939 and serial number.

318 3086-0

INSTRUCTION MANUAL

GASTECHTOR

HYDROCARBON SUPER SURVEYOR

MODEL 1314

PPM/LEL GAS INDICATOR WITH OXYGEN SECTION

AND

MODEL 1238

PPM/LEL GAS INDICATOR

SERIAL NO.: ____________

CALIBRATED FOR: ____________

LEL Alarm: ____________ %LEL

PPM Alarm: ____________ ppm

Oxygen Alarm: ____________ $\%O_2$ (Falling)

____________ $\%O_2$ (Rising)

CONTENTS

MADE BY:

GASTECH, INC.
8445 CENTRAL AVENUE
NEWARK, CALIFORNIA 94560
TELEPHONE: (415) 794-6200
TELEX: 334-462

I. GENERAL DESCRIPTION

The Model 1314 GasTechtor Hydrocarbon Surveyor is a battery-powered portable instrument that can detect and indicate concentrations of combustible gas or vapor in air, in the explosibility and parts per million ranges, simultaneously with measurement of oxygen and detection of oxygen deficiency. It can detect and indicate gas concentrations up to the lower explosive limit and actuate a characteristic audible signal if concentration exceeds a preset level. It also analyzes for oxygen over a range of 0 to 25%, and actuates a different audible signal if oxygen concentration drops below a preset level. In later models, a third characteristic audible signal is actuated if for any reason the oxygen concentration exceeds 25%. Samples of the atmosphere under test are drawn continuously by means of a built-in pump and analyzed for combustible gas on a heated catalytic platinum element. A solid-state amplifier is used to amplify indications of the catalytic element to give adequate meter deflection even on trace gas concentrations. At the same time, the sample passes over an oxygen detector which gives an output in terms of percent oxygen.

Power for the instrument is provided by a built-in rechargeable battery. An extension hose permits withdrawal of samples from specific points or enclosed spaces. An audible alarm, active in both combustibles ranges and in the oxygen range, sounds whenever gas concentration reaches a preset level, and an audible signal is also given in case of malfunction or a dead battery. Instrument is designed to withstand severe service including exposure to water, dust, bumps and rough handling.

The Model 1238 is an equivalent instrument for measurement of combustible gas in two ranges, but without inclusion of the oxygen section. If using the Model 1238, disregard all references to oxygen measurement in this manual.

Primary application is in determining concentrations of various organic vapors around industrial operations. The Surveyor is adaptable for any measurements where small concentrations of combustible gas are to be detected. Other uses are in determining explosion hazard in tanks and other confined spaces, checking for presence of flammable vapors, and investigating cases of suspected arson. With the Model 1314, every test for combustibles or toxic gas is automatically accompanied by a test for oxygen deficiency.

II. DETAILED DESCRIPTION

A. Housing

The Model 1314 is housed in a fiberglass case which is durable, shock-resistant, and protected against entry of water. The lower half, containing the batteries, sensors and sample-drawing system, has no openings near the bottom and hence can safely be placed in mud or water up to 4 cm depth without hazard to the internal components.

The upper half contains all of the electronic circuitry, and is provided with a substantial carrying handle. The lip of the upper case overlaps the lower, to shed water. Upper half is clamped to lower by means of a heavy-duty knurled thumbscrew.

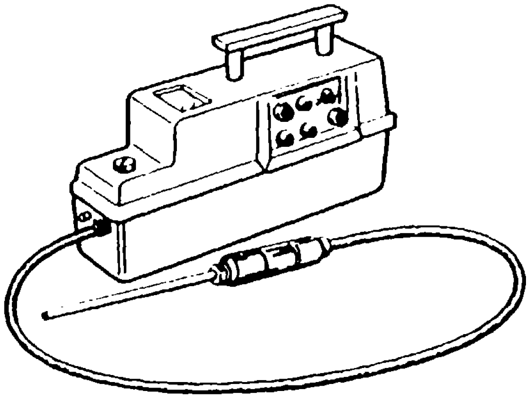


FIGURE 1. MODEL 1314 HYDROCARBON SUPER SURVEYOR

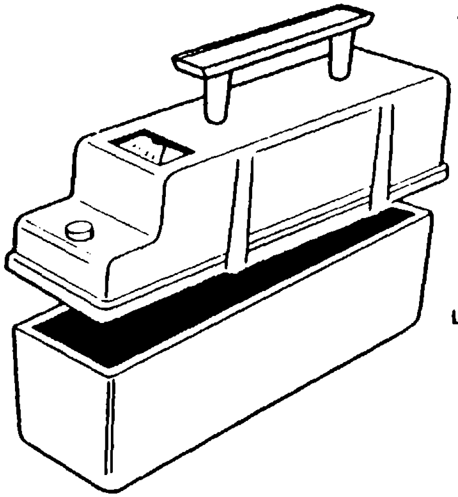


FIGURE 2. MODEL 1314 HOUSING

B. Combustible Gas Sensor

The combustible gas sensitive detector is a replaceable assembly which is installed within an anodized aluminum enclosure or reaction chamber at front of instrument. Detector is retained in chamber by means of a threaded ring, and sealed by an O-ring gasket. Sample enters chamber from the front, flows over the detector, then to the oxygen detector and finally is exhausted to the pump.

The active detector element is of the platinum catalyst type, and an electrically identical but non-catalytic reference element mounted in the same environment serves to stabilize the measurement and compensate for effects of non-combustible gases, temperature variations, etc. Elements are protected by a sintered stainless steel flame arrestor, which permits access of surrounding atmosphere but prevents outward propagation of flame should an explosive atmosphere be sampled. Flame arrestor also acts as a diffuser to isolate elements from flow fluctuations.

Detector assembly connects electrically to circuit board by means of three screw terminals, accessible when upper half of housing is removed.

C. Oxygen Sensor

The oxygen-sensing detector is an electrochemical cell in which gold and lead electrodes are immersed in an alkaline electrolyte, and covered by a permeable fluorocarbon membrane. Oxygen from the surrounding atmosphere diffuses through the membrane and enters into an electrochemical reaction whose rate is directly proportional to the partial pressure of oxygen, the end product of this reaction being lead oxide. The current generated by this reaction is amplified and used to drive the meter and the alarm circuit.

The detector is clamped into a cavity in an anodized aluminum block, through which the sample flows after it leaves the combustibles detector.

D. Meter

Indications of the instrument are displayed on a meter, visible through a window on top face of instrument case. On LEL, the insensitive combustibles scale, meter reads gas concentration in units of explosibility, 0-100% LEL, where 100% LEL represents the minimum concentration of gas in air, below which propagation of flame does not occur when placed in contact with an ignition source.

A mark on scale, "BATT CK", represents the minimum permissible battery voltage, as an indication of state of charge of the battery.

A second scale, 0-500 ppm, is provided for use when instrument is in the PPM range. (0-1000 ppm is an optional range.)

A third scale, for oxygen, reads 0-25% oxygen. A mark on scale, "O_2 CAL", corresponds to the normal oxygen content of atmospheric air, 21%.

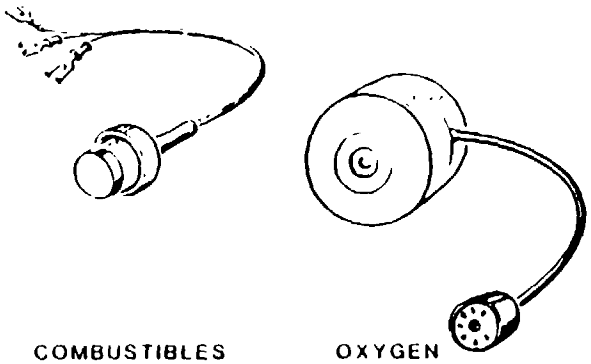


FIGURE 3. SENSORS

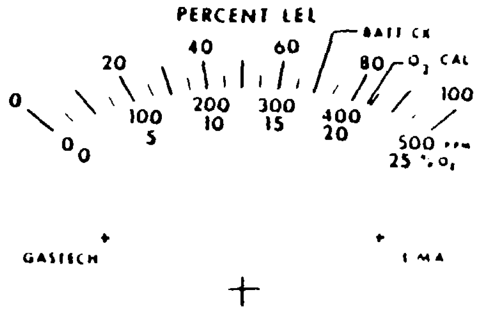


FIGURE 4. METER DIAL

E. Controls & Indicators

1. Controls

The six controls that are used in normal operation of the instrument are arranged on the left side of instrument as viewed from the rear. These controls are recessed to minimize possibility of accidental operation.

a) POWER switch, an alternate-action pushbutton switch which energizes circuit when pressed. An orange indicator dot is exposed when the switch is in the ON position, serving as a mechanical pilot light.

b) BATTERY CHECK, a momentary pushbutton switch, when pressed connects meter as a voltmeter for battery condition check.

c) PPM/LEL ZERO, a potentiometer which is used to adjust combustibles circuit to read zero in the absence of combustible gas. The potentiometer shaft may be fitted with a control knob for convenience in adjustment, or optionally with a screwdriver-adjust slot to minimize accidental change.

d) LEL-PPM switch, an alternate-action pushbutton switch used to select combustibles operating range. When out, the instrument is in LEL range. When in, as indicated by the colored indicator dot, circuit is in the sensitive ppm range.

e) OXY-PPM/LEL switch, an alternate-action pushbutton switch which selects the operating range, either combustibles (PPM/LEL) in the "out" position or oxygen (OXY) in the "in" position. A colored indicator dot shows when the switch is "in". (Not found on Model 1238)

f) OXY CAL, a potentiometer which is used to adjust circuit to read 21% when detector is surrounded by known normal air. It also may be fitted with a knob or an optional slotted shaft. (Not found on Model 1238)

g) Other controls, used in adjustment but not in routine operation, are described in Circuit Board Section below.

2. Indicators

Alarm lights, red and amber, illuminate when the corresponding section of instrument is in alarm condition. Red light blinks in an on-off pattern of equal length pulses, to show that instrument is in combustible gas (LEL or PPM) alarm condition. Amber light blinks in a short-long pattern to show that instrument is in abnormal oxygen condition. (Not found on Model 1238)

F. Buzzer

A solid-state electronic buzzer is mounted at the rear of instrument, behind perforations which permit transmission of sound. The buzzer gives a pulsed tone on detection of gas or oxygen deficiency, and a continuous tone in case of excess oxygen or a malfunction, either low battery voltage or downscale drift of meter. The audible tone pulses correspond to the visual pulses of the corresponding alarm light, except in the case of excess oxygen which gives a steady tone.

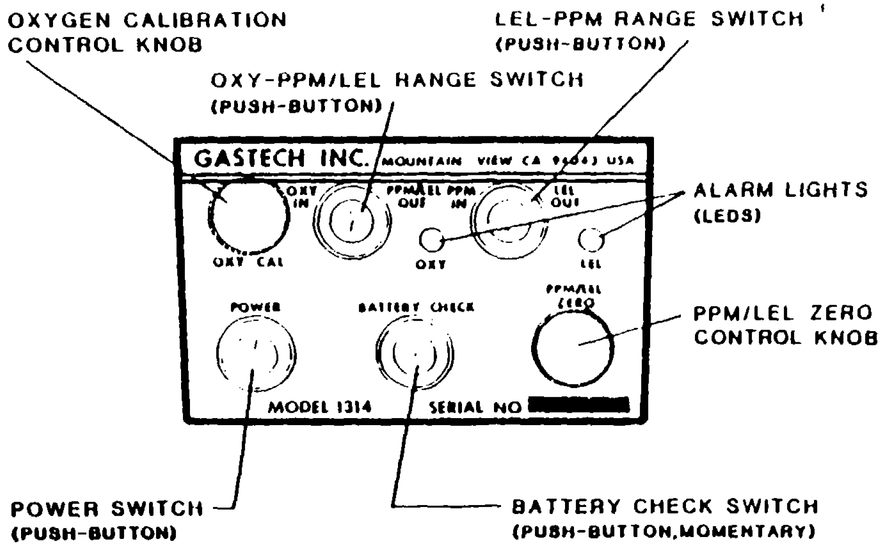


FIGURE 5. CONTROLS AND INDICATORS

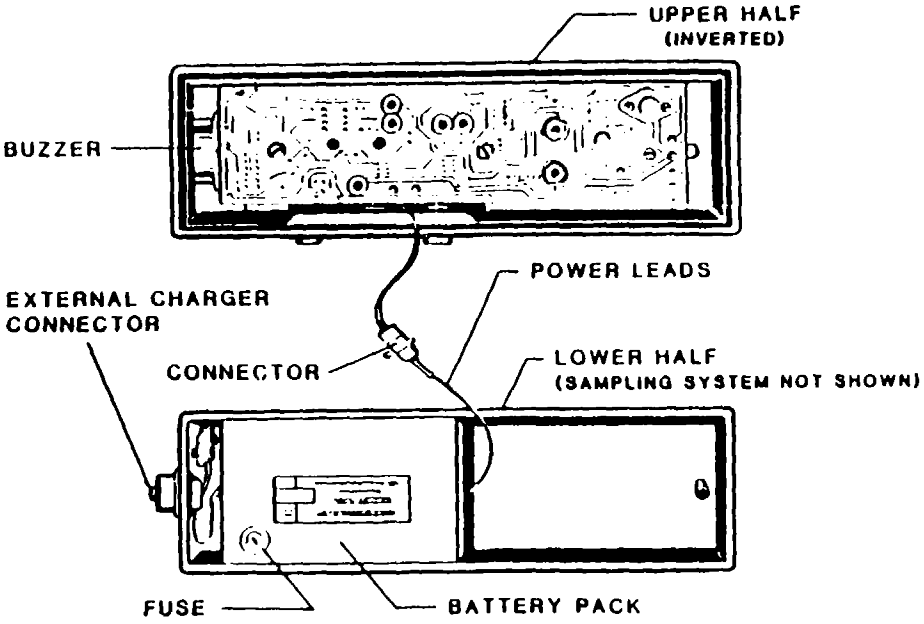


FIGURE 6. INTERIOR OF UPPER AND LOWER HALF

G. Batteries

The battery pack, consisting of seven 3.5 ampere-hour nickel-cadmium cells in series, is secured within lower half of case. The cells are sealed as a unit, either with threaded bushings in bottom for clamping to instrument case, or with holes all the way through to accommodate 3"-long screws and a hold-down bar. Power output (red and black) leads extend from front end of pack, and terminate in a plastic plug connector which mates with a connector on the main circuit board. A similar connector at rear connects to the charger socket, so that battery may be unplugged at both ends for convenient removal. Current limiting resistors sealed into the pack limit maximum current that can be drawn on short circuit. Battery pack will power the instrument for approximately 10 hours. A protective fuse (type 3AG 1 amp) is installed in a recessed fuseholder set into top surface of pack, and serves as an added protection against short circuit or overload.

GasTechtor instruments may be supplied with the 49-8051 Battery Pack, with replaceable cells. This design was developed for the convenience of replacing any cell that may fail, in lieu of having to replace an entire battery pack. This battery pack is permanently secured by two screws through the bottom of the case. Instruments bearing the UL classification label always use this pack.

H. Circuit Board

All circuit components are arranged on two epoxy-glass printed circuit boards. The main board includes the power supply, the combustibles amplifier and alarm circuits and associated controls. A second board is installed above the main board, and is related primarily to the oxygen detection circuit. It is inaccessible while instrument is assembled, except for the two potentiometers which are reached through access holes on main board. *(Second board not found in Model 1238).*

1. Five miniature adjustment potentiometers are provided on underside of main circuit board, available for user adjustment when case is opened, by use of a small screwdriver:
   a) Coarse ZERO, used to balance the Wheatstone bridge to zero initially, when a new detector is installed.
   b) LEL ALARM Threshold, to set the audible alarm to be actuated at a specific meter reading on the LEL range. A typical setting is 20% LEL.
   c) PPM ALARM Threshold, to set the audible alarm to be actuated at a specific meter reading on the ppm range. 100 ppm would be a typical setting.
   d) LEL SPAN, is used to set sensitivity or span in LEL range.
   e) PPM SPAN, is used to set sensitivity in ppm range.

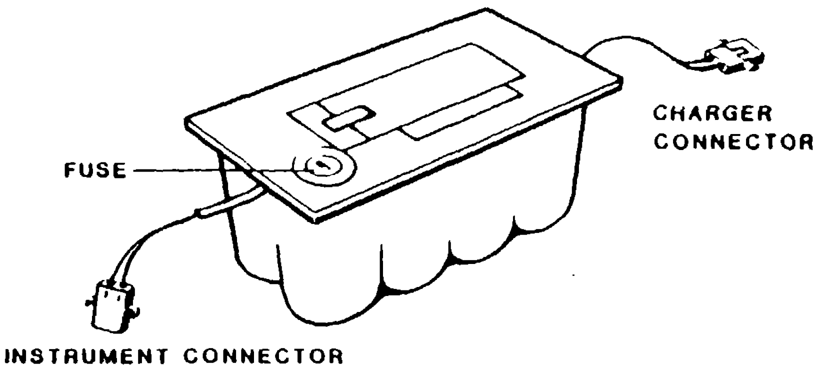


FIGURE 7. STANDARD BATTERY PACK

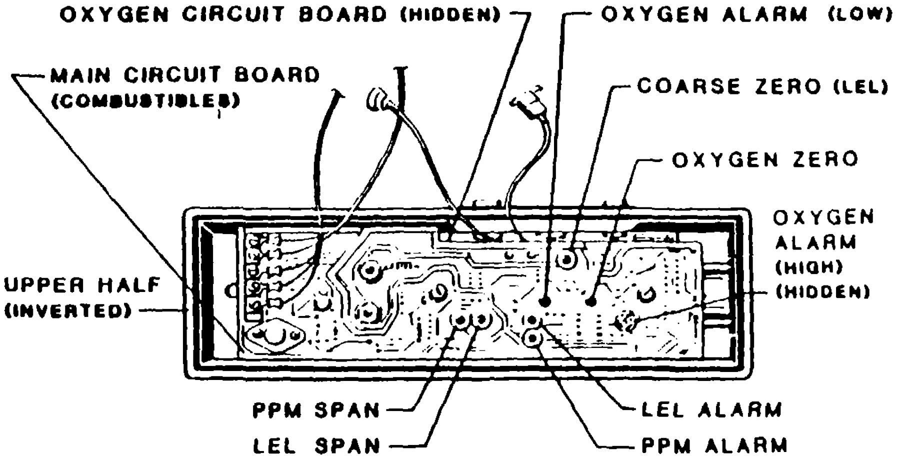


FIGURE 8. CIRCUIT BOARDS WITH ADJUSTMENTS

2. Two miniature adjustment potentiometers are provided on the underside of upper oxygen circuit board, accessible when case is opened and adjustable by use of a small screwdriver through the two holes in main board.

   a) ZERO, to balance the oxygen circuit for zero output while the detector is sampling oxygen-free gas such as nitrogen. This is the control closer to the rear.

   b) ALARM Threshold, to set the oxygen concentration at which the oxygen deficiency alarm is actuated.

   c) The high oxygen alarm (25%), provided on the later models, is factory set, and can be readjusted only when the main board is removed.

I. Sample System

Sample system consists of the flow path, from probe to hose to sample inlet to reaction chamber to pump, to oxygen chamber and exhaust. These components are further described below.

1. Probe consists of a 10" long 1/4" OD plastic tube with a dust filter chamber at the upper end, forming a handle. This filter chamber is of transparent acrylic plastic, so the filter condition can readily be inspected. To replace filter, unscrew filter chamber where it connects to the nickel-plated threaded base.

2. Hose, a 5' flexible polyurethane tube equipped with a male quick-connect coupling with an O-ring seal, to engage inlet fitting of instrument on one end. The opposite end has a threaded fitting onto which the probe is fitted.

3. Inlet fitting, a quick-release female coupling on front of instrument, is screwed directly into reaction chamber. A sintered stainless steel disk is permanently installed within fitting, and serves as a filter to remove dust from incoming sample.

4. Reaction chamber, housing combustibles detector, is an anodized aluminum block with threaded neck and lock nut to retain detector in flow path of sample. An outlet nipple and flexible tube connect chamber to pump.

5. Pump is of the motor driven diaphragm type, with a brushless DC motor having no commutator or sparking contacts. It operates directly from the battery output whenever power switch is on.

6. Oxygen chamber, holding oxygen detector, is an anodized aluminum block with a cavity into which oxygen cell is clamped. An O-ring seal is provided to prevent leakage from chamber, and a spring clamp bar maintains pressure against the seal, but can be swung aside and removed when changing cell.

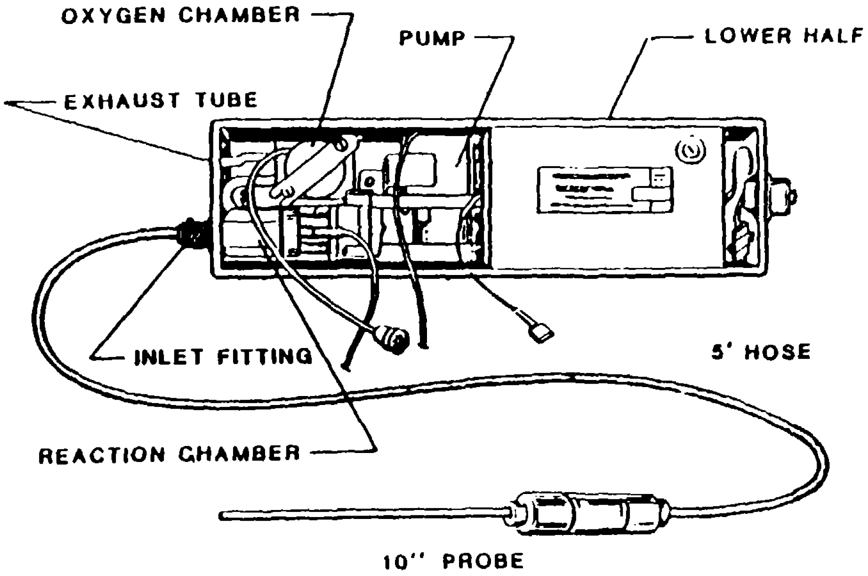


FIGURE 9. SAMPLE DRAWING SYSTEM

J. Charger

A separate battery charger is provided, which plugs into socket in rear of case. Charger provides current at a rate sufficient to recharge batteries overnight. Current tapers down to the point that it can be left connected for several days without damaging battery; however, avoid charge periods longer than 24 hours if possible.

Charger is wired for 115V or for 230AC 50/60 Hz power source (see nameplate for voltage rating of charger supplied with this instrument.)

K. Continuous Operation

Instrument can be operated continuously from a 12 volt DC source, such as a 12 volt vehicle battery, by use of a Continuous Operation Adapter. This is a power cord with voltage-dropping diodes built in, and with a mating plug to fit charger socket. When connected to instrument and to a 12 volt source, it will carry the load and tend to recharge the battery. It may also be used as a DC charger.

When connecting the Adapter, be sure that polarity is observed, with the lead marked + connected to the + 12 volts DC source.

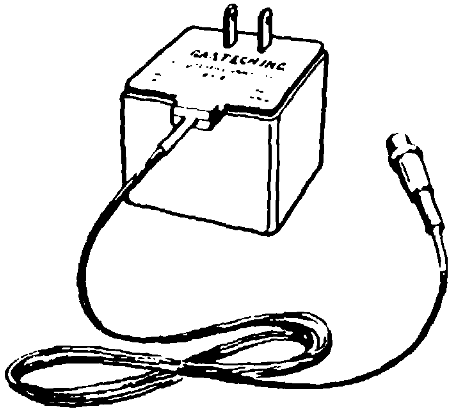


FIGURE 10. BATTERY CHARGER

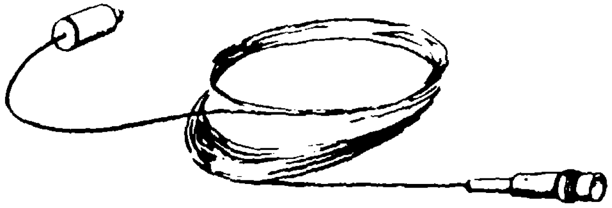


FIGURE 11. CONTINOUS OPERATION ADAPTER

III. OPERATION

A. Normal Operation

To use instrument, carry out the following steps:

1. Attach hose to instrument by means of the quick release fitting.

2. Put LEL-PPM switch in LEL (out) position, with black indicator showing, and OXY-PPM/LEL switch also in LEL (out) position.

   Press POWER switch to turn instrument on, with orange indicator dot showing. Meter will normally rise upscale and pulsing or steady alarm signal may sound. Audible hum of pump will be noticed. Cause of alarm condition (combustibles, oxygen, or both) can be identified by the blinking lights.

4. Press BATTERY CHECK button and note meter reading. If reading is close to or below BATT CHECK mark on meter, recharge batteries.

5. Allow to warm up until meter stabilizes (about a minute). If pulsed oxygen alarm continues to sound, turn OXY CAL potentiometer clockwise to stop it. If the sound is steady, turn the potentiometer counterclockwise. Then, with hose inlet in a gas-free location, turn PPM/LEL ZERO potentiometer to bring meter to "0" indication. (If impossible to reach zero within span of potentiometer, adjust COARSE ZERO. See V.A.2. and 3.)

6. Next put OXY-PPM/LEL switch in the OXY (in) position, so that orange indicator shows. Turn OXY CAL potentiometer to bring meter to the O_2 CAL mark (21%).

   As a quick check, gently breathe into hose inlet and allow instrument to sample expired air. Reading should come down to about 16, and alarm should sound at 19.5%. Allow it to return to 21, then put switch back in LEL position.

7. An atmosphere containing more than the normal 21% oxygen content will produce an increased oxygen reading. If instrument is provided with a high oxygen alarm, then it will sound in a steady tone and the amber alarm lights will blink when reading reaches or exceeds 25%.

8. Instrument will automatically test for oxygen whenever it is used, and will give pulsed audible and amber light alarm if oxygen content drops to 19.5%. It is not necessary to use instrument with switch in the OXY position unless oxygen measurements are of primary interest. If both abnormal gas conditions exist simultaneously, both lights will blink in their normal pattern, but buzzer will sound continuously.

9. For readings in the 0-100% LEL range, hold [illegible] let at point to be tested. Watch meter and observe maximum reading as taken from the upper set of graduations, 0-100% scale. If reading rises above alarm setting (initially 20% LEL), pulsed red light and audible alarm will commence, and will continue as long as reading remains above alarm point. After taking reading, purge instrument with fresh air before turning off.

10. If reading on 0-100% range is imperceptible or very small, use the sensitive range, 0-500 ppm. First allow to warm up in the LEL range, and then push LEL-PPM range switch to put circuit in PPM range (colored indicator shown). Rezero carefully with the PPM/LEL ZERO potentiometer.

    Because of the very high sensitivity of this range, meter will tend to drift until instrument is thoroughly warmed up. Always let it run for 5 minutes or more, whenever possible, before operating on the PPM range. Take reading immediately after zeroing, and observe maximum deflection as taken from the middle set of graduations, 0-500 PPM scale. Again, alarm will sound whenever reading rises above preset alarm level (initially 100 ppm).

NOTE

Instrument may be equipped with the optional 0-1000 ppm sensitive range, or with some special range. See Title page for information on actual range of instrument as supplied by factory.

IV. INTERPRETATION

A. LEL Range

This range gives readings in terms of nearness to the lower explosive limit (LEL), with 100% corresponding to the LEL of the gas for which the instrument is calibrated.

Detection in this range is by catalytic oxidation on a platinum element, with the heat of oxidation producing a temperature rise and hence a resistance rise of the element. This change is approximately linear up to the LEL provided there is sufficient oxygen in the sample to support combustion.

B. PPM Range

This is a very sensitive range, obtained by amplification of the signal from the catalytic element. Sensitivity is set for a direct reading in ppm of the gas for which the instrument is calibrated.

Even though the sensing element is compensated to minimize the effect of non-combustible gases, a residual effect is still observable at the high sensitivity level. Thus the instrument may need to be rezeroed if exposed to a change in humidity, or to a change in background level of CO_2 or other inert gas.

Other combustible gases will give a response on the PPM range, but will not be direct-reading and will require a calibration curve or correction factor. A few typical conversion factors are included in this manual; refer to Table I, page 32.

C. Oxygen Range (Model 1314 only)

Normal readings will be around 21%, with alarm set about 19.5% for decreasing oxygen. If instrument is provided with a high oxygen alarm, it will sound at 25% on increasing oxygen . However, readings are linear all the way from 0-25%. If readings are to be taken close to zero, as in checking inert gas, first check and adjust zero setting, as described in Sect. V.

D. Abnormal Indications

1. If battery voltage drops below the designed value (about 8.2 volts) the low battery alarm will sound. This is a continuous audible tone. To verify the cause of the alarm, press BATTERY CHECK switch and note that meter reads below check mark. Intensity of alarm sound will increase gradually over a period of a half hour, giving ample warning prior to actual failure.

2. If combustibles range (LEL or PPM) drifts or moves below 0 by 10% or more, the low limit alarm will sound. This is also a continuous tone, and the cause can be recognized by a glance at the meter, in the LEL or PPM range. Downscale meter movement can be caused by incorrect zero adjustment, or by a break in detector or detector wiring.

3. If oxygen cell output declines or deteriorates, as is likely toward the end of cell life, this will produce a reduced reading, and alarm.

4. If oxygen detector is unplugged, or if one of the wires connecting it internally is broken, reading will go to zero, or below, and alarm will come on.

5. On some later models, the steady audible tone sounds when the oxygen reading exceeds 25%. This characteristic is provided to warn against the increased fire hazard due to excess oxygen. It also serves as a warning in case of oxygen cell failure in the high-output mode, which can occur occasionally. It further precludes accidental or intentional incorrect adjustment of the oxygen calibration control to an abnormally high level above 25.

V. CALIBRATION AND ADJUSTMENT

A. Combustibles Calibration

To check and adjust calibration on a known gas sample.

1. Turn instrument on and allow it to warm up and stabilize, preferably for 5 minutes. Be sure batteries are charged sufficiently to read above the check mark.

2. Open instrument case by loosening captive screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate COARSE ZERO potentiometer on underside of circuit board (marked "ZERO").

3. Turn external PPM/LEL ZERO control to center of its span. Then turn COARSE ZERO potentiometer to bring meter to zero reading.

4. To calibrate the LEL range, insert sample inlet tube into a vessel or other source of known calibrating gas. Watch meter and note highest reading. If it is incorrect, turn LEL SPAN potentiometer to give desired reading.

5. For PPM calibration, follow same procedure with range switch in PPM position, and use PPM SPAN potentiometer. Before making this adjustment, allow system to warm up and stabilize thoroughly, and zero carefully in the PPM range.

NOTE

In the sensitive ppm range it is important that the humidity of the sample be the same as that of the air used for zero adjustment. If they are different, a significant offset in zero reading may be observed. To overcome this, a humidifier may be used for both zero and calibration tests, providing the calibrating gas is one that will not be absorbed in water. The GasTech Calibration Kit is supplied complete with humidifier and accessories for this effect. See Appendix A.

6. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

B. Combustibles Alarm Threshold

The reading at which the alarm is actuated in each range can be set by use of the corresponding ALARM Threshold potentiometer.

To Set:

1. With instrument in range to be set, turn PPM/LEL ZERO adjust to bring meter to desired alarm setting. It may be necessary to use the COARSE ZERO to reach this point, in LEL range.

2. Turn corresponding (LEL or PPM) ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will lower alarm setting. Verify setting by turning PPM/LEL ZERO control to bring meter indication into and out of alarm zone.

3. When the combustibles Alarm Threshold has been satisfactorily set, readjust the zero potentiometers to establish a zero meter reading as in A.3 above.

C. Oxygen Zero Adjustment

The following steps should be carried out with OXY-PPM/LEL switch on OXY (in) position. To check and adjust zero on a known oxygen-free sample:

1. While instrument case is open, identify ZERO potentiometer, which is located on oxygen (upper) circuit board and which can be reached through the rearmost of the two clearance holes in the main circuit board.

2. Allow instrument to sample a known oxygen-free sample, such as nitrogen, argon, or helium.

3. Watch meter carefully. If reading does not go exactly to zero, adjust it by turning ZERO potentiometer. Counterclockwise rotation will decrease reading.

4. If zero adjustment cannot be made, have oxygen cell reactivated.

5. After zero adjustment has been completed, return hose inlet to normal atmospheric air. Readjust OXY CAL control as necessary to bring meter reading to 21.

6. If reading cannot be set high enough, have oxygen cell reactivated.

D. Oxygen Alarm Threshold

The reading at which the oxygen alarm is actuated can be set by use of the ALARM Threshold potentiometer.

To Set:

1. Turn OXY CAL to bring meter to desired alarm setting.

2. Locate oxygen alarm threshold potentiometer, on oxygen circuit board, which is accessible through the hole adjacent to the LEL Alarm adjustment.

3. Turn ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning OXY CAL control to bring meter into and out of alarm zone.

4. When the oxygen Alarm Threshold has been satisfactorily set, readjust the OXY CAL potentiometer to bring the meter reading to 21% (O_2 CAL).

E. Oxygen High Alarm (25%)

This alarm point is factory set and generally need not be changed. It can be readjusted to some other level, by trial, but this can only be done when the main board is loosened and pulled aside (see Section VI.D. steps 1-6). The high alarm potentiometer is the one closest to the rear, without an access hole.

VI. MAINTENANCE

A. Batteries

1. Check battery voltage periodically by pressing BATTERY CHECK switch. Recharge before voltage reaches minimum.

   When connecting charger, always follow these steps:

   a) Confirm that the plug is inserted in the correct way, with the THIS SIDE UP label upwards. The socket is polarized, with the pins offset below the centerline, but can sometimes be forced on the wrong way, particularly if it has become worn with use.

   b) Verify that a charge is actually entering battery. To do this, turn instrument on and check meter reading while BATTERY CHECK button is pressed. Observe reading while charger is plugged and unplugged at wall socket. If reading increases when charger is connected, and decreases when unplugged, battery is receiving a charge. If no change is observed, then probably charger or power circuit is at fault. If charger is defective, return it for repair or replacement.

   After verifying that instrument is accepting a charge, turn instrument switch off. Do not attempt to charge while instrument is turned on.

2. If sufficient voltage cannot be obtained after charging, open instrument and:

   a) Check voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   If voltage is acceptable, but volt check reading is too low, meter or switch could be at fault. If voltage is too low, battery is at fault.

   b) If no output voltage can be obtained, check fuse by unscrewing recessed cap, marked "FUSE", and removing fuse. It can be checked visually or with an ohmmeter. If burned out, replace with a new one, but be sure to attempt to identify the cause of the overload or short circuit. Fuse must be type 3AG-1A.

   c) If battery voltage is too low, and cannot be brought up by overnight charging, it probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector at charging end.

3. If the replaceable cell battery pack has been installed and is found defective, open the pack and check the voltage of each individual cell with a voltmeter. Remove two screws on the top of the pack with a 1/8" Allen wrench. The lid is spring loaded and may be held down by hand to ease the screw removal. Carefully remove the lid and the individual cells.

   a) The cells supplied are the Stock No. 49-1501 rechargeable D-size nickel-cadmium type, 3.5-4.0 AH, and when charged, measure about 1.35 volts. Discard and replace faulty cells.

   b) Examine the battery cavity and carefully clean out all foreign substances. Re-insert the cells into the pack in accordance with the diagram on the lid. (Negative end to springs, button end to rivets.) Leave the proper space open for the fuse cartridge.

   c) Place the lid onto the cells, press down firmly and insert screws. The convoluted case will assure cell alignment. Tighten the screws snugly, do not overtorque. It may be necessary to spring sides of instrument case apart slightly to clear battery lid.

   d) Join all loose connectors, re-assemble instrument and charge battery as required.

   e) If normal operation from disposable batteries is desired, use the Stock No. 45-8052 battery pack instead of the 49-8051 pack. This assembly has a quick change feature, a retainer strap which can be pushed aside with thumb pressure to release the lid and give access to the cells. Duracell* type disposable batteries are recommended for a proper fit.

   This battery pack has no charger connection, so there is no danger of inadvertent charging of disposable cells. It can be used with rechargeable cells, but they must be charged separately.

*Duracell is a trade name for Duracell Inc., Bethel, CT 06801.

B. Combustibles Detector

1. Sensor assembly may require replacement if:

   a) Meter cannot be set to zero within range of ZERO potentiometer. (Including COARSE ZERO)

   b) Meter cannot be set to desired level within range of SPAN Adjust, either range.

2. To replace detector:

   a) Open instrument case.

   b) Unscrew the red, green and white wires at terminals on main circuit board, noting color coding.

   c) Unscrew knurled retaining cap at reaction chamber.

   d) Pull out original detector and install new one, being sure that O-ring is in place, under flange of detector.

   e) Connect wires to terminals, turn power on, and adjust COARSE ZERO as in Sect. V.A.3.

C. Oxygen Detector

1. Oxygen sensor assembly may require repair if:

   a) Meter cannot be set to desired level within range of OXY CAL Adjust.

   b) Meter cannot be set to zero within range of ZERO potentiometer.

2. If oxygen sensor assembly requires repair, it should be sent to factory for reactivation. Alternatively, a complete new detector can be ordered, on an exchange basis.

   Oxygen cell is an electrochemical device similar to a battery, which gradually depletes itself, regardless of usage of the cell. It requires periodic reactivation, consisting of replacement of the electrolyte and the membrane, plus cleaning and inspection of the electrodes. This is most economically done at the factory.

   New and reactivated oxygen cells carry a factory guarantee based on length of time from date of original shipment, and are date-coded. Cells returned for reactivation are inspected and in-warranty cells are tested for operability. Any that fail prematurely receive a warranty allowance.

   To replace oxygen sensor:

   a) Open instrument case. Locate oxygen cell.

   b) Swing retainer clamp clockwise and remove it to release cell.

   c) Tilt cell upward and pull it out of case. Unplug cell wire at socket.

   d) Reinstall new or newly reactivated cell in same position. Before installing, remove protective seal from face of cell, and shake out any drops of water that may be found under seal.

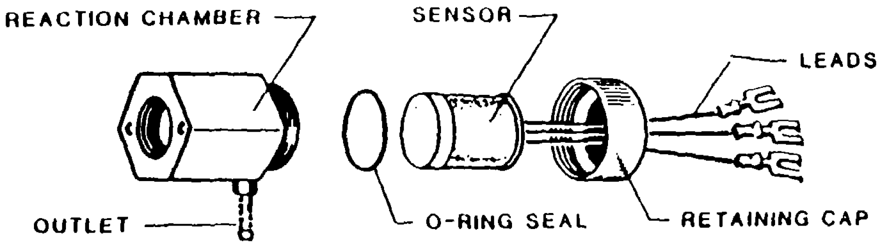


FIGURE 12. COMBUSTIBLES DETECTOR

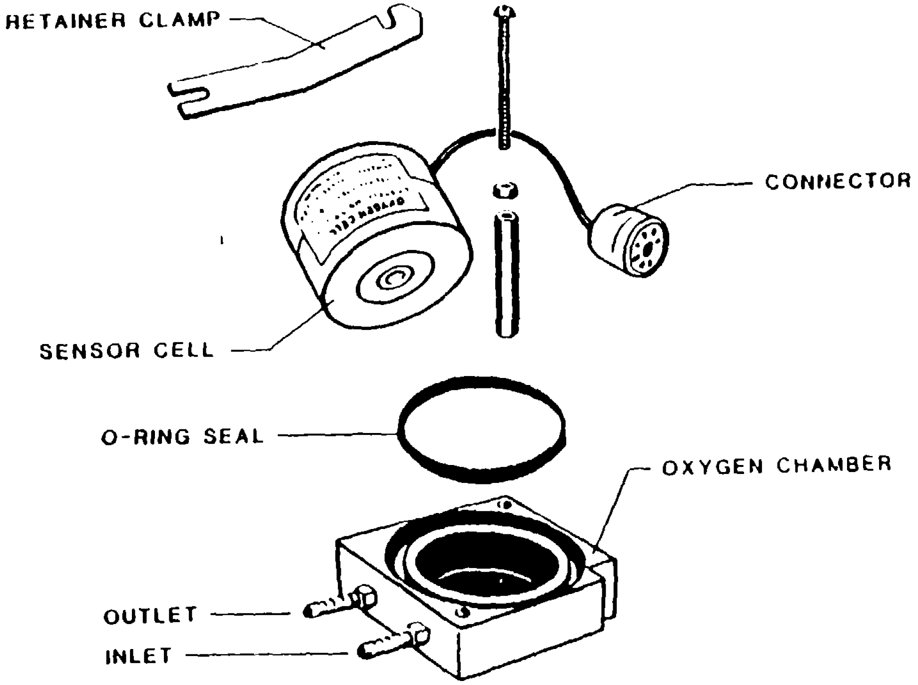


FIGURE 13. OXYGEN DETECTOR

D. Meter

If meter is damaged, it can be removed for repairs or replacement, as follows:

1. With upper half of instrument removed from lower half and inverted, loosen internal lock nuts from POWER and BATTERY CHECK switch bushings and PPM/LEL ZERO potentiometer bushing.
2. Remove external lock nut from PPM/LEL ZERO potentiometer. (First remove knob, if one is used.)
3. Remove external face nuts from switch bushings.
4. Remove three screws holding circuit board into case.
5. Remove two nuts from meter studs.
6. Pull circuit board out of case as far as connecting wires permit.
7. Lift out meter.

E. Buzzer

If buzzer fails, it can be removed by first taking out circuit board (Steps D.1-D.6) and unsoldering red and black wires at board. Then remove retaining screws and nuts.

Note: Before removal, first verify that buzzer is actually defective. Connect to a 6 volt battery (Red +, Black -). A good buzzer will give a steady tone.

F. Circuit Board

Main circuit board can be removed by steps D.1-D.6, plus E, plus disconnection of pump and detector wires at terminals. This allows the board to be pulled out of the case and put aside for access to the oxygen circuit board. However, it will remain connected to the oxygen board until the interconnecting wires are unsoldered.

Preferably, both boards will be removed as a unit, and returned to factory for repairs. To complete removal, loosen internal lock nuts, remove external lock nuts from remaining controls, and take off the hex plastic spacers which hold oxygen board in place.

G. Filter

The filter element in inlet fitting is pressed in but can be pushed out and replaced. When necessary, the complete fitting can be replaced.

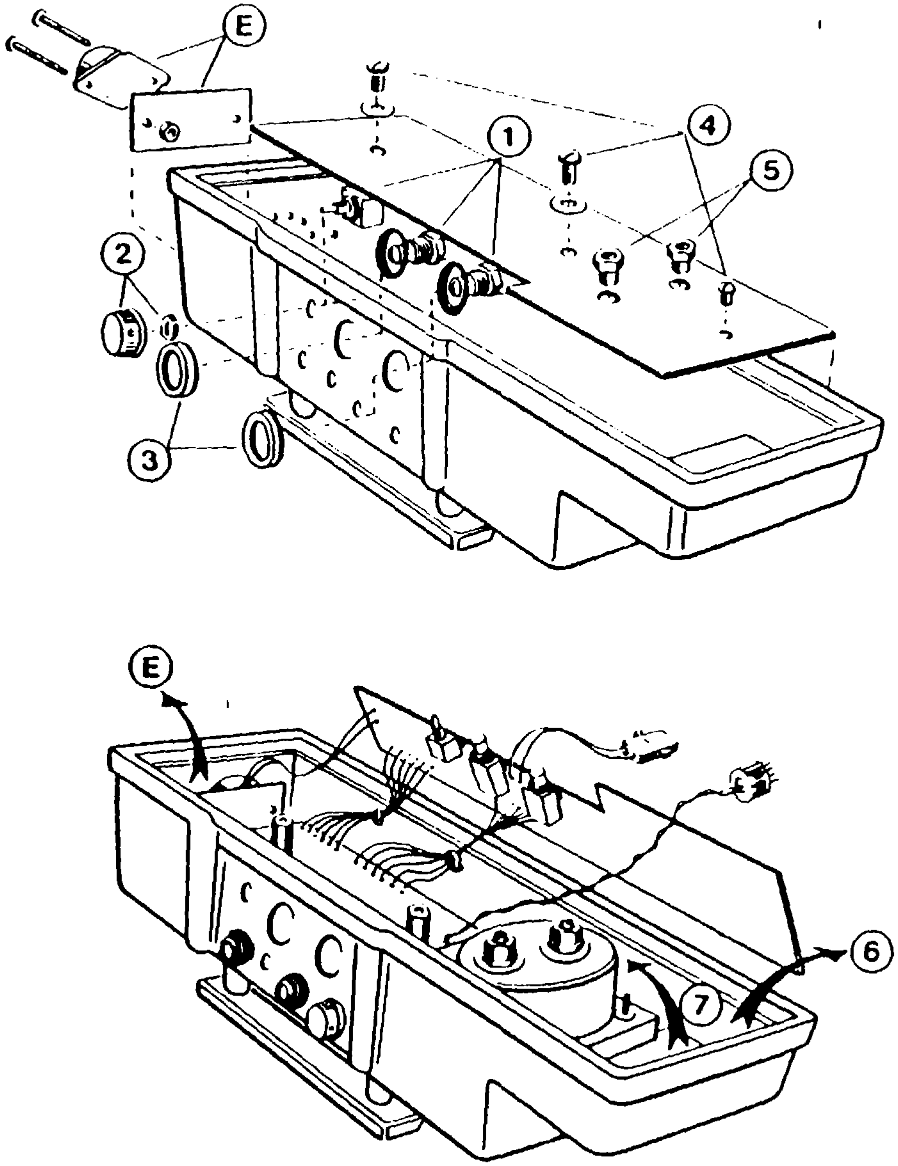


FIGURE 14. METER, BUZZER AND CIRCUIT BOARD REMOVAL / REPLACEMENT

H. Pump

Pump used is a diaphragm type, driven by a brushless DC motor. It should have long life, several years in normal operation, but it may lose efficiency if dirt is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for initial gas response to occur. This should be within 5 seconds for a 10' hose. It may also be checked with the flowmeter provided as a calibration *accessory. Flow should be 2.0 cfh or greater.*

If pump needs servicing, it can be removed by taking out the clamp retaining screw which extends through case bottom. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies and diaphragms are available.

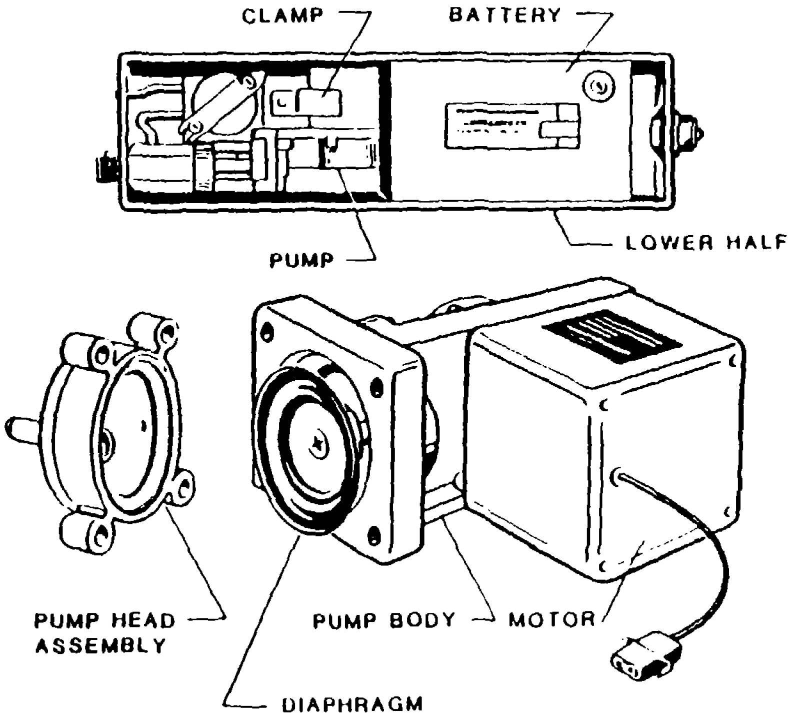
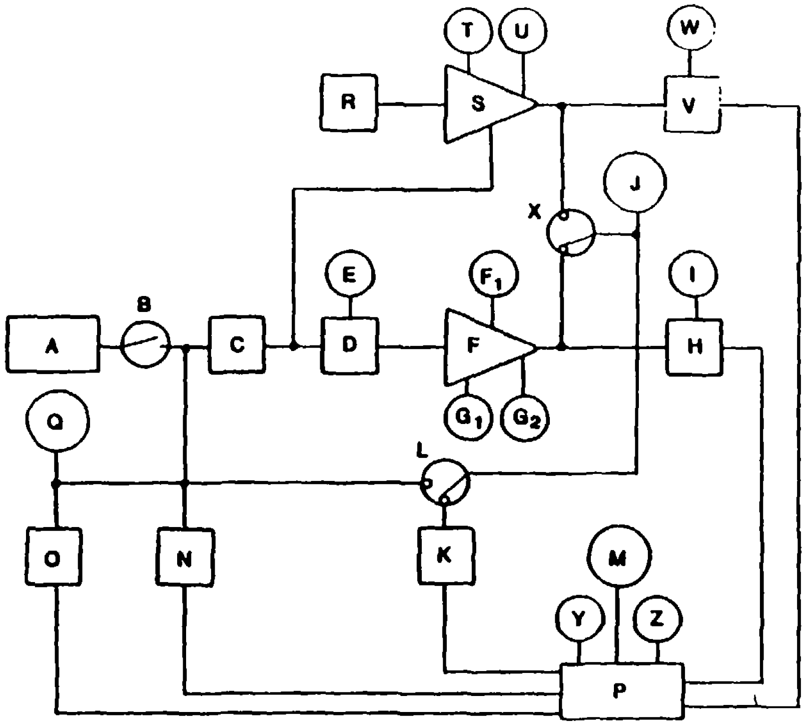


FIGURE 15. PUMP ASSEMBLY FOR MODEL 1314

VII. CIRCUIT DESCRIPTION

Referring to block diagram:



A. Battery pack, rechargeable, nickel-cadmium, giving 8 hours of operation.

B. On-off switch, push on/push off.

C. Voltage regulator, input 8.0 - 10 volts, output 6.0 volts ± .05.

D. Combustibles detector, with active (catalytic) and reference (non-catalytic) elements, forming half of Wheatstone bridge measuring circuit. Two fixed resistors complete bridge.

E. Zero Adjust, a potentiometer in the fixed side of the bridge used to bring the bridge to balance in the absence of gas. Two potentiometers are used, a coarse and fine adjustment.

F. Amplifier, Signal differential, to increase output of bridge to a suitable level for indication and alarm actuation.

F1. Range switch, alternate-action pushbutton, to select LEL or PPM ranges by change of amplifier gain.

G. Span Adjust, to set meter reading to desired value for a known sample. Two adjusters, G1 and G2, serve PPM and LEL ranges respectively.

H. Alarm switching circuit, to turn on combustibles alarm signal when amplifier output reaches a predetermined point.

I. Alarm threshold adjustment, to set the point at which combustibles alarm is actuated. (One each for LEL and PPM ranges)

J. Meter, reads output of amplifier, in units of percent explosibility, in PPM, or in percent oxygen depending upon range.

K. Malfunction alarm switching circuit, turns on alarm due to amplifier output below zero.

L. Batt. Test switch, to connect meter as a voltmeter momentarily, to check battery voltage.

M. Buzzer, a solid-state electronic sounder which delivers a continuous tone when energized.

N. Multi-Vibrator, an oscillating circuit to give a pulsating signal to buzzer, as an identification of alarm condition.

O. Voltage-sensing circuit, to detect low battery voltage and actuate alarm signal.

P. Logic circuit, to accept signals of various types and direct them to buzzer circuit.

Q. Pump, vibratory diaphragm type, to draw sample continuously through sample system and over detector.

R. Oxygen Sensor, which supplies a signal voltage proportional to oxygen concentration.

S. Amplifier, oxygen, to increase output of sensor to a suitable level for indication and alarm actuation.

T. Zero, oxygen, a potentiometer used to balance output of amplifier to zero in the absence of oxygen.

U. Span, oxygen, a potentiometer used to set gain of amplifier to give desired sensitivity on a known calibrating sample.

V. Alarm switching circuit to turn on oxygen alarm signal when amplifier output drops or rises to a preset point.

W. Alarm Threshold adjustment, to set the point at which oxygen alarm comes on. (One each for falling and rising alarm.)

X. Range switch, to select range for readout of meter, either oxygen or combustibles.

Y. Alarm light, oxygen, which blinks on and off whenever system is in oxygen alarm condition.

Z. Alarm light, LEL, which blinks on and off whenever system is in combustibles alarm condition.

VIII. PRECAUTIONS AND NOTES ON OPERATION

A. Heated Samples

When sampling spaces such as hot tanks that are warmer than the instrument, remember that condensation can occur as the sample passes through the cooler sample line. Water vapor condensed in this way can block the flame arrestor and interfere with pump operation.

If heated hydrocarbon vapors of the heavier hydrocarbons (flash point 90°F or above) are present, they may also condense in the sample line and fail to reach the filament. Thus an erroneous low reading may be obtained.

B. Filament Poisoning

Certain substances have the property of desensitizing the catalytic surface of the platinum filament. These substances are termed "catalyst poisons" and can result in reduced sensitivity or in failure to give a reading on samples containing combustible gas. The most commonly encountered catalyst poisons are the silicone vapors, and samples containing such vapors even in small proportions should be avoided.

Occasional calibration checks on known gas samples are desirable, especially if the possibility exists of exposure to silicones. Where persistent poisoning action occurs, special silicone-resistant elements are available.

C. Other Gases and Vapors

The instrument is designed and calibrated specifically for the gas specified in the original order. It can be recalibrated and used on other gases and vapors, by proper use of the calibration control while sampling a known gas-air mixture.

D. Rich Mixtures

When sampling rich mixtures, on the 100% LEL range, the following instrument action may be expected:

1. mixtures up to 100% L.E.L. - Reading on scale
2. mixtures between L.E.L. and Upper Explosive Limit (U.E.L) - Readings at top of meter
3. mixtures above U.E.L. - As sampling continues, the meter first goes to top of scale, then comes back down on scale. Very rich mixtures will give close to a zero reading.

E. Oxygen Deficient Mixtures

Samples which do not have the normal proportion of oxygen may tend to read low, as there is not enough oxygen to react with all combustible gas present in the sample. As a general rule, samples containing 10% oxygen or more have enough oxygen to give a full reading on any combustible gas sample up to the L.E.L.

F. Arson Investigation

Flammable liquids (gasoline, kerosene or paint solvent) are often used in starting intentional fires. Investigation of such fires can be greatly aided if the presence and location of such liquids can be determined at the site, as soon as possible after the fire is extinguished. The Hydrocarbon Surveyor can be of great assistance in making this determination.

In testing for residual flammable liquids, look for places where the liquid could have been trapped and where it might remain even after the fire. Naturally, if the entire structure has been consumed there is little likelihood of any liquid or vapors remaining. Conversely, the earlier the fire has been extinguished, the greater the chance of finding significant amounts of liquid remaining.

In checking for residual volatile liquids, set the instrument up in accordance with the preceding instructions, allowing it to run for at least 5 minutes, in the LEL range. Then turn to ppm range and balance zero carefully immediately before taking the test.

Hold end of hose or probe at point where vapors may be present, and watch meter carefully for any sign of a deflection. Check at joints or cracks between boards, for example under baseboards or plates in contact with flooring. Pry boards up to form a small crack where hose or probe may be inserted. Check also under unburned portions of rug or upholstery, or any point where liquid might logically have soaked in and remained.

If a positive indication is obtained, trace it to the point of maximum reading. This is the point where samples should be taken for further lab analysis.

IX. PARTS LIST

Stock No.	Description
06-5012	Hose, Polyurethane, inlet, 5'
07-6010	O-Ring Seal, hose (probe end)
07-6011	O-Ring Seal, hose (instrument end)
07-6014	O-Ring Seal, inlet fitting
07-6115	O-Ring Seal, combustibles detector
07-6216	O-Ring Seal, oxygen cell cavity
17-0434	Inlet fitting w/filter
33-1016	Filter disk only, inlet fitting
30-0016	Pump, rotary DC
30-0340	Pump head, replacement
30-0342	Pump valves, replacement, set of 2
43-4140	Fuse, battery, 3AG 1A
45-8051	Battery Pack, replaceable, rechargeable cell, less batteries
45-8052	Battery Pack, replaceable, disposable cell, less batteries
49-1201	Battery, alkaline size D disposable (for use in 45-8052)
49-1501	Battery, Ni-Cad, rechargeable (for use in 45-8051)
49-1571	Battery Pack, encapsulated with Ni-Cad batteries
49-2033	Battery Charger, 115 volts, for Ni-Cad batteries
49-2034	Battery Charger, 230 volts, for Ni-Cad batteries
49-8051	Battery Pack, replaceable, rechargeable cell, with batteries
50-1229	Meter, PPM/LEL/O_2 Scale
52-1005	Buzzer
61-0120	Detector Ass'y, wired for Surveyor
65-0601	Oxygen cell, new
65-0601E	Oxygen cell, reactivated (exchange)
71-0115	Instruction Manual, Model 1314/1238
80-0150	10" Probe
80-0204	Moisture Trap

TABLE I

Relative Response of New GasTechtor to Various Gases (Referenced to Hexane or Toluene)

GAS	LEL Scale			PPM Scale		
	LEL in %*	Conversion Factor		TLV in ppm**	Conversion Factor	
		Hexane	Toluene		Hexane	Toluene
Acetone	2.15	0.65	0.63	1000	1.55	1.30
Acrylonitrile	3.0	-	-	1	1.31	1.1
Benzene	1.3	0.87	0.84	10	1.11	0.93
Butadiene	2.0	0.88	0.85	1000	2.0	1.7
Chloroform	-	-	-	50	8.0	6.7
Carbon Monoxide	12.5	0.60	0.58	50	4.4	3.7
Ethyl Acetate	2.0	0.81	0.79	400	1.61	1.35
Ethyl Alcohol	3.3	0.60	0.58	1000	2.0	1.67
Formaldehyde***	7.0	1.96	1.9	3	7.4	6.2
Heptane	1.0	1.03	1.00	500	0.98	0.82
Hexane	1.1	1.00	0.97	500	1.00	0.84
Hydrogen Sulfide	4.0	1.96	1.9	20	5.0	4.2
Methyl Chloroform	-	-	-	350	3.7	3.1
Methyl ethyl Ketone	1.7	0.84	0.81	200	1.3	1.09
Methylene Chloride	3.3	2.78	2.7	500	4.4	3.7
Methane	5.0	0.42	0.41	-	2.4	2.0
Pentane	1.5	0.71	0.69	1000	1.81	1.52
Perchloroethylene	-	-	-	100	4.5	3.8
n-Propyl Acetate	1.7	0.77	0.75	200	1.36	1.14
n-Propyl Alcohol	2.1	0.80	0.78	200	1.52	1.28
Styrene	1.1	1.24	1.2	100	1.31	1.1
Toluene	1.2	1.03	1.00	200	1.19	1.00
Trichloroethylene	12.5	0.59	0.57	25	4.4	3.7

Please note, that response varies from one sensor to another and the relative response of a sensor can change with age, so these data should be used for estimation purposes only.

Assuming an instrument calibrated directly for hexane or toluene, but used to observe a different gas, the equivalent response in %LEL (or ppm) for that gas is secured by multiplying the observed %LEL (or ppm) reading by the LEL (or ppm) scale conversion factor.

* Values from National Fire Protection Association, NFPA 325M, 1977, except for methylene chloride and n-propyl alcohol for which 1969 NFPA 325M values were used.

** Values from Federal Register 40,23072, May 28, 1975 and current as of November 1979, except for trichloroethylene where a CAL/OSHA November 1980 value is listed.

*** Methanol free.

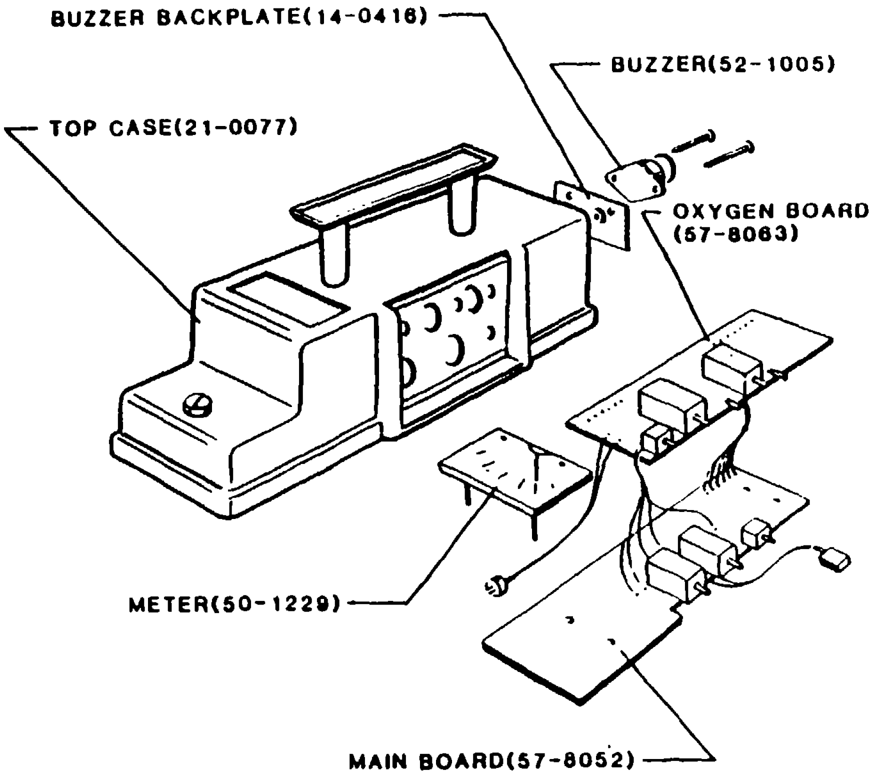


FIGURE 16. PARTS LOCATION-TOP HALF

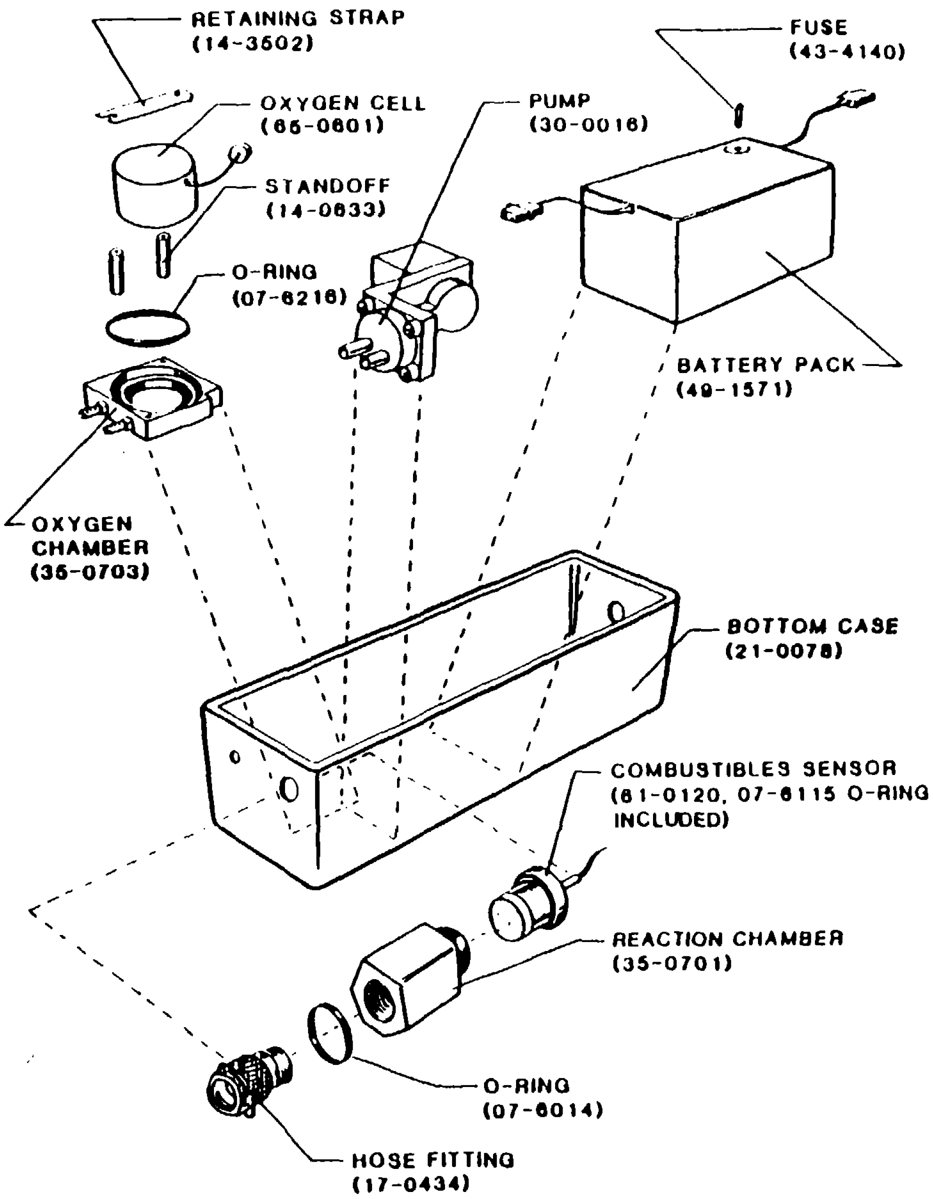
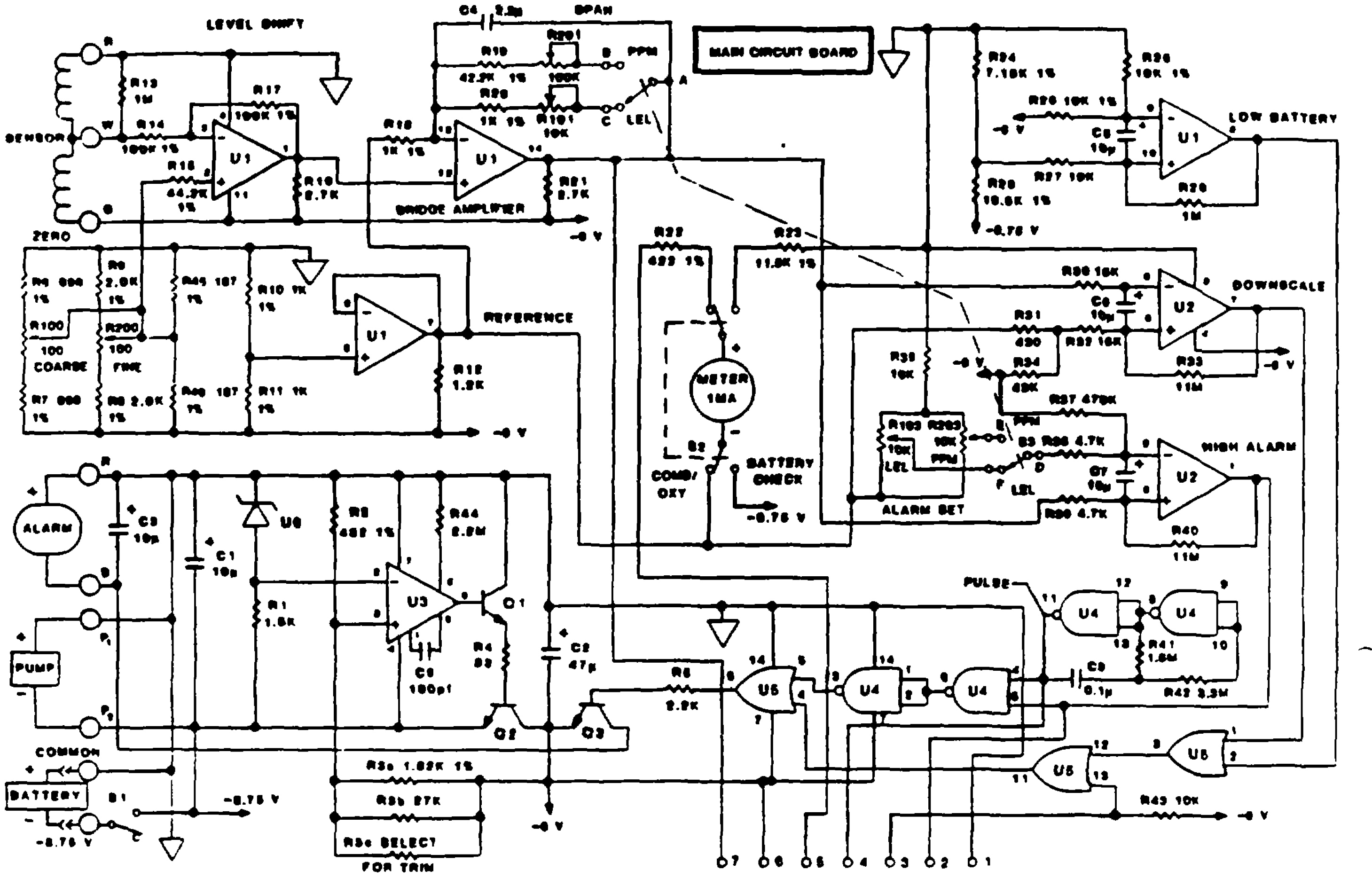
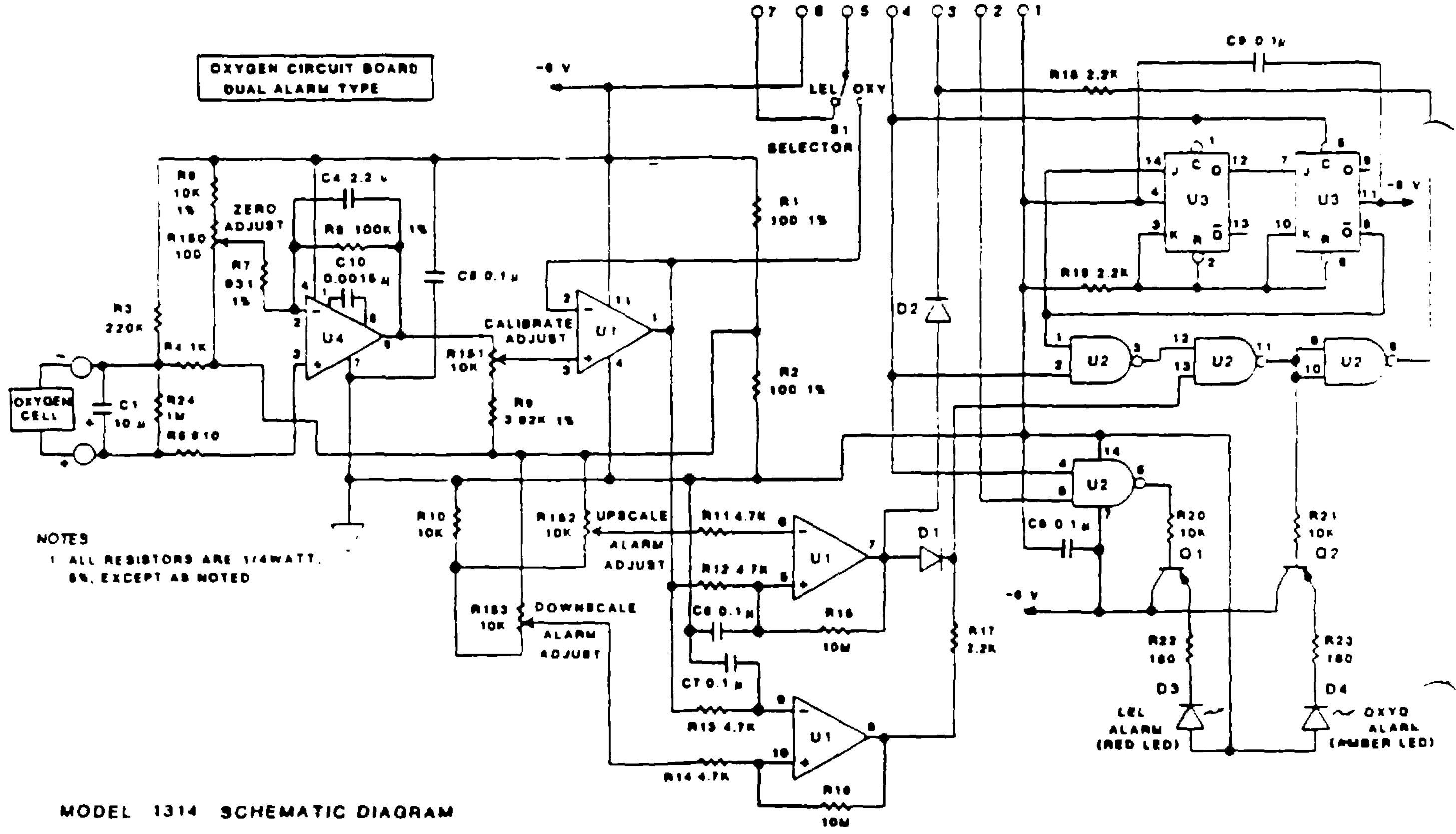


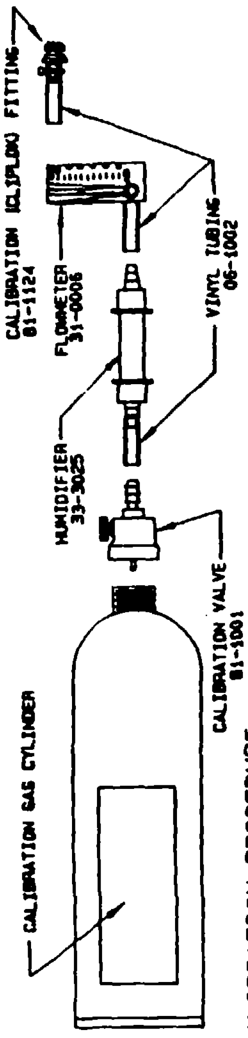
FIGURE 17. PARTS LOCATION-LOWER HALF





NOTES
1 ALL RESISTORS ARE 1/4WATT, 5%, EXCEPT AS NOTED

MODEL 1314 SCHEMATIC DIAGRAM



CALIBRATION PROCEDURE

(A) PPM RANGE

1. TURN ON INSTRUMENT. ALLOW TO WARM UP AND ADJUST ZERO IN NORMAL WAY.
2. ADD A FEW DROPS OF WATER TO GLASS WOOL PACKING INSIDE HUMIDIFIER. GLASS WOOL SHOULD BE MOIST BUT NOT DRIPPING.
3. COUPLE FLOWMETER TO CLIPLOK FITTING, AND HUMIDIFIER TO FLOWMETER INLET, AS SHOWN.
4. COUPLE CLIPLOK FITTING TO INSTRUMENT INLET.
5. READJUST ZERO AS REQUIRED AFTER INSTRUMENT STABILIZES.
6. NOTE FLOWMETER READING.
7. CONNECT CALIBRATION VALVE TO PPM-RANGE CYLINDER. OPEN VALVE SLIGHTLY TO PRODUCE A SMALL FLOW.
8. COUPLE VALVE OUTLET TO HUMIDIFIER INLET.
9. ADJUST VALVE TO GIVE SAME FLOW ON FLOWMETER AS OBSERVED IN 6.
10. WATCH METER AS GAS ENTERS INSTRUMENT. OBSERVE HIGHEST READING.
11. COMPARE READING WITH MARKED GAS CONCENTRATION ON CYLINDER.
12. IF NOT CORRECT, ADJUST CALIBRATION AS SHOWN IN CALIBRATION SECTION OF INSTRUCTION MANUAL.
13. TURN OFF VALVE AND DISCONNECT CALIBRATION COMPONENTS.

(B) LEL RANGE

USE SAME PROCEDURE AS ABOVE, BUT IN LEL RANGE. HOWEVER, OMIT HUMIDIFIER AS IT IS NOT NECESSARY IN LEL RANGE. USE LEL RANGE CYLINDER.

LTR.	REVISION
B	REDRAW ON CAD KHC 5-23-86

DO NOT SCALE DRAWING
DEBURR | BREAK EDGES ± .015 R
TOLERANCES & FINISHES UNLESS OTHERWISE NOTED:
.XX ± .010 ANGLES ± 0°30'
.XXX ± .005 CONC. .010 TIR
FRACTIONS ± .015 FINISH 125
FINISH FOR O RING GROOVES 3 SIDES 32

GASTECH INC.
NEWARK, CALIFORNIA 94560

TITLE
CALIBRATION GAS - FLOW DIAGRAM
SCALE NONE | DR. BY KHC | DRAWING NO. 2127-A14 | REV B
DATE 5-23-86 | CKD. BY DJJ

GASTECH CALIBRATION KIT

A convenient calibration kit is available for accurate on-site adjustment, without the use of special tools or fixtures. The 81-0222 Calibration Kit is designed expressly for use with the models 1314 and 1238, and consists of the following:

20-0110	Padded carrying case
81-1124	Calibration fitting
31-0006	Flowmeter
33-3025	Humidifier
81-1001	Calibration gas dispensing valve
81-0007	Calibration gas cylinder 40% LEL hexane
81-0091	Calibration gas cylinder 400 ppm toluene
06-1002	Vinyl plastic tubing

To check and adjust calibration on a known gas sample, assemble the various calibration kit items in accordance with GasTech Drawing 2127-A14, but do not attach the calibration system to the instrument or gas cylinder until the corresponding steps are completed:

1. Turn instrument on and allow it to warm up and stabilize, preferably for 5 minutes. Be sure batteries are charged sufficiently to read above the check mark.

2. Add water to humidifier, thoroughly moistening the glass wool, and shake out any excess liquid.

3. Open instrument case by loosening captive screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate COARSE ZERO potentiometer on underside of circuit board (marked "ZERO").

4. Turn external zero control to center of its span. Then turn COARSE ZERO potentiometer to bring meter to zero reading.

5. To calibrate in PPM range, press the LEL-PPM switch to the ppm range. Attach the flowmeter and the humidifier to the instrument. Readjust zero as necessary with the external zero adjustment. Note flow reading on flowmeter.

6. Connect PPM-range cylinder to humidifier inlet and slowly open the calibration valve until the same flow is indicated on the flowmeter as observed previously. Watch meter and note highest reading. If it is not the same as indicated on the calibration cylinder, turn PPM SPAN potentiometer to give desired reading.

7. For LEL calibration, follow steps 1 through 5 with range switch in LEL position, and use LEL SPAN potentiometer. However, humidifier is not necessary and may be omitted.

8. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

9. Disassemble and store the calibration kit.

Standard Warranty

Gas Detection Instruments

We warrant gas alarm equipment manufactured and sold by us to be free from defects in materials, workmanship and performance for a period of one year from date of shipment to ultimate user. Any parts found defective within that period will be repaired or replaced, at our option, free of charge, f.o.b. factory. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired or replaced on a routine basis. Such items may include:

a) Catalytic or oxygen sensor elements (these are covered by a separate warranty based on the specific application)

b) Fuses

c) Batteries (battery pack has separate pro-rated two year warranty)

Warranty is voided by abuse including rough handling, mechanical damage, alteration or repair procedures not in accordance with instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs or contingent expenses incurred without our prior approval.

GasTech Inc.'s obligation under this warranty shall be limited to repairing or replacing, and returning any product which shall be returned to GasTech Inc. at its manufacturing facilities, with transportation charges prepaid, and which GasTech Inc. Material Review Board examination shall disclose to its satisfaction to have been defective.

This warranty is expressly in lieu of any and all other warranties and representations, express or implied, and all other obligations or liabilities on the part of GasTech Inc. including but not limited to, the warranty of fitness for a particular purpose. In no event shall GasTech Inc. be liable for direct, incidental or consequential loss or damage or any kind connected with the use of its products or failure of its product to function or operate properly.

SAFETY NOTICE

All necessary precautions must be observed when operating the Velometer in the vicinity of moving equipment such as motors and blowers. The user must exercise care to ensure that the probe or the instrument does not interfere with any moving equipment.

CAUTION

The maximum temperature at which the Velometer can be used is 250° F (120° C), and must not be exceeded. The Velometer is NOT designed for gas mixtures other than air. Use beyond the operational temperature range and/or on gasses which are combustible or which may deteriorate materials in the Velometer is not recommended and is at the user's risk.

WARRANTY

Your warranty information and reply card are enclosed elsewhere in this package. After locating this material, please return the reply card and maintain the Certificate of Calibration.

TRADEMARKS

The following are Trademarks of the ALNOR Instrument Company;

ALNOR
AL-TEMP
BALOMETER
COMPUFLOW
DEWPOINTER
DIGICON
DIGITHERM
PYROCON
PYRO LANCE
PYROMATIC
PYRO POINT
PYROTAC
PYROTROLLER
THERMOCON
VELOMETER
VELOMETER JR.

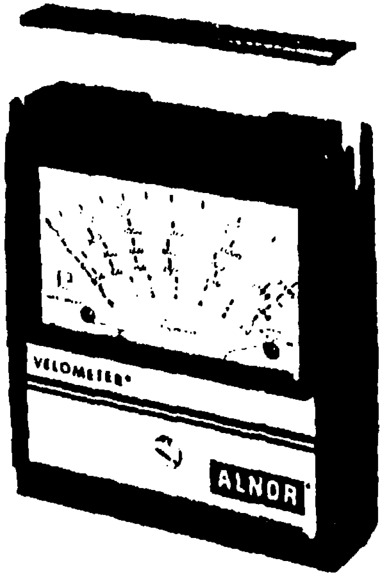
ALNOR INSTRUMENT COMPANY
Niles, Illinois 60648

ALNOR

VELOMETER SERIES 6000 OWNER'S MANUAL

TABLE OF CONTENTS

GENERAL DESCRIPTION



The *Alnor* Velometer is a direct reading instrument for measuring air velocities. It is designed to measure velocities inside heating and ventilating ducts, or in open areas such as at fume hoods, grilles, diffusers, slots on ventilated plating tanks, and so forth. It may also be used for measuring duct static pressures.

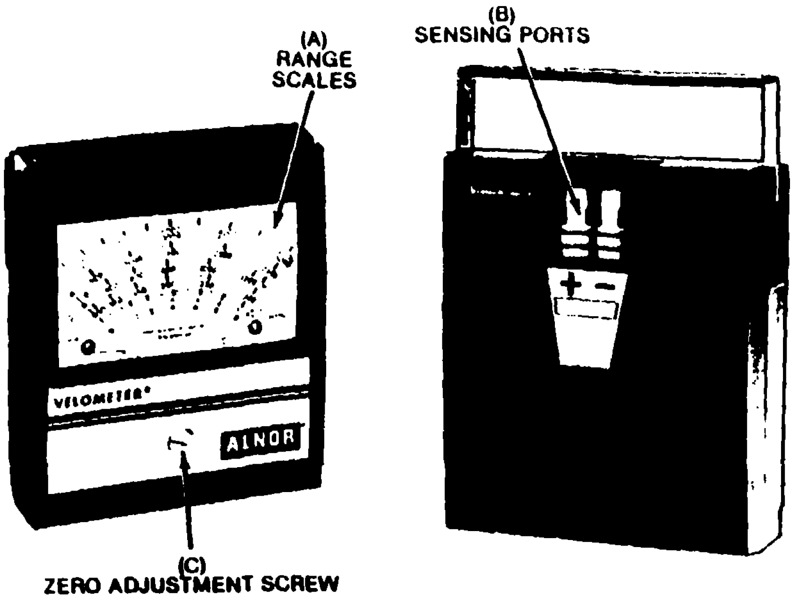
The Velometer set consists of the meter, velocity and static pressure range selectors, measuring probes and connecting hoses.

The Velometer is basically an air flow meter reading in feet per minute (or meters per second).

The Velometer is built with a taut band meter movement; it is carefully balanced so that you may hold the meter in any normal position and still get an accurate reading. All Velometers are uniformly calibrated to factory standards; hence, all accessories are interchangeable from instrument to instrument.

Before using the Velometer, study the operational instructions and procedures to insure proper use of the instrument for accurate results.

METER



The Meter is the nerve center of the Velometer set. It receives the sensing signal from the various probes and translates it to a velocity or static pressure reading.

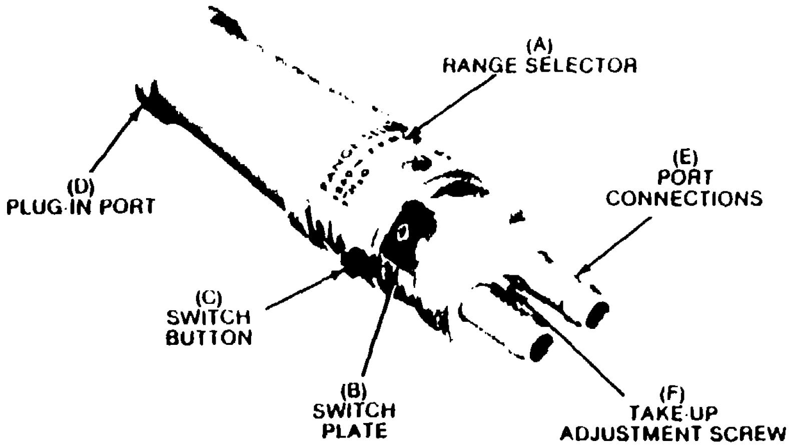
On the face of the meter there is a series of range scales (A) which enables you to read accurately the measured value. Since there are a number of ranges, it is important that the scale read on the meter face corresponds to the velocity or static pressure range that is set on the Range Selector.

On the back side of the meter there are two sensing ports (hose connections) (B) which are for interconnecting to one of the two Range Selectors with hoses. One port is marked postive (+) and the other negative (—).

Sensing port caps are provided and you should place them over the sensing ports when the meter is not in use.

Check to see that the pointer is at zero each time the meter is put into service. The zero adjustment screw (C) enables you to make an adjustment. With the caps still on the ports, use a screwdriver to bring the pointer to zero. It should continue to read zero whether the meter is lying flat, standing upright or is at any position in between, including the position where one end of the scale is lower than the other.

RANGE SELECTOR



The range selector (A) allows you to switch to one of two velocity ranges or a static pressure range by means of a switch plate (B).

A switch button (C) is provided for changing the Velometer from use with a Pitot Probe to use with either a Diffuser Probe or a Static Pressure Probe.

CAUTION:

WHEN USING THE PITOT PROBE, TURN THIS BUTTON AND ALLOW IT TO SPRING OUT; WHEN USING EITHER THE DIFFUSER PROBE OR A STATIC PRESSURE PROBE, PUSH THE BUTTON IN AND TURN TO LOCK IT IN POSITION. IN THIS POSITION THE SWITCH BUTTON SLOT MUST BE VERTICAL (ALIGNED WITH ARROWS ON LABEL) FOR PROPER INSTRUMENT OPERATION.

Do not block switch button during operation.

The Range Selector is provided with a plug-in port (D) which accepts the various probes and allows you to rotate them 360°. (+) and (—) ports (E) are provided for hose connections to the Meter.

Depending on your model, your set will include one or two Range Selectors that are indentified by red or black lettering. This color coding relates to the same colored scales on the meter.

The Range Selector with the black lettering has the following ranges:

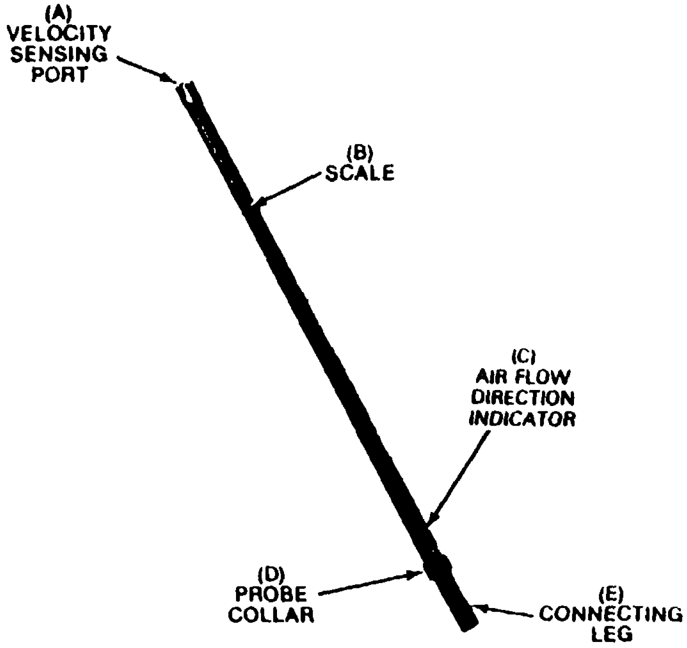
Velocity:	0 to 1250 feet per minute 0 to 2500 feet per minute
Static Pressure:	0 to 1 inches of water (6000AP set) 0 to 3 inches of water (6000BP set)

The Range Selector with red lettering has the following ranges:

Velocity:	0 to 5000 feet per minute 0 to 10,000 feet per minute
Static Pressure:	0 to 10 inches of water

A take-up adjustment screw (F) is provided for tightening the switch plate (B) which may work loose through normal wear. A noticeable effort to change the setting of the switch plate will indicate proper tightness.

PITOT PROBE



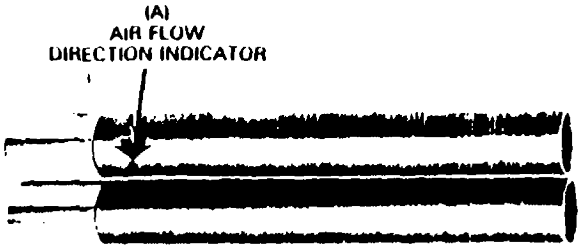
The Pitot Probe is designed to measure the velocity of air in ducts and also in unrestricted areas such as air intakes at grinding/buffing wheels or ventilation slots at plating tanks. For the procedure to measure duct velocities see pages 18 and 19; for other applications see pages 14 and 15.

The air intake (and discharge) for the probe is at (A). The probe should be held at right angles to the air flow; an arrow at the base of the probe (C) should point in the direction of the air flow.

The probe is marked in one-inch increments (B) for convenience in positioning the probe inside ducts.

The probe collar (D) acts as a stop when inserting the probe into the Range Selector; an O-ring acts as a seal when the connecting leg is inserted into the Range Selector.

LO-FLOW PROBE

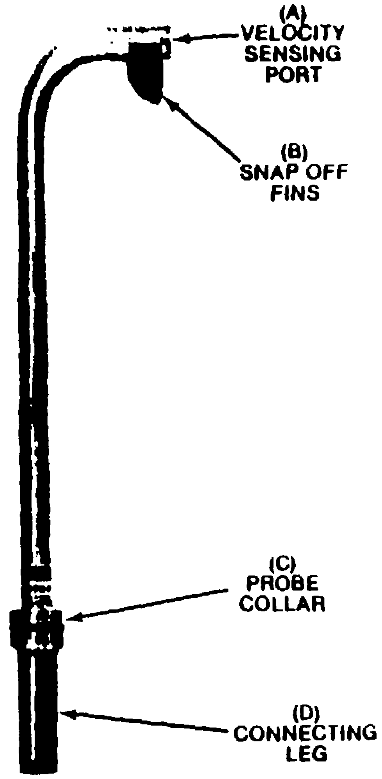


The Lo-Flow Probe is designed for measuring velocities below 300 feet per minute in open spaces; it attaches directly to the Meter without hoses.

An arrow (A) on the probe serves as a reminder of the direction you must orient the probe and the Meter when taking measurements.

Refer to page 14 for the proper velocity measuring procedure.

DIFFUSER PROBE



The Diffuser Probe is designed to measure the velocity at diffusers, registers and grilles. The *volume* of air being supplied or exhausted can be determined by multiplying the measured velocity times an air flow factor*. Refer to page 16 for proper diffuser, register, and grille measuring procedures.

The velocity sensing port (A) senses the velocity at the diffuser, register, or grille.

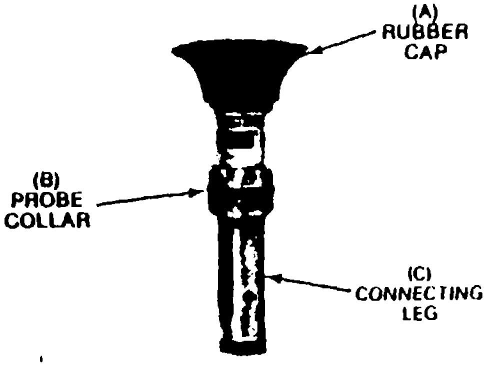
- Air flow factors, sometimes known as "K" factors, are generally available from the manufacturer of the grille or diffuser.

The snap-off fins (B) allow you to accurately position the probe vertically, horizontally or radially.

The probe collar (C) acts as a stop when connecting the probe to the Range Selector, and the O-ring acts as a seal.

The connecting leg (D) is inserted into the Range Selector.

STATIC PRESSURE PROBE



The Static Pressure Probe is designed for measuring duct static pressure.

The rubber cap (A) provides a seal around the ¼" hole (in the duct) where measurements are to be taken.

The probe collar (B) acts as a stop when connecting the probe to the Range Selector; the O-ring acts as a seal.

The connecting leg (C) is inserted into the Range Selector.

Refer to page 10 for the proper static pressure measuring procedure.

PREPARATION FOR USE

DIFFUSER PROBE

Step 1: Remove sensing port caps

Step 2: Connect two hoses (C) to sensing ports (B)

Step 3: Select proper Range Selector (D)

NOTE: For velocities below 2500 feet per minute, use the Range Selector with black letters; for velocities above 2500 feet per minute, use the Range Selector with red letters.

Step 4: Connect Range Selector (D) to loose ends of hoses (C) that are already connected to the Meter (A) as follows:

FOR SUPPLY MEASUREMENTS

Connect the plus (+) sensing port of the Meter to the plus (+) sensing port of the Range Selector, and the minus (—) sensing port of the Meter to the minus (—) sensing port of the Range Selector.

FOR RETURN AND EXHAUST MEASUREMENTS

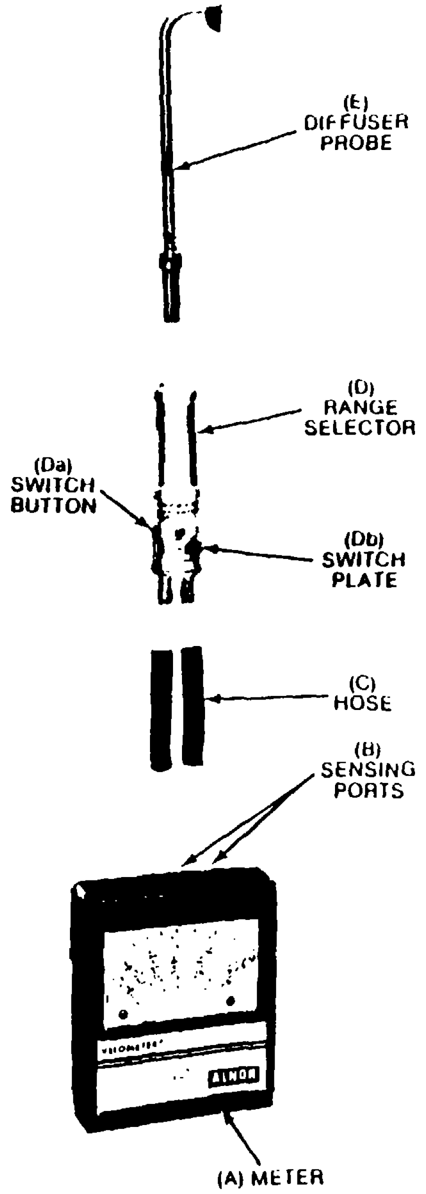
Connect the plus (+) sensing port of the Meter to the minus (—) sensing port of the Range Selector, and the minus (—) sensing port of the Meter to the plus (+) sensing port of the Range Selector.

Step 5: Insert Diffuser Probe (E) into the Range Selector (D). Push the Diffuser Probe firmly down until the collar of the probe rests against the top of the Range Selector.

Step 6: Check position of switch button (D_a) on Range Selector (D). It must be pushed in and turned to latch it in.

Step 7: Check position of switch plate (D_b) on Range Selector (D). It must be positioned for the proper velocity range.

Step 8: Proceed to make necessary velocity measurements; see page 16 for procedures.



STATIC PRESSURE PROBE

Step 1: Remove sensing port caps

Step 2: Connect two hoses (C) to sensing ports (D)

Step 3: Select proper Range Selector (D)

NOTE: For 0-1" static pressures, use Range Selector with black letters; for 1-10" static pressures, use Range Selector with red letters.

Step 4: Connect the hoses to the Range Selector (D) as follows:

For Positive Pressure Measurements

Connect the plus (+) sensing port of the Meter to the plus (+) sensing port of the Range Selector. Connect the minus (—) sensing port of the Meter to the minus (—) sensing port of the Range Selector.

For Negative Pressure Measurements

Connect the plus (+) sensing port of the Meter to the (—) sensing port of the Range Selector. Connect the minus (—) sensing port of the Meter to the plus (+) sensing port of the Range Selector.

Step 5: Select the proper Static Pressure Probe (E)

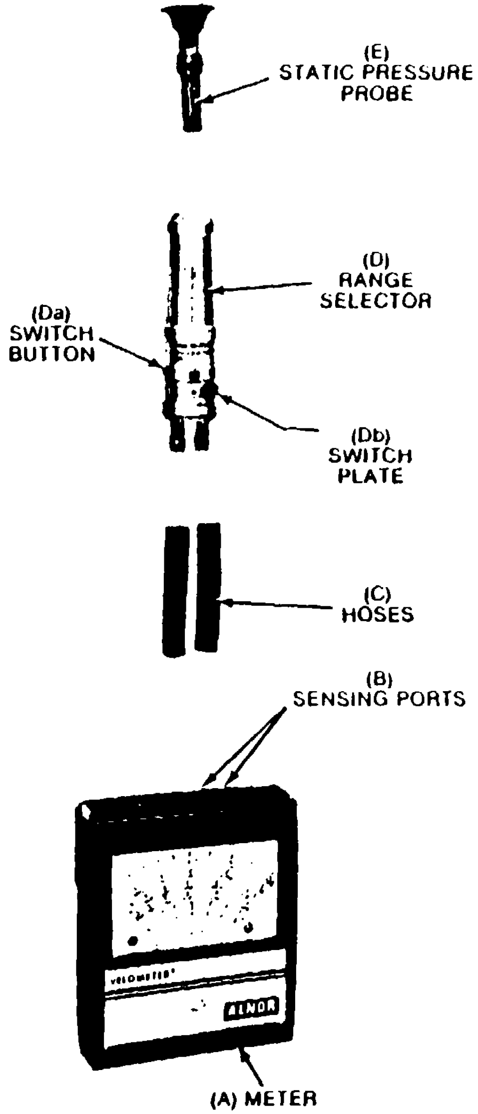
NOTE: For 0-1" static pressures, use the Static Pressure Probe with black letters. For 1-10" static pressures, use the Static Pressure Probe with red letters.

Step 6: Insert the Static Pressure Probe (E) into the Range Selector (D). Push the probe firmly down until the collar of the probe rests against the top of the Range Selector.

Step 7: Check position of switch plate (D_a) on the Range Selector (D). It must be pushed in and turned to lock it in position.

Step 8: Check position of switch plate (D_b) on Range Selector (D). It must be to the extreme left.

Step 9: Proceed to make duct static pressure measurements. See page 18 for proper procedure.



PITOT PROBE

Step 1: Remove sensing port caps

Step 2: Connect two hoses (C) to sensing ports (B)

Step 3: Select proper Range Selector (D)

NOTE: For velocities below 2500 feet per minute, use the Range Selector with black letters; for velocities above 2500 feet per minute, use the Range Selector with red letters.

Step 4: Connect the hoses to the Range Selector (D) as follows: The plus (+) sensing port of the Meter to the plus (+) sensing port of the Range Selector and the minus (—) sensing port of the Meter to the minus (—) sensing port of the Range Selector.

Step 5: Insert the Pitot Probe (E) into the Range Selector (D). Push the Pitot Probe firmly down until the collar of the probe rests against the top of the Range Selector.

Step 6: Check position of switch button (D_a) on Range Selector (D). It must be released and left in the out position.

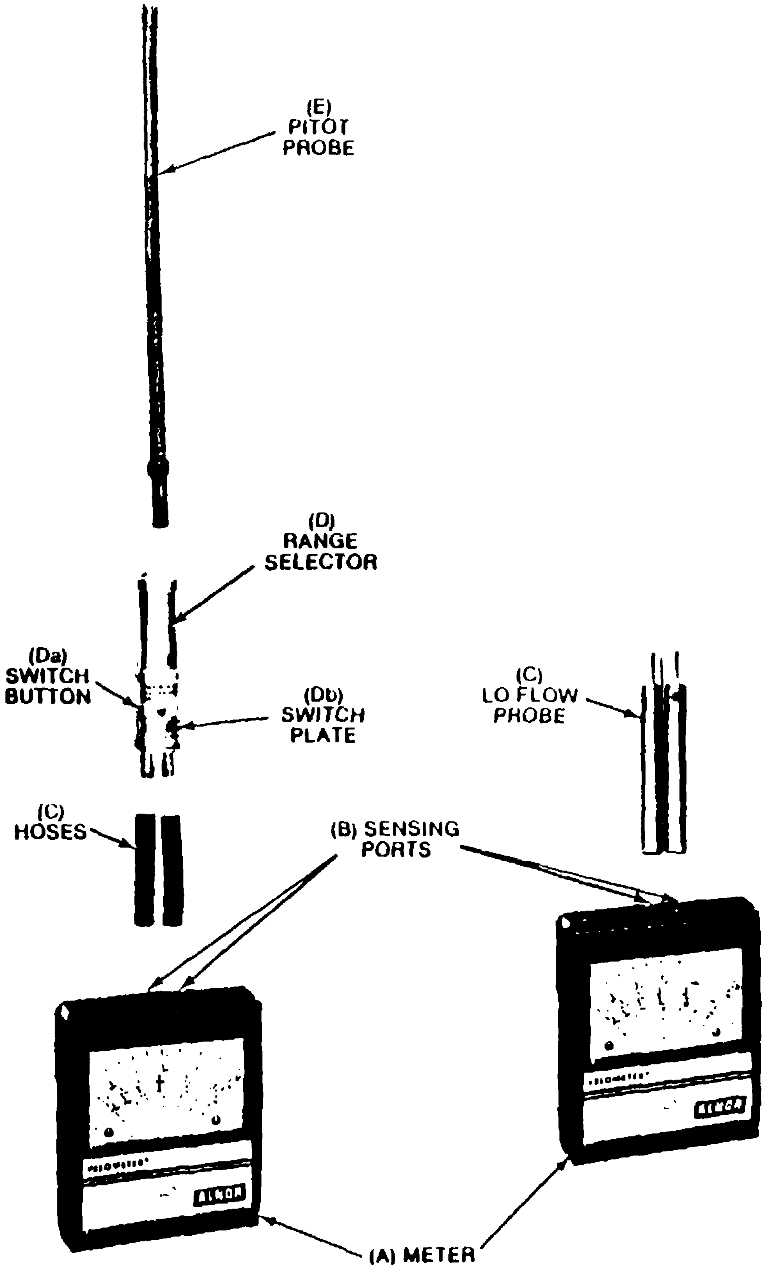
Step 7: Check position of switch plate (D_b) on Range Selector (D). It must be positioned for the proper velocity range.

Step 8: Proceed to make necessary duct velocity measurements. See *page 19 for proper procedures.*

LO-FLOW PROBE

Step 1: Remove sensing port caps

Step 2: Connect the Lo-Flow Probe (C) directly to the Meter (A) by placing it onto the sensing ports (B); no hoses are required. It fits only one way onto the Meter, with the arrow pointing to the left when viewing the Meter from the front.



OPERATION

After assembling the correct probe to the Velometer as shown on pages 6 to 8 you are ready to take the necessary measurements. Below are some typical applications and cautions when using the various probes. When using the Velometer for measuring air velocity at conditions other than 30 in. Hg and 72° F refer to the correction chart on page 24 for maximum accuracy.

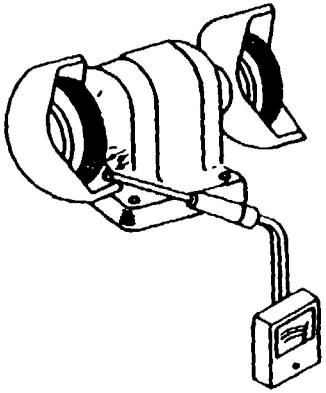
PROCEDURE FOR MEASURING VELOCITY WITH LO-FLOW PROBE

1. Place the meter where you wish to measure the air flow. If you are holding it, keep it at arm's length and stand so you do not obstruct the free flow of air past the Meter.
2. Hold the Meter so that the arrow on the probe points in the direction of air flow; if the direction is not known, turn the Meter until you observe the maximum pointer deflection.
3. Read the air velocity on the 0 to 300 FPM scale.
4. Record the reading on an appropriate air balancing worksheet.

VELOCITIES AT SUCTION OPENINGS-EXCEPT DIFFUSERS OR GRILLES

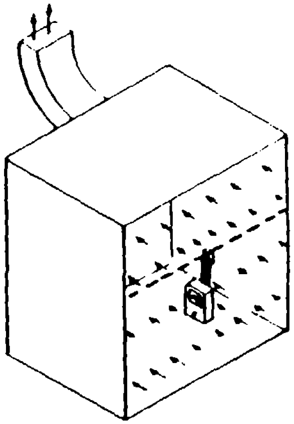
At Grinding or Buffing Wheels:

When measuring velocities at grinding or buffing wheels, use the Pitot Probe or the Lo-Flow Probe. The head of the probe should be held in a plane defined by the outside edge of the hood.



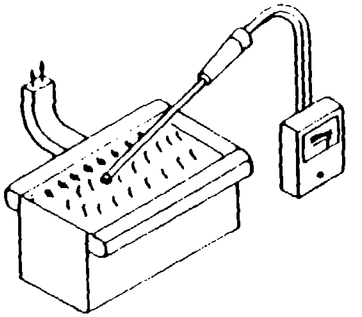
At Spray Booths:

When measuring the velocity at spray booths, use the Lo-Flow Probe. The head of the probe should be placed in a plane defined by the outside edge of the spray booth.



Velocities at Plating Tanks:

To measure the velocity at plating tanks, use the Pitot Probe. The probe should be held close to the exhaust port of the tank, with the arrow on the probe pointing toward the exhaust port.



PROCEDURE FOR MEASURING DIFFUSER, REGISTER AND GRILLE VELOCITIES WITH DIFFUSER PROBE

To calculate the air *volume* passing through a diffuser, register or grille outlet, measure the velocity *at the* outlet, applying the air flow factor that *is provided* by the outlet manufacturer, and use the following equation:

$$Q = K \times V$$

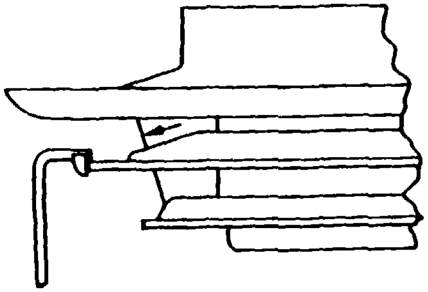
Where	English Units	Metric Units
Q = Quantity of Air	ft³/min	m³/s
K = Manufacturers' flow factor	—	—
V = Average measured velocity	ft/min	m/s

Instructions for positioning the Diffuser Probe at the outlet for measuring the velocity, as well as an appropriate flow factor, are available from the outlet manufacturer. Shown below is a typical example:

TYPICAL DIFFUSER AIR FLOW MEASURING PROCEDURE

To determine the volume of air discharged, a Velometer with a Diffuser Probe may be used as shown below.

Note that the bottom of the positioning fins on the probe are level with (and touching) the bottom of the intermediate spinning of the diffuser. The probe is held vertically. The flow factors shown in the accompanying table are applied to an average of six velocity readings taken at equally spaced positions around the periphery of the diffuser.

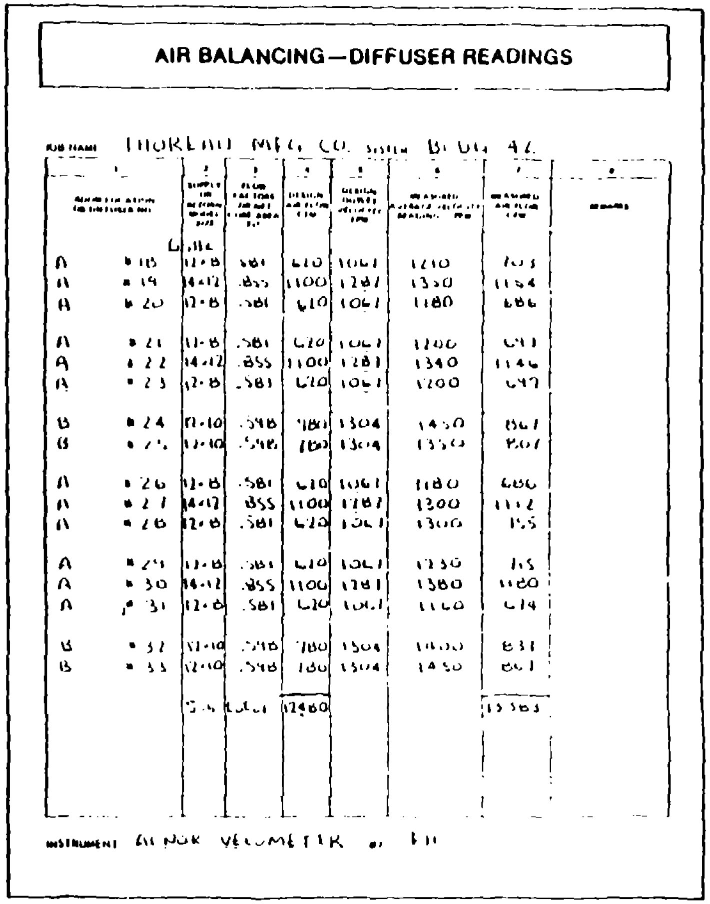


DIFFUSER SIZE	AIR FLOW FACTOR
10	.42
12	.66
14	0.9
17	1.3
20	1.8
24	2.8
32	4.9
40	7.7

For maximum accuracy observe the following precautions:

1. Use only the appropriate diffuser, register or grille manufacturers' measuring procedures.
2. Make a complete and accurate velocity reading.

3. Record the velocity measurements on a diffuser air balancing worksheet as shown.



AIR BALANCING—DIFFUSER READINGS

JOB NAME THORLAND MFG. CO. SYSTEM BLDG. 42

1		2	3	4	5	6	7	8
		GRILLE						
A	#18	12×8	.581	610	1061	1210	703	
A	#19	14×12	.855	1100	1287	1350	1154	
A	#20	12×8	.581	610	1061	1180	686	
A	#21	12×8	.581	620	1061	1200	697	
A	#22	14×12	.855	1100	1281	1340	1146	
A	#23	12×8	.581	620	1061	1200	697	
B	#24	12×10	.598	780	1304	1450	867	
B	#25	12×10	.598	780	1304	1350	807	
A	#26	12×8	.581	610	1061	1180	686	
A	#27	14×12	.855	1100	1287	1300	1112	
A	#28	12×8	.581	620	1061	1300	755	
A	#29	12×8	.581	610	1061	1230	715	
A	#30	14×12	.855	1100	1281	1380	1180	
A	#31	12×8	.581	620	1061	1160	674	
B	#32	12×10	.598	780	1304	1400	837	
B	#33	12×10	.598	780	1304	1450	867	
		SUB	TOTAL	12460			15363	

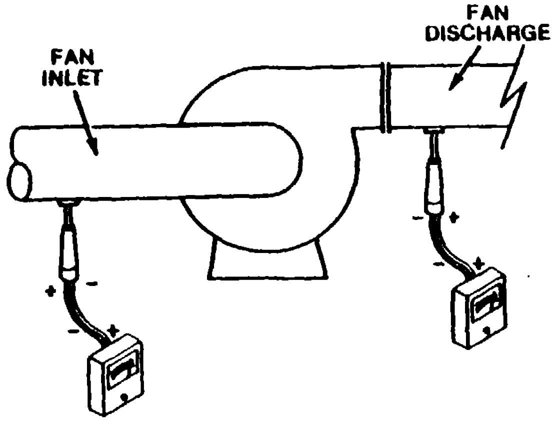
INSTRUMENT ALNOR VELOMETER # [illegible]

4. When the procedures instruct you to apply an average velocity reading, divide the opening into a number of equal areas and determine an average of single readings taken at the center of the equal areas.

5. When making a record of the measurements, include room location, outlet model, flow factor, design air volume if known, measured outlet velocity and calculated air volume.

PROCEDURE FOR MEASURING STATIC PRESSURE

1. Select the location for the static pressure reading, and drill a ¼" hole. You may wish to paint a circle around the hole and number it, for future convenience.
2. Assemble the Velometer for positive (or negative) readings as described above.
3. Place the rubber cup of the probe firmly over the hole, and read the static pressure on the black or red "Inches of Water Gauge" scale.
4. Record the reading on an appropriate air balancing worksheet.



PROCEDURE FOR AIR FLOW MEASUREMENT IN DUCTS

To calculate the air volume passing through a duct, measure the average velocity inside the duct, determine the cross-sectional area of the duct, and apply the following equation:

$$Q = A \times V$$

Where	English Units	Metric Units
Q = Quantity of Air	ft^3/min	m^3/s
A = Cross-section area	ft^2	m^2
V = Average duct velocity	ft/min	m/s

Determine Cross-Section Areas

The cross-section of the duct is based on the actual inside duct area through which air flows. If the duct is internally lined with insulation, the thickness of that insulation must be taken into consideration when calculating the duct area.

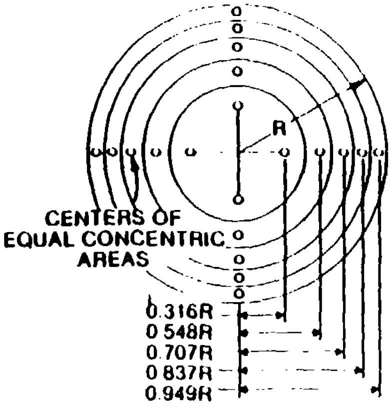
Example: 24" wide x 12" high duct with no internal insulation has a cross-section area of 2 square feet.

38" wide by 14" high duct with 1" internal insulation has a cross-section area of 3 square feet.

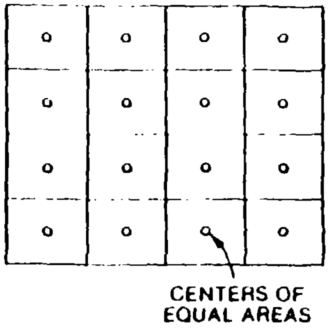
Measuring Duct Velocity

The velocity of an air stream in a duct is not unifom throughout the cross-section; air near the walls moves more slowly due to friction. Elbows, transitions and obstructions also cause variations in the velocity at any one cross-section.

To obtain the average velocity in ducts of 4" diameter or larger, drill a ½" diameter or larger hole in the duct and take a series of duct velocity readings (commonly referred to as a traverse), with the Pitot Probe, at points of equal area across the duct. A formal pattern of sensing points is recommended and these points are referred to as traverse point readings. Shown are recommended velocity reading point locations for traversing round and square (or rectangular) ducts.



ROUND DUCT TRAVERSE POINTS



NOTE: PITOT PROBE STATIONS INDICATED BY o

SQUARE AND RECTANGULAR DUCT TRAVERSE POINTS

In round ducts, take velocity readings at the center of *equal concentric areas*; take at least 20 readings along two diameters. In square or rectangular ducts, take a minimum of 16 and a maximum of 64 readings at centers of equal areas. Calculate the average of all readings.

For maximum accuracy, observe the following precautions:

1. Perform the traverse in a section of the duct where the air stream is as uniform as practical. This is generally a location of eight or more duct diameters of straight duct upstream from the traverse location.
2. Do not take the traverse near a duct elbow, transition or obstruction.
3. Make a complete, careful and accurate traverse and record the results on a worksheet.

LIST OF MODELS AND ACCESSORIES

Series 6000 Velometer Sets

MODEL	DESCRIPTION	PART NUMBER
6000AP	All Purpose Set	634-090-010
6000BP	Air Conditioning Set	634-090-028
6000AP-M/S	Metric All Purpose Set	634-091-016
6000BP-M/S	Metric Air Conditioning Set	634-091-023

Series 6000 Accessories

MODEL	DESCRIPTION	PART NUMBER
6006AP	Velometer for Set A (1)	634-010-014
6006BP	Velometer for Set B (2)	634-010-021
6006AP-M/S	Velometer for Set A-M/S	634-011-010
6006BP-M/S	Velometer for Set B-M/S	634-011-027
6030BP	Range Selector (0-1250/2500 + 0-3" H_2O) (2)	634-020-026
6030CP	Range Selector (0-1250/2500 + 0-1" H_2O) (1)	634-020-033
6030DP	Range Selector (0-5000/10000 + 0-10" H_2O) (1)	634-020-040
6030BP-M/S	Range Selector (0-6.25/12.5 MPS + 0-75 mm H_2O)	634-021-021
6030CP-M/S	Range Selector (0-6.25/12.5 MPS + 0-25 mm H_2O)	634-021-039
6030DP-M/S	Range Selector (0-25/50 MPS + 0-250 mm H_2O)	634-021-046
6050P-1	Lo-Flow Probe (1) (2)	634-030-020
6060P-12	12" Pitot Probe (305 mm) (1) (2)	634-031-019
6060AP-24	24" Pitot Probe (610 mm)	634-031-026
6060BP-36	36" Pitot Probe (915 mm)*	634-031-033
6070P	*Diffuser Probe, 7" Long-90g* (1) (2)	634-032-014
6070P36	Diffuser Probe, 36" Long-90g	634-032-021
6070P-36S	Troffer Probe, 36" Long-straight	634-032-039
6080AP	Static probe (0-10" H_2O) (1)	634-033-010
6080BP	Static probe (0-3" H_2O) (2)	634-033-027
6080CP	Static probe (0-1" H_2O) (1)	634-033-034
6080AP-mmW	Static probe (0-250 mm H_2O)	634-033-041
6080BP-mmW	Static probe (0-75 mm H_2O)	634-033-059
6080CP-mmW	Static probe (0-25 mm H_2O)	634-033-066
	Single Hose (1) (2), 24 in. long	634-040-018
	Case - Set A or B (1) (2)	634-040-025

(1) Included in 6000AP Set, with two hoses
(2) Included in 6000BP Set, with two hoses

*The 36" Pitot Probe, due to the friction of the air in the longer tube, will cause the Velometer to read 100 feet per minute low across the entire scale.

MAINTENANCE

GENERAL

Alnor Velometers require very little service except for replacement of O-ring gaskets, and cleaning or replacing the filter elements in the Range Selectors. If any difficulties in the operation of the Velometer should develop, please contact the nearest Alnor Sales Representative or the Alnor Instrument Company. Do not return any instruments without written authorization from Alnor Instrument Company.

CLEANING OF THE VELOMETER

In case it is necessary to clean the exterior of the meter, use a damp cloth or a cloth moistened with alcohol and wipe the exterior carefully. Do not rub excessively. DO NOT USE CARBON TETRACHLORIDE.

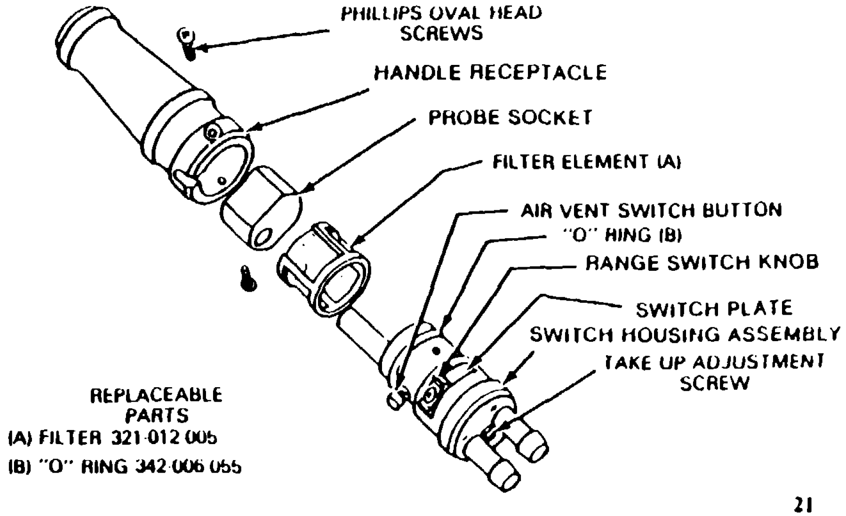
REPLACEMENT PARTS AND ACCESSORIES

In case additional parts are required to convert one Velometer set to another, or in case broken or damaged parts must be replaced, order the parts from the factory. All parts are interchangeable and no specific calibration or probes is required with any particular instrument; simply specify the Alnor number of the replacement part or accessory.

Replacement of Range Selector Filter

To replace the filter of the Range Selector, proceed as follows:

Remove the two Phillips Head screws on the collar above the Range Selector switch. Exert slight pressure to hold the upper and lower half of the Range Selector assembly together to permit easy withdrawal of the two screws. Carefully pull the upper and lower half of the Range Selector assembly apart.



REPLACEABLE PARTS
(A) FILTER 321-012-005
(B) "O" RING 342-006-055

Withdraw the filter Part Number 321-012-005. Carefully clean the filter element by means of a brush or vacuum cleaner, or wash it in hand-warm water and with grit-free soap. In case the filter element is damaged, replace it. *Before* reassembling the Range Selector, carefully clean all parts.

To install the cleaned or replacement filter, slip the bore of the filter over the protruding nipple portion of the lower Range Selector part. Place the filter element onto the lower Range Selector part with the open end down. Then slip the probe socket over the protruding nipple portion. Carefully align all three outside diameters of the lower Range Selector part, the filter and the probe socket. Slip all three parts into the upper Range Selector housing so that the air vent switch button protruding from the lower Range Selector assembly aligns with the channel in the upper Range Selector assembly. Exert slight pressure when inserting the Phillips Head screw and lightly tighten both Phillips Head screws.

Replacement of O-Rings in Probes

To replace the O-ring in the probes remove the old O-ring by means of a hook-shaped tool, or by squeezing. Clean the O-ring groove before installing the new O-ring. Slip the new O-ring in place and apply a thin film of Silicone grease or lubricant on the outside of it. The O-ring Part *Number* 342-006-048 fits all Velometer probes.

Replacement of O-Rings on the Meter

Replace the O-rings of the Meter connection ports first by removing the old O-rings using a hook or by squeezing; clean the grooves and then slip new O-rings Part Number 342-006-030 in place.

RECALIBRATION

Your Velometer should be returned to the factory for checking and/or recalibration six months after first use, and thereafter at least once a year, depending on how it is used.

It should be carefully packed according to the instructions in this manual and shipped to

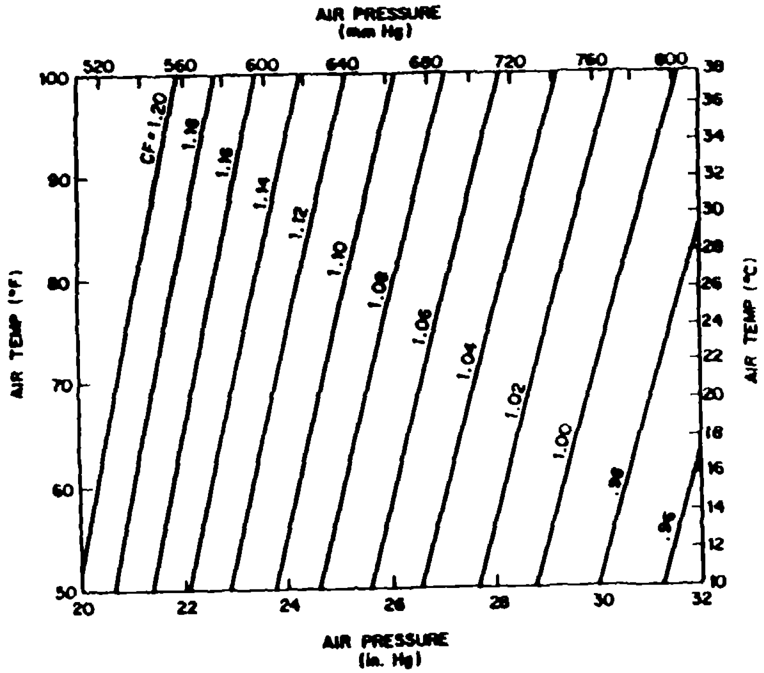
ALNOR INSTRUMENT COMPANY
7300 N. Natchez Avenue, Niles, IL 60648
Attention: SERVICE DEPARTMENT

TROUBLE SHOOTING GUIDE

PROBLEM	CORRECTION
Velometer not at zero (before use.)	Velometer not adjusted. See zero adjustment method, page 2.
	Assembled probe and meter accidentally reading pressure or air flow. Check adjustment with caps on sensing ports.
	If Velometer does not remain at zero in all positions it should be returned to the factory for calibration.
Readings not the same from *range to range.*	Different probes being used. The same probe should be used on both ranges.
	Wrong probe being used. See pages 8-13 for correct application.
	Measurement technique is different. Hold probe in the same way, and at the same place in the air flow, on all ranges.
	Different Range Selector in use. Be sure that both Range Selectors are in operating condition: O-rings not worn, filters clean.
	Range Selector switch not in operating position. Switch plate must be at either extreme of its travel.
Readings are low.	Verify that the proper probe is being used.
	Check for leaks in the O-rings in the meter, range selector and probe. Replace if necessary.
	Filter in the range selector needs to be cleaned.
	Wrong scale is being read, or probe switch not set properly.
	Hoses are not 24 in. long. Do not use hoses that are different (longer or shorter) than those originally provided with the Velometer.
No readings.	Air flow is being blocked by operator's hands.
	Hand on the switch button of Range Selector. (See page 3).
	Hoses or probe not connected.
Negative readings.	Probe not being used properly. (See section of manual describing use of specific probes).
	Hose connections must be reversed, either at the Range Selector or at the Meter.

TEMPERATURE AND PRESSURE CORRECTIONS

The maximum temperature of the air or gas that can be tested by the Velometer is 250° F (120° C). When the temperature of the gas inside a duct is appreciably different from the temperature at which the Velometer was calibrated, a correction factor may be needed to obtain the most accurate measurement. The actual velocity is obtained by multiplying the measured velocity by a correction factor as shown in the figure below.



NOTE: 1 (in. H_2O) X $7.36(10^{-2})$ = 1 in Hg

VELOMETER CORRECTION FACTORS

SPECIFICATIONS

Accuracy		
	Velocity	± 2% of full scale, all ranges
	Static Press.	± 5% of full scale, all ranges
Read-out time		4 to 8 seconds
Dimensions (Meter)		6 1/2 x 6 x 2 1/2 inches Weight 1.75 lbs.
Ranges (Scale markings)		
6006-AP	Velocity	0 to 300, 1250, 2500, 5000, 10000 FPM (0 to 1.5, 6.25, 12.5, 25, 50 meters/sec)
	Static Press.	0 to 1.0, 10.0 in. water (0 to 25,250 mm.)
6006-BP	Velocity	0 to 300, 1250, 2500 FPM (0 to 1.5, 6.25, 12.5 meters/sec)
	Static Press.	0 to 3.0 inches water (0 to 75 mm.)

WARRANTY/REPAIR INFORMATION FORM

Contact Alnor Instrument Company before returning your Alnor Instrument to the factory. Send your instrument to the factory transportation prepaid. To assure fast turn-around time, *fill out this form with as much detail as possible* and attach it to the instrument.

Instrument Model ____________________

Serial Number ____________________

Describe malfunction ____________________

____

____

____

Describe environment ____________________

____

____

____

Return instrument to:

Name ____________________
(Your name or company)

Address ____________________

____

Telephone ____________________

Address correspondence to:

Name ____________________

Address ____________________

____

Telephone ____________________

INSTRUCTIONS FOR RETURN

Damaged In Transit

All shipments are carefully examined by *Alnor Quality Assurance* and carefully packed for shipment. They are insured in the customer's name with the carrier.

On receipt, if the shipping container appears to have been damaged during shipment, the instrument should be thoroughly inspected. The delivering carrier's papers should be signed noting the apparent damage.

If the instrument itself has been damaged, a claim should be promptly filed against the carrier by the customer. Alnor will assist the customer by supplying all pertinent shipping information, however, claim must be filed by the insured.

If the instrument is damaged beyond use, a new order should be placed with Alnor while awaiting reimbursement from the carrier for the damaged instrument.

Malfunction

If any fault develops, the following steps should be taken:

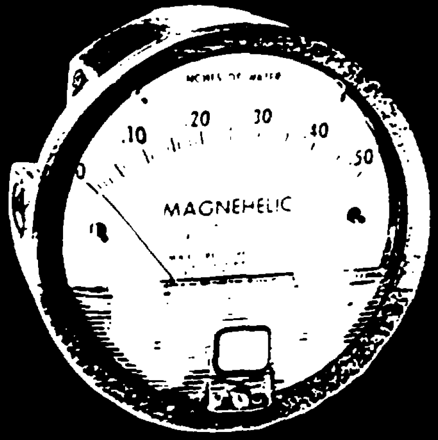
1. Notify the factory, stating model and details of the difficulty.

2. Upon receipt of shipping instructions, send the product to the factory with your purchase order, transportation prepaid. If the product is *not under warranty*, a charge will be made. If requested, an estimate can be given before work is started.

Shipping

All Alnor products should be packed in strong containers and surrounded by at least two inches of suitable shock-absorbing material.

Ship to:
Alnor Instrument Company
7300 North Natchez Avenue
Niles, Illinois 60648
Attention: Service Department

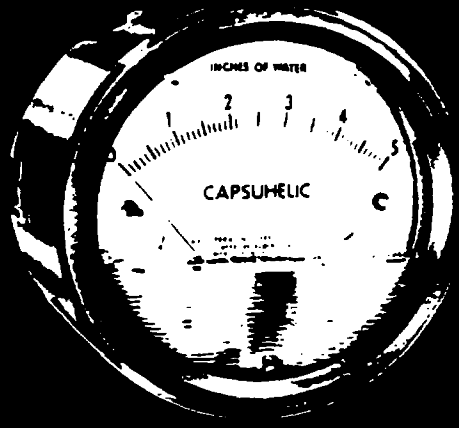


Dwyer®

The low pressure people®

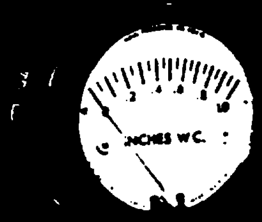
DIFFERENTIAL PRESSURE GAGES

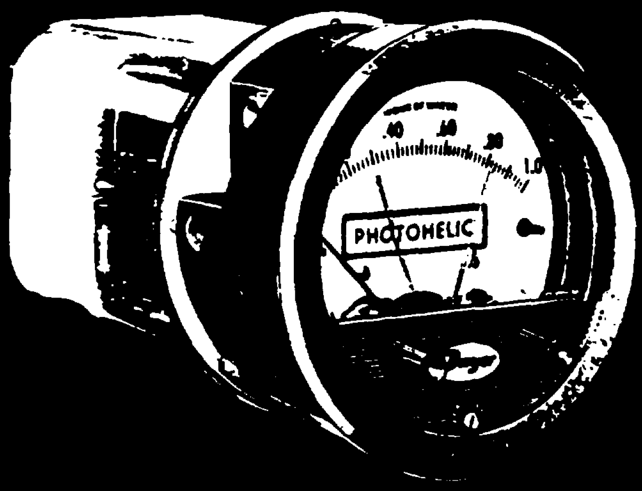
Magnehelic®
Capsuhelic®
Minihelic®



PRESSURE SWITCH/GAGES

Photohelic®
Capsu-Photohelic®





Dwyer

MAGNEHELIC® PRINCIPLE...The Dwyer feature that has created new standards in the measurement and control of low differential air pressures

Dwyer's exclusive Magnehelic Principle eliminates wear, backlash and hysteresis in Magnehelic, Capsuhelic, Minihelic and Photohelic Gages. The result is a remarkably high standard of accurate, dependable gage performance at a modest price.

WHAT IT IS

The Magnehelic Principle is Dwyer's method of transmitting the effect of changes in air pressure from a diaphragm to an indicating pointer – by means of magnetic linkage and *without* the use of gears or other direct mechanical linkages. This system avoids wear and physical contact which might destroy the accuracy and sensitivity of the instrument.

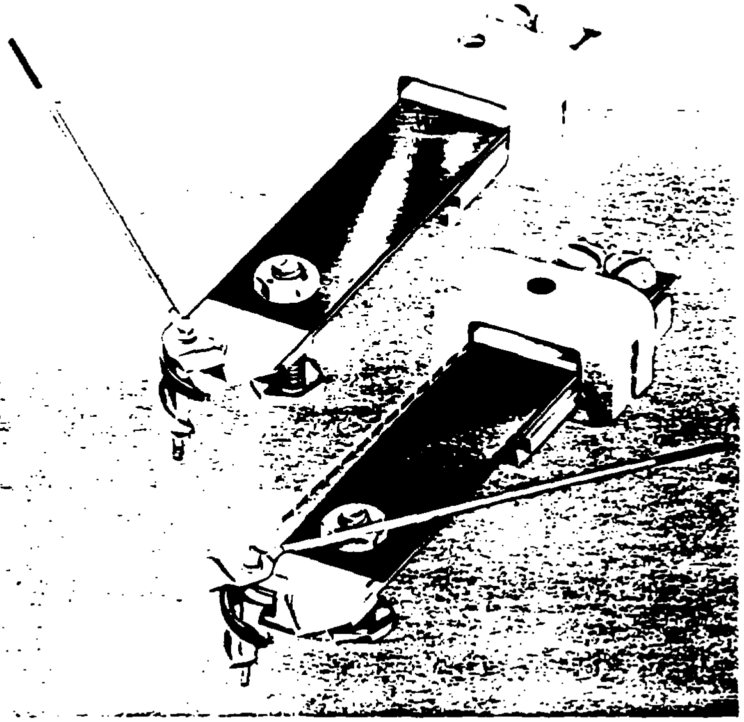
HOW THE MAGNETIC LINKAGE WORKS

(1) With pointer at zero, pressures on both sides of diaphragm are equal. Diaphragm is linked to the leaf spring, which is anchored at one end. A magnet attached to the free end of the spring is in close proximity to – but does not touch – the helix.

The helix is of high magnetic permeability. It aligns itself with the magnetic field, thus maintaining the minimum gap between the magnet and the outer edge of the helix.

(2) When air pressure changes move the diaphragm, spring and magnet, the helix turns to maintain the minimum gap, and the pointer turns with it.

The flat spring (which determines the range of the instrument) resists the diaphragm's movement. Precise calibration of the instrument is accomplished by varying the live length of spring through adjustment of spring clamp.



ADVANTAGES

Each gage based on the Magnehelic Principle offers these operating and installation advantages:

- It is exceptionally responsive. Accuracy is guaranteed within 2% of full scale. (3% on Capsuhelic, 5% on Minihelic).
- Inertia-free, drift-free pointer movement.
- Virtually no hysteresis.
- High resistance to shock and vibration.
- Unharmed by pressure surges up to 15 psig (500 psig on Capsuhelic, 50 psig on Minihelic).
- Ambient temperature range, 20° to 140° F. (Magnehelic lower limit to −65° F. on special order.)
- Operation in any position. (Low ranges require special calibration for other than vertical position.)
- Choice of more than 60 standard Magnehelic, Capsuhelic and Photohelic ranges, from .25" w.c. to 300 psig, in a single case size for each series.
- Magnehelic, Capsuhelic, and Minihelic Gages can be surface or flush mounted. Magnehelic has both side and back connections.
- Prices are modest for these responsive precision gages.

CONSIDER THIS VERSATILITY

The Magnehelic Principle adds to the unusual versatility of Dwyer's Differential Pressure Gages. They are suitable for a wide range of fixed and portable applications where differential pressure is less than 30 psig and total pressure is less than 500 psig in compatible fluids. See page 6 for numerous Magnehelic options and accessories and page 5 for special OEM models.

A few typical gage applications are listed below.

USES INCLUDE:

As an Air Filter Gage to measure pressure drop across an air filter to indicate when filters need servicing.

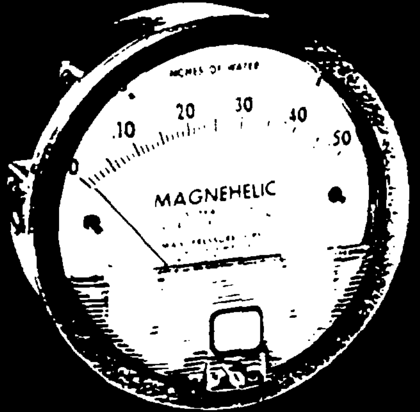
Sensing static pressure in an air stream.

To measure air velocity in determining volume of flow.

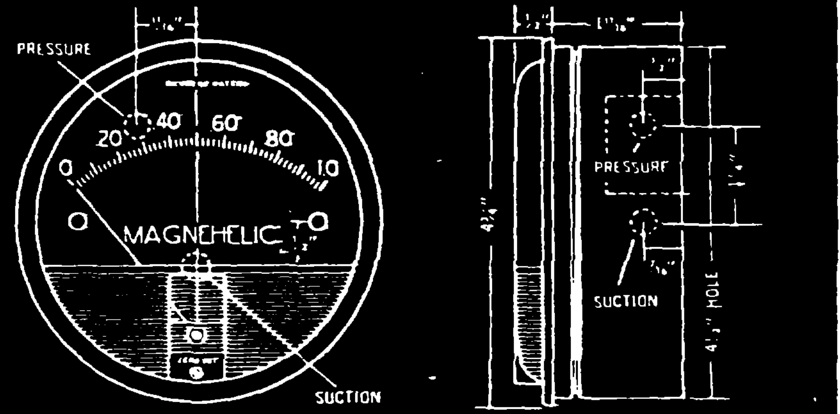
Liquid level measurement by measuring back pressure of purge air in a dip tube.

As an Orifice Meter by measuring back pressure of purge air or compatible fluids.

Dwyer SERIES 2000 Magnehelic® Differential Pressure Gages



Standard Magnehelic® Pressure Gage has a large, easy-to-read 4" dial.



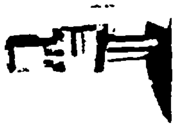
Dimensions, Standard Series 2000 Magnehelic® Pressure Gages. (Slightly different on medium and high pressure models)

Select the Dwyer Magnehelic® gage for high accuracy – guaranteed within 2% of full scale – and for the wide choice of 81 ranges available to suit your needs precisely. Using Dwyer's simple, frictionless Magnehelic® movement, it quickly indicates low air or non-corrosive gas pressures – either positive, negative (vacuum) or differential. The design resists shock, vibration and over-pressures. No manometer fluid to evaporate, freeze or cause toxic or leveling problems. It's inexpensive, too.

Widely used to measure fan and blower pressures, filter resistance, air velocity, furnace draft, pressure drop across orifice plates, liquid levels with bubbler systems and pressures in fluid amplifier or fluidic systems. It also checks gas-air ratio controls and automatic valves, and monitors blood and respiratory pressures in medical care equipment.

Flush... Surface... or Pipe Mounted

Mounting. A single case size is used for most ranges of Magnehelic gages. They can be flush or surface mounted with standard hardware supplied. With the optional A-610 Pipe Mounting Kit they may be conveniently installed on horizontal or vertical 1¼"-2" pipe. Although calibrated for vertical position, many ranges above 1 inch may be used at any angle by simply re-zeroing. However, for maximum accuracy, they must be calibrated in the same position in which they are used. These characteristics make Magnehelic gages ideal for both stationary and portable applications. A 4½" hole is required for flush panel mounting. Complete mounting and connection fittings plus instructions are furnished with each instrument.



Vent valves

In applications where pressure is continuous and the Magnehelic gage is connected by metal or plastic tubing which cannot be easily removed, we suggest using Dwyer A-310A vent valves to connect gage. Pressure can then be removed to check or re-zero the gage.

HIGH AND MEDIUM PRESSURE MODELS

Installation is similar to standard gages except that a 4¾" hole is needed for flush mounting. The medium pressure construction is rated for internal pressures up to 35 psig and the high pressure up to 80 psig. Available in all ranges. Because of larger case, will not fit in portable case. Weight 1 lb., 10 oz. (Installation of the A-321 safety relief valve on standard Magnehelic gages often provides adequate protection against infrequent overpressure; see Bulletin S-101).

PHYSICAL DATA

Ambient temperature range: 20° to 140°F.*

Rated total pressure: −20" Hg. to 15 psig.†

Connections: ⅛" NPT high and low pressure taps, duplicated – one pair side and one pair on back.

Housing: Die cast aluminum. Case and aluminum parts Iridite-dipped to withstand 168 hour salt spray test. *Exterior finish is baked dark gray hammerloid.*

Standard ranges: See facing page.

Accuracy: Plus or minus 2% of full scale (3% on -0 and 4% on -00 ranges), throughout range at 70°F.

Standard accessories: Two ⅛" NPT plugs for duplicate pressure taps, two ⅛" pipe thread to rubber tubing adapters, and three flush mounting adapters with screws. (Mounting ring and snap ring retainer substituted for 3 adapters in MP & HP gage accessories.)

Weight: 1 lb. 2 oz.

*Low temperature models available as special option.

†For applications with high cycle rate within gage total pressure rating, next higher rating is recommended. See Medium and High pressure options at lower left.

OPTIONS AND ACCESSORIES

Transparent overlays

Furnished in red and green to highlight and emphasize critical pressures.

Adjustable signal flag

Integral with plastic gage cover; has external reset screw. Available for all ranges (not high pressure). Can be ordered with gage or separately.

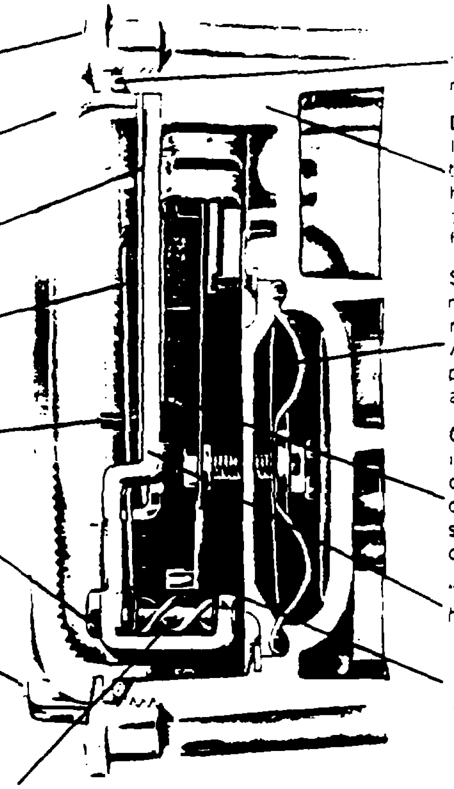
Portable units

Combine carrying case with any Magnehelic gage of standard range (not high pressure). Includes 9 ft. of 3/16" I.D. rubber tubing, stand-hang bracket, and terminal tube with holder.

Air filter gage accessory package

Adapts any standard Magnehelic for use as an air filter gage. Includes aluminum surface-mounting bracket with screws, two 5 ft. lengths of ¼" aluminum tubing, two static pressure tips and two molded plastic vent valves, integral compression fittings on both tips and valves.

Quality design and construction features



Bezel provides flange for flush mounting in panel.

Clear plastic face is highly resistant to breakage. Provides undistorted viewing of pointer and scale.

Precision litho-printed scale is accurate and easy to read.

Red tipped pointer of heat treated aluminum tubing is easy to see. It is *rigidly* mounted on helix shaft.

Pointer stops of molded rubber prevent pointer over-travel without damage.

Sapphire bearings are shock-resistant mounted; provide virtually friction-free motion for helix. Motion damped with high viscosity silicone fluid.

Zero adjustment screw is conveniently located in plastic cover, accessible without removing cover. "O" ring seal provides pressure tightness.

"O" ring seal for cover assures pressure integrity of case.

Die cast aluminum case is precision made. Iridite-dipped to withstand 168 hour salt spray test. Exterior finished in baked dark gray hammerloid. One case size used for all standard pressure ranges, and for both surface and flush mounting.

Silicone rubber diaphragm with integrally molded "O" ring is supported by front and rear plates. It is locked and sealed in position with a sealing plate and retaining ring. Diaphragm motion is restricted to prevent damage due to overpressures.

Calibrated range spring *is a flat leaf of* Swedish spring steel in temperature compensated design. Small amplitude of motion assures consistency and long life. It reacts to pressure on diaphragm. Live length adjustable for calibration.

"Wishbone" assembly provides mounting for helix, helix bearings and pointer shaft.

Samarium cobalt magnet mounted at end of range spring rotates helix without mechanical linkages.

Helix is precision milled from an alloy of high magnetic permeability, deburred and annealed in a hydrogen atmosphere for best magnetic qualities. Mounted in jeweled bearings, it turns freely to align with magnetic field of magnet to transmit pressure indication to pointer.

SERIES 2000 MAGNEHELIC® – MODELS AND RANGES

The models below will fulfill most requirements. Page 5 also shows examples of special models built for OEM customers. For special scales furnished in ounces per square inch, inches of mercury, metric units, etc., contact the factory.

Model Number	Range, Inches of Water	Minor Div.
2000-00†	0-.25	.005
2000-0†	0-.50	.01
2001	0-1.0	.02
2002	0-2.0	.05
2003	0-3.0	.10
2004	0-4.0	.10
2005	0-5.0	.10
2006	0-6.0	.20
2008	0-8.0	.20
2010	0-10	.20
2015	0-15	.50
2020	0-20	.50
2025	0-25	.50
2030	0-30	1.0
2040	0-40	1.0
2050	0-50	1.0
2060	0-60	2.0
2080	0-80	2.0
2100	0-100	2.0
2150	0-150	5.0

Model Number	Range, Zero Center Inches of Water	Minor Div.
2300-0†	.25-0-.25	.01
2301	.5-0-.5	.02
2302	1-0-1	.05
2304	2-0-2	.10
2310	5-0-5	.20
2320	10-0-10	.50
2330	15-0-15	1.0

Model Number	Range, PSI	Minor Div.
2201	0-1	.02
2202	0-2	.05
2203	0-3	.10
2204	0-4	.10
2205	0-5	.10
2210*	0-10	.20
2215*	0-15	.50
2220*	0-20	.50
2230**	0-30	[illegible]

*MP option standard
**HP option standard

Dual Scale Air Velocity Units

Model Number	Range, Inches of Water	Range, Air Velocity F.P.M.
2000-00AV†	0-.25	300-2000
2000-0AV†	0-.50	500-2800
2001AV	0-1.0	500-4000
2002AV	0-2.0	1000-5600
2010AV	0-10	2000-12500

For use with pitot tube.

Model Number	Range, MM of Water	Minor Div.
2000-6MM†	0-6	.20
2000-10MM†	0-10	.20
2000-25MM	0-25	.50
2000-50MM	0-50	1.0
2000-80MM	0-80	2.0
2000-100MM	0-100	2.0
Zero Center Range		
2300-20MM†	10-0-10	.50

Model Number	Range, CM of Water	Minor Div.
2000-15CM	0-15	.50
2000-20CM	0-20	.50
2000-25CM	0-25	.50
2000-50CM	0-50	1.0
2000-80CM	0-80	2.0
2000-100CM	0-100	2.0
2000-150CM	0-150	5.0
2000-200CM	0-200	5.0
2000-250CM	0-250	5.0
2000-300CM	0-300	10.0
Zero Center Ranges		
2300-4CM	2-0-2	.10
2300-10CM	5-0-5	.20
2300-30CM	15-0-15	1.0

†These ranges calibrated for vertical scale position.

Model Number	Range, Pascals	Minor Div.
2000-60 Pa†	0-60	2.0
2000-125 Pa†	0-125	5.0
2000-250 Pa	0-250	5.0
2000-500 Pa	0-500	10.0
2000-750 Pa	0-750	25.0
Zero Center Ranges		
2300-250 Pa	125-0-125	5.0
2300-500 Pa	250-0-250	10.0

Model Number	Range, Kilopascals	Minor Div.
2000-1 kPa	0-1	.02
2000-1.5 kPa	0-1.5	.05
2000-2 kPa	0-2	.05
2000-3 kPa	0-3	.10
2000-4 kPa	0-4	.10
2000-5 kPa	0-5	.10
2000-8 kPa	0-8	.20
2000-10 kPa	0-10	.20
2000-15 kPa	0-15	.50
2000-20 kPa	0-20	.50
2000-25 kPa	0-25	.50
2000-30 kPa	0-30	1.0
Zero Center Ranges		
2300-1 kPa	.5-0-.5	.02
2300-3 kPa	1.5-0-1.5	.10

Suggested Specifications

A Differential pressure gage for measuring (state purpose) shall be installed. Gage shall be the diaphragm-actuated dial type 4" O.D. with white dial, black figures and graduations and pointer zero adjustment. Gage shall be Dwyer Instruments, Inc., Magnehelic®, Catalog No. ______ reading to ______" water column, in ______ divisions.

Special Purpose Ranges

Scale No. 2401	Scale No. 2402
Square Root	Blank Scale
Specify Range	Specify Range

Model 2000-00N, Range –.05 to +.20" W.C. For room pressure monitoring.

APPENDIX L

GENERAL PROCEDURE FOR GAGING STREAMS

A S Grant

U.S. DEPARTMENT OF THE INTERIOR

March 3 1849

Techniques of Water-Resources Investigations of the United States Geological Survey

GENERAL PROCEDURE FOR GAGING STREAMS

BOOK 3

CHAPTER A6

choice of systems thus depends on the characteristics of the site.

Water-stage recorders

Both strip-chart and digital-tape water-level recorders are in general use. Either recorder may be actuated by the float or bubble-gage system. Figure 5 shows a bubble-gage digital-punch arrangement.

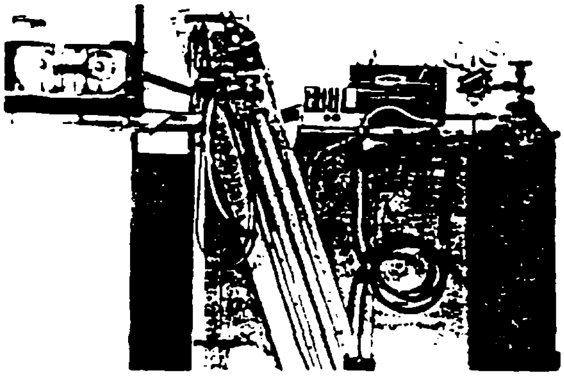


Figure 5.—Bubble-gage digital-recorder arrangement. Gas tank on right; digital-punch recorder on left.

A strip-chart recorder produces a graphic record of the rise and fall of the water surface with respect to time. A gage-height scale of 1:6 and a time scale of one day being equal to 2.4 inches are commonly used. Continuous recorders such as the Stevens A-35 will operate unattended for periods of 60–90 days and provide a very satisfactory record of stage.

A digital stage recorder punches coded values of stage on paper tape at preselected time intervals. A time interval of 15 minutes is normally used. The Fischer-Porter recorder is battery operated and will run unattended for periods of 60–90 days. The code consists of four groups of four punches each: the four punches represent 1, 2, 4, and 8 in each group. The punching of a stage requires only a 0.1-inch advance of paper tape. The recorder is actuated by a cam on a battery-driven mechanical clock.

Digital recorders are gradually replacing strip-chart recorders at gaging stations in the United States. The two recorders are about equal in accuracy, reliability, and cost, but the digital recorder is compatible with the use of electronic computers in computing discharge records. This automated system as developed by the Geological Survey offers greater economy and flexibility in the computation-publication process than do manual methods associated with graphical recording. However, the use of graphical recorders will be continued at those sites where a graphical record is necessary to detect ice effects, backwater, or frequent malfunctions of the recording system.

Reference gages

Because of the possibility of plugged intakes or other malfunctions, a nonrecording gage is installed so that the water level in the stream can be directly measured. Comparative readings on the inside and outside gages are taken during each visit to the station by engineering personnel. Datum of all gages is checked at periodic intervals—usually every 2 or 3 years. In figure 2, the outside gage is on the bridge. Outside staff gages are visible in figures 3 and 4 in the pools near the gage structures.

Discharge Measurements

Discharge measurements are made at each gaging station to define the discharge rating for the site. The discharge rating may consist of a simple relation between stage and discharge or a more complex relation in which discharge is a function of stage, slope, rate of change of stage, or other factors.

Discharge measurements are normally made by the current-meter method, which consists of determinations of velocity and area in the parts of a stream cross section. However, indirect methods are frequently used in determining flood peak discharges. These methods utilize hydraulic equations in conjunction with the information on channel characteristics and floodmarks obtained in a field survey after the flood event.

Discharge measurements may also be made by the dilution method. This method depends on determination of the degree of dilution of an added tracer solution by the flowing water.

Current-meter measurements

In the making of a discharge measurement the cross section is divided into 20–30 partial sections, and the area and mean velocity of each is determined separately. A partial section is a rectangle whose depth is equal to the sounded depth at a meter location (a vertical) and whose width is equal to the sum of half the distances to the adjacent verticals. At each vertical the following observations are made: (1) The distance to a reference point on the bank, (2) the depth of flow, and (3) the velocity as indicated by current meter at one or two points in the vertical. These points are at either the 0.2 and 0.8 depths (two-point method) or the 0.6 depth (one-point method) from the water surface. The average of the two velocities, or the single velocity at 0.6 depth, is taken to be the mean velocity in the vertical. The discharge in each partial section is computed as the product of mean velocity times depth at the vertical times the sum of half the distances to adjacent verticals. The sum of the discharges in all the partial sections is the total discharge of the stream.

The measurement can be made by wading the stream with a current meter which slides on a graduated depth rod as shown in figures 2 and 6, or it can be made from a supporting structure such as a bridge (see fig. 7), cableway, or boat, the meter being suspended by a cable.

The Price current meter is used to observe velocity, except in shallow depths where the pygmy current meter is used. The rotor on both these meters has a vertical axis and six cone-shaped cups. Each meter is individually calibrated in the rating flume at the National Bureau of Standards. Figure 8 shows a velocity-azimuth-depth assembly, which has been in use since 1958, primarily on large rivers and in estuarine studies.

These methods and the associated equipment have been developed by the Geological Survey over a period of 60 years. Satisfactory results have been obtained in measuring discharges ranging from the trickle of a small stream to the 7,500,000-cfs flow of the Amazon River. Methods and equipment used in making discharge measurements by the current-meter method are described in detail in book 3, chapter A8, of this series, by Buchanan and Somers.[1]

Indirect discharge measurements

During floods, it is frequently impossible or impractical to measure the peak discharges when they occur, because of conditions beyond control. Roads may be impassable; structures from which current-meter measurements might have been made may be nonexistent, not suitably located, or destroyed; knowledge of the flood rise may not be available sufficiently in advance to permit reaching the site near the time of the peak; the peak may be so sharp that a satisfactory current-meter measurement could not be made even with an engineer present at the time; the flow of debris or ice may be such as to prevent use of a current meter; or limitations of personnel might make it impossible to obtain direct measurements of high-stage discharge at numerous locations during a short flood period. Consequently, many peak discharges must be determined after the passage of the flood by indirect methods such as slope-area, contracted-opening, flow-over-dam, or flow-through-culvert, rather than by direct current-meter measurement.

To evaluate the accuracy of indirect methods, comparisons have been made at every opportunity. When it has been possible to compare peak discharge computed by indirect means with peak discharge measured by current meter or other direct means, the agreement, in general, has supported confidence in the auxiliary methods.

Indirect measurements make use of the energy equation for computing discharge. The specific equations differ for different types of flow, such as open-channel flow, flow over dams, and flow through culverts. These equations relate the discharge to the water-surface profile and the geometry of the channel. A field survey is made after the flood to determine the location and elevation of high-water marks and the geometry of the channel.

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[1] Buchanan, T. J., and Somers, W. P., Discharge measurements at gaging stations: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A8, unpub. data.

Figure 6.—Measuring discharge with current meter by wading

section downstream from the injection point permits the computation of stream discharge. The accuracy of the method critically depends upon complete mixing of the injected solution through the stream cross section before the sampling station is reached and upon no adsorption of the tracer on stream-bottom materials. The method is recommended only for those sites where conventional methods cannot be employed owing to shallow depths, extremely high velocities, or excessive turbulence. A detailed description of the procedures and equipment used in measuring discharge by a dye-dilution method is given by Cobb and Bailey.[4] Figure 9 shows the pressurized constant-rate tanks used to inject fluorescent dye solutions into the streams, and figure 10 shows collected sample bottles ready for field testing with a fluorometer on the tailgate of a vehicle.

Discharge Ratings

The computation of continuous records of discharge at gaging stations depends on definition of the discharge rating for the channel. Discharge ratings may be simple or complex. The rating may consist of a simple relation between stage and discharge or of several relation curves which define discharge as a function of stage, slope, rate of change of stage, or other variables. The expression "discharge rating" is an all-inclusive term to describe the one or more relations used to determine the discharge from measured parameters of flow.

Stage-discharge relations

Discharge ratings at a large majority of gaging stations consist of relations between stage and discharge. These stage-discharge relations are rarely permanent, particularly at low flow, because of changes in the stream channel such as scour and fill, aquatic growth, ice, or debris or because of changes in bed roughness. Frequent discharge measurements are necessary to define the stage-discharge relation at any time.

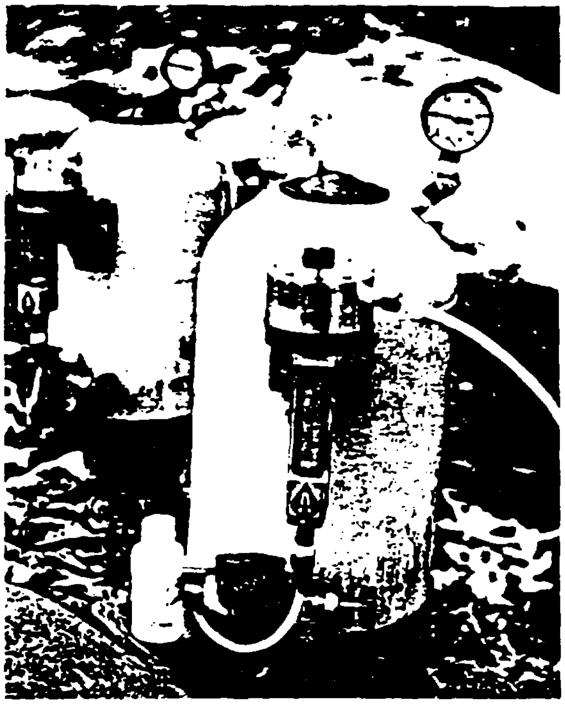

Figure 9.—Pressurized constant-rate injection tanks for injection of dye into streams.

The relation of stage to discharge is generally controlled by a section or reach of channel below the gage, known as the station control. Section controls may be either natural or constructed, and may consist of a ledge of rock across the channel, a boulder-covered riffle, an overflow dam or any other physical feature capable of maintaining a fairly stable relation between stage and discharge. Section controls are commonly effective only at low discharges, and are completely submerged by channel control at medium and high discharges. Channel control consists of all the physical features of the channel which determine the stage of the river at a given point for a certain rate of flow. These features include the size, slope, roughness, alinement, constrictions and expansions, and shape of the channel. The reach of channel which acts as the control may lengthen as the discharge increases; such changes introduce new features which affect the stage-discharge relation.

Knowledge of the channel features which

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[4] Cobb, E. D., and Bailey, J. F., Measurement of discharge by dye-dilution methods: U.S. Geol. Survey Techniques Water-Resources Inv., unpub. data.

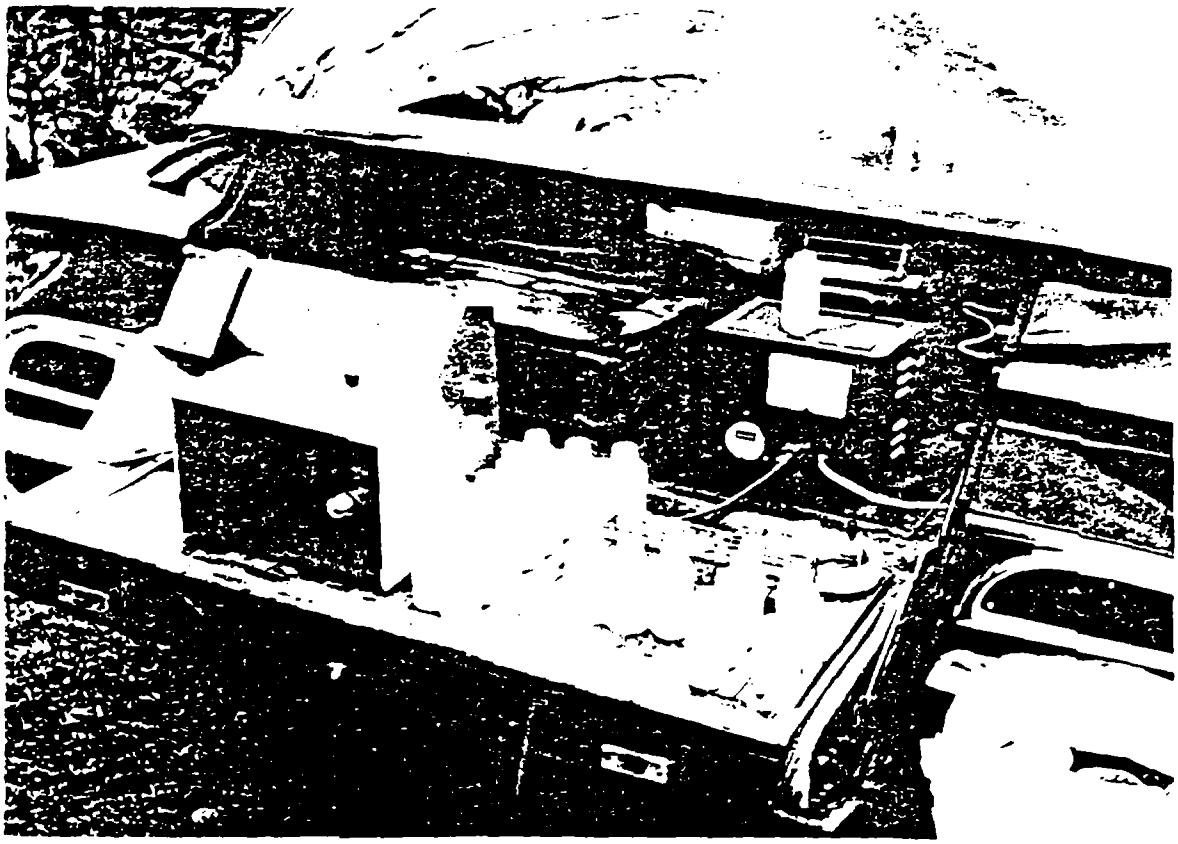

Figure 10.—Equipment for fluorometer testing of water samples in the field

[illegible] the stage-discharge relation is [illegible]. The development of stage-discharge curves where more than one control is effective and the number of measurements is limited generally requires judgment in interpolating between measurements and in extrapolating beyond the highest measurements. This judgment is particularly necessary where the controls are not permanent and various discharge measurements represent different positions of the stage-discharge curve.

Stage-discharge relations are developed from a graphical analysis of the data plotted on either rectangular-coordinate or logarithmic plotting paper. A good analysis of the data requires a knowledge of the characteristics of the channel and a knowledge of open-channel hydraulics. The discharge measurements available for the analysis rarely define a unique stage-discharge relation because of changes in the channel during the period represented by the measurements. The determination of the proper shape of the rating curve and its position at various times requires considerable engineering knowledge, experience, and judgment. In general, a base stage-discharge relation is used, and deviations from this relation with *time (shifts)* are determined by consideration of the plotting of individual discharge measurements. These shifts, in the form of a stage adjustment, are then used with the base rating in computing the discharge record.

The stability of the stage-*discharge relation* governs the number of discharge measurements that are necessary to define the relation at any time. If the channel is stable, one measurement a month is generally sufficient; in sand-channel streams, three measurements a week may be required because of the random shifting of the stream channel.