Quality Assurance/ Quality Control Plan

Refuse Hideaway Landfill
Town of Middleton, Dane County, WI

Revision 2
November 2019

Prepared For:

Wisconsin Department of Natural Resources
101 S. Webster Street
Madison, WI 53707

Prepared By:

TRC
708 Heartland Trail, Suite 3000
Madison, WI 53717

Katherine Vater, P.E.
Project Manager

Meredith Westover, P.G.
Senior Hydrogeologist

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 Introduction

1.1 Background

The Refuse Hideaway Landfill (RHL) is located at 7562 Highway 14 in the Town of Middleton, Wisconsin. The landfill closed in 1988 and became a Superfund site. The State of Wisconsin, through the Wisconsin Department of Natural Resources' (WDNR) Remediation and Redevelopment Program, is responsible for performing monitoring activities including groundwater quality sampling of both monitoring wells and residential supply wells, and monitoring for explosive gases at the landfill perimeter. To this end, the WDNR put out a Request for Bid (RFB) in March 2019 (updated in April 2019) that provided details of the monitoring scope of work (SOW).

TRC Environmental Corporation (TRC) performed the first round of groundwater monitoring in May 2019, and performed an evaluation of the condition of the monitoring network in accordance with the SOW and the Quality Assurance/Quality Control Plan (QA/QC Plan), Revision 1 (TRC, 2019). Well and pump repairs are scheduled for fall 2019, as well as a site-wide changeover of groundwater sampling methodology to low-flow purging beginning in November 2019.

1.2 Purpose

This QA/QC Plan (Revision 2) has been prepared to support groundwater and landfill gas monitoring activities at the RHL. The purpose of the QA/QC Plan is to define technical details of sampling and data gathering methods to be used during field activities, provide details of the laboratory analytical program, and provide the specific quality assurance (QA) and quality control (QC) activities associated with the data collection.

1.3 Scope

This QA/QC Plan consists of seven sections, including:

- **Section 1** describes the background, purpose, and scope of the SAP.
- **Section 2** describes the field sampling scope of work.
- **Section 3** covers the details of sample identification, control, and field records.
- **Section 4** describes the sampling equipment and procedures for collecting samples for field and laboratory analyses.
- **Section 5** identifies the sample handling and analytical procedures to be followed, and the specific laboratory analyses to be performed.
- **Section 6** describes management of waste materials that will be produced during the fieldwork.
- **Section 7** provides a list of references contained in the document text.

2.0 Scope of Work

TRC will perform the following field sampling program as described in the RFB dated March 2019 and revised April 2019:

- Measure depth to water and report groundwater elevations at 58 monitoring wells in May and November. Measurements will be collected prior to sampling to ensure a static level measurement is obtained;
- The groundwater monitoring program is summarized in Attachment 1. Monitoring wells will be sampled for VOCs as per Attachment 1 Table 1 in May and November. Additional monitoring wells listed in Attachment 1 Table 2 will also be sampled for VOCs in May; and Attachment 1 Table 3 wells will be included in the May 2019 sampling event. Monitoring well samples for VOCs will be analyzed by SW846 Method 8260.
- Select monitoring wells (P-16D, P-22S, P-22D, P-24D, P-27S, P-27D, P-31IA, P-31IB, P-401I, and P40D) will be also be sampled in May 2019 for per- and polyfluoroalkyl substances (PFAS) compounds listed in Attachment 1 Table 5. PFAS analysis will be conducted by modified EPA Method 537.1.
- Private residential wells will be sampled for VOCs as specified in Attachment 1 Table 4. The private well samples will be analyzed by EPA Method 524.2. The residents will be notified prior to sample collection.
- Inspection of the water level control devices in four wells over the 2019-2020 winter (months December through March).
- Perform landfill gas monitoring on a monthly basis to monitor pressure, percent methane, methane LEL, percent oxygen, and percent carbon dioxide at the 33 gas probes illustrated on Figure 1.

The following report sections provide details of the sampling methodology and equipment to be used to perform the scope of work.

3.0 Sample Identifiers, Control, and Field Records

3.1 Sample Identifiers

Samples will be named in a manner consistent with the current sampling program, and with the existing WDNR Groundwater and Environmental Monitoring System (GEMS) database records. Samples will be assigned a unique alpha-numeric sample descriptor identifying the media type and sample location. Each sample will be labeled as follows:

[sample type]-[sample location or QA/QC number]

The following subsections describe the sample numbering system in greater detail.

3.1.1 Sample Type

Sample type codes for the fieldwork include the following:

- FB – field blanks
- FDUP – single-blind field duplicate samples
- GP – gas probe
- GW – gas well
- P – monitoring wells
- RB – reagent blank
- SG – surface water
- TB – trip blanks
- [Street address] – residential water supply wells

3.1.2 Sample Locations

Following the convention above, samples collected from the existing monitoring wells and gas probes will be labeled as identified on the site map shown on Figure 1. A groundwater sample collected from the location of P-8S will be labeled "P-8S"; field notes for gas data collected from point GP-1 will be labeled "GP-1", and so on. Samples collected from the residential water supply wells will be labeled with the residence address (e.g., "4310 Fawn Ct").

3.1.3 QA/QC Sample Numbers

Quality control samples (e.g., field blanks, trip blanks, and blind duplicates) will be numbered sequentially each event beginning with "1," and will be recorded on the appropriate field form. For example, the complete sample identifier for the second field blank collected during a monitoring event would be "FB-2". The third blind duplicate would be identified as "FDUP-3". The duplicate sample label will not include a sample time so as to not reveal the source of the duplicate. The name and location of the field duplicate sample will be recorded on the field form associated with the primary sample point.

A sample for which additional volume is collected for matrix spike/matrix spike duplicate analyses will have the suffix of "-MS/MSD" (or separately labeled as "-MS" and "-MSD") added to the sample

identification number. An MS/MSD collected for a groundwater sample for P-8S would read, "P-8S MS/MSD."

3.1.4 GEMS Database Submittal

The analytical laboratory will prepare an electronic data deliverable (EDD) of the groundwater sampling data in a format compatible with the WDNR GEMS database. The data submittal will uniquely identify each result by the site license number (#1953), the WDNR point ID, sample date, and analytical parameter. In order to prepare the GEMS submittal, the analytical laboratory will be provided with the field sampling data, and locations of the blind field duplicate samples (after the final analytical reports are prepared). The EDD will be submitted to the WDNR along with an exceedance report and a signed electronic data certification form.

3.2 Chain-of-Custody Procedures

The sampler is responsible for sample custody from the time of sample collection to receipt at the laboratory or until samples are shipped by commercial carrier. A sample is considered under custody if:

- the sample is in a person's possession,
- the sample is in that person's view after being in his or her possession,
- the sample was in that person's possession and then placed in a secured location, or
- the sample is in a designated secure area.

Sets of sample containers that are shipped together will be assigned a Chain-of-Custody form, which will travel with the sample containers to the analytical laboratory. A copy of the Chain-of-Custody form will be kept by the field team to help identify samples that might become separated from the discrete sample delivery group. When shipped by a commercial carrier, custody seals will be attached to each cooler to ensure that the samples are not tampered with during transit, and the shipment airbill will be kept as Chain-of-Custody documentation. An example of the Chain-of-Custody form is included in Attachment 2.

3.3 Field Records

This section describes requirements and procedures for documenting field activities. All fieldwork personnel will be cognizant of the requirement that all field documentation must provide a clear, unbiased description of field activities.

Daily field activities and sampling data will be recorded on paper field forms, or electronically on a field tablet computer. Example forms are provided as Attachment 2. Entries into the field forms will be legibly written and will provide a clear record of field activities. Entries will be made in waterproof ink, in language that is objective, factual, and generally free of personal opinions, or terminology that might later prove unclear or ambiguous. No field notes may be destroyed or discarded, even if they are illegible, or known to contain inaccuracies. Errors in the field notes will be indicated by drawing a single line through the text, such that the text in error remains legible. Errors addressed in this manner will be initialed by the person making the correction. The person filling out the field forms will sign and date each page and will identify the date, the time, the location on-site, the field personnel present, and the weather conditions observed.

4.0 Sampling Equipment and Procedures

This section describes the equipment to be used and the procedures to be followed for collecting samples in the field. Samples will be collected to obtain a representative portion of the matrix being sampled. Valid and reliable results depend on the following:

- Obtaining samples that are as representative as possible of the matrix being sampled
- Using proper sample collection, handling, and preservation techniques
- Identifying the collected samples and documenting their collection in permanent field records
- Maintaining sample Chain-of-Custody procedures
- Protecting the collected samples by properly packing and transporting them to the WDNR-approved laboratory for analysis

The procedures presented in this QA/QC Plan will be followed as precisely as possible, given the specific conditions present at the time of sampling. Deviations from the specified procedures will be documented in the field notes. The WDNR Project Manager will be notified of deviations after the sampling event in the letter documenting the results of the sampling event.

4.1 General Considerations

The following factors and procedures are general considerations to be used in planning and performing sampling. These factors and procedures will be considered with respect to the specific objectives and scope of the field investigation, as presented in this QA/QC Plan:

- Safety of sampling personnel
- Selection of representative sampling sites
- Selection and proper preparation of sampling equipment
- Selection of parameters to be measured and evaluation of sample fractions to be analyzed (e.g., dissolved, suspended, or total fractions for water samples)
- Required sample volumes
- Selection and proper preparation of sample containers
- Sample preservation
- Sample holding times
- Sample handling
- Sample identification
- Transportation and shipping of samples
- Sample Chain-of-Custody

4.2 Decontamination Procedures

An appropriately-developed, executed, and documented equipment decontamination procedure is an integral and essential part of environmental site investigations. The benefits include minimizing the spread of contaminants (within a study area and from site to site), reducing the potential for worker exposure by means of contact with contaminated sampling equipment, and improved data quality and reliability.

4.2.1 Single-Use and Dedicated Sampling Equipment

To the extent practicable, single-use or dedicated sampling equipment and materials will be used for the collection of samples. The single-use materials used will be new and clean, and will be placed in plastic for transport to the site. Once used, single-use equipment will be placed in plastic bags and managed as investigation-derived waste material. Dedicated equipment will remain in the wells or sealed in clean plastic bags for storage. Single-use equipment includes, but is not limited to, the following:

- Low-density polyethylene (LDPE), High-density polyethylene (HDPE), and/or silicon tubing
- Polypropylene rope
- Disposable HDPE bailers

Dedicated and single-use equipment and materials will not require field decontamination.

4.2.2 Non-dedicated Sampling Equipment

Proper decontamination of sampling equipment is essential to minimize the possibility of cross-contamination of samples. Non-dedicated equipment used for purging monitoring wells or sampling groundwater will be cleaned before its initial use in the field and again before use at each subsequent sampling location. Equipment subject to this decontamination procedure includes, but is not limited to, the following:

- Non-dedicated submersible pumps (not expected to be needed)
- Water level indicator
- Groundwater flow through-cell
- Groundwater multi-parameter sensors
- Stainless steel bailers (not expected to be needed)

Non-dedicated sampling equipment will be decontaminated prior to its initial use on-site and in between sampling points, unless new and transported to the site in a protected and decontaminated condition. Decontamination procedures will include the following steps:

- Wash the equipment in a non-phosphate detergent.
- Rinse with potable tap water.
- Rinse with laboratory-certified PFAS-free water (required for PFAS sampling only).

Field decontamination of sampling equipment may take place at the sampling location. Decontamination water will be collected in 5-gallon buckets or similar container(s) and managed as described in Section 6.

When field cleaning of sampling equipment is required, a piece of the field-cleaned equipment will be selected for collection of a field equipment blank sample at the frequency specified, and in accordance with the methods described in Section 4.6.

4.3 Groundwater Sampling

Groundwater samples from the site monitoring wells and residential wells will be collected in a manner consistent with historical sampling methods. The following sections describe the specific equipment and methods that will be utilized to perform the scope of work.

4.3.1 Water Level Measurements

Depth to water measurements will be obtained on the first day of each groundwater monitoring event or within a 24-hour period (i.e., "synoptic water levels"), prior to any purging or sampling activities. Water level measurements will be collected using an electronic water level indicator. The water level indicator consists of a spool of small-diameter insulated steel cable with a probe attached to the end. A Slope Indicator Model 51453 (or equivalent) small-diameter water level indicator will be used. When the probe comes in contact with water, the circuit is closed and a meter, light, and/or buzzer attached to the probe signals contact with water. Batteries are normally used for a power source. Depth to water is read from permanent marks on the cable to which the probe is attached. Depth is recorded to the nearest 0.01 foot. A copy of the manufacturer's operation and maintenance instructions is included in Attachment 3. Measurements will be taken from the established reference point marked on the casing, or if such a marking is not present, then from the high point of the well casing.

4.3.2 Well Inspection

The condition of the site wells will be inspected and documented during each monitoring event prior to the collection of data. The following information will be noted on a monitoring well inspection form:

- The ground surface condition around the well (grading, vegetation, safety hazards, access hazards, etc.)
- Well security features (presence of lock, lock key number, protective bollards, paint, visibility devices, evidence of tampering, traffic hazards, etc.)
- Condition of the well surface completion, including surface protector, protective cover, vented cap on well casing, presence/condition of reference point, and surface seal
- Evidence of potential contamination at the wellhead, including staining or suspicious containers

4.3.3 Groundwater Sampling Procedures – Monitoring Wells

Groundwater samples will be collected from the selected monitoring wells using a low-flow pumping technique. This sampling method involves purging the well with the pump intake set at the desired sampling depth at a rate that should not mobilize naturally non-mobile colloidal matter, that does not create excessive water level drawdown, that minimizes pressure changes in the purged water, and that does not appreciably change the redox state of the sample. This sampling method minimizes the disturbance of the sample, thereby reducing sampling artifacts, and improves the consistency and quality of the groundwater sample results. In addition, the low-flow sampling method significantly reduces the volume of potentially contaminated purge water generated during the sampling process. In general, low-flow purging and sampling methods developed by USEPA (USEPA, 1996) will be followed.

Dedicated bladder pumps are installed in most of the site monitoring wells that are in the current monitoring program. For wells without dedicated pumps installed, the wells will be purged using a portable bladder pump, a peristaltic pump, or a submersible sampling pump (e.g., Grundfos or equivalent), as appropriate depending on the well depth and depth to water. Portable sampling pumps will be set in the well such that the pump intake is approximately 1 to 2 feet above the base of the well screen, and will be utilized in the same manner as the dedicated pumps.

Each well will be pumped at a flow rate ranging from 0.2 to 1.0 liter/minute. The pumping rate for each monitoring well will be dependent on the hydraulic properties of the formation the well is screened across, and will be determined in the field to be the highest flowrate attainable without creating drawdown greater than approximately 0.1 meter, or at a minimum of 0.2 liter/minute. In the event that the well cannot produce sufficient water to limit drawdown to 0.1 meter at the lowest specified pumping rate (0.2 liter/minute), sampling will be conducted at the 0.2 liter/minute rate after field parameter measurements and the water level have stabilized as described below.

An In-Situ SmarTroll (or equivalent) equipped with temperature, specific electrical conductance, and pH electrodes will be used to collect field measurements during purging to evaluate stabilization. The pump discharge will be connected to a flow through cell for the collection of field parameters. A minimum of 1-Liter of water will be purged from the well between measurements. Field parameter measurements will be considered stable when three consecutive readings are within the limits listed below:

- pH: +/- 0.1 unit
- Specific Conductivity: +/- 3%
- Temperature: +/- 0.5 degrees Celsius
- The water level drawdown is within 0.16 ft. in a 2” diameter well (or 0.04 ft. in a 4” diameter well) for every liter of water removed (or less than 10 percent of the water purged resulting from drawdown).

The wells will be sampled immediately following stabilization. The samples will be collected directly from the pump discharge after the flow-through cell has been disconnected. Final measurements of pH, temperature, specific conductance; and qualitative observations of color, odor, and sample turbidity will be recorded on the field forms. In the event that stabilization of the indicator parameters is not achieved in a reasonable amount of time (1 hour), the well may be sampled after a minimum of four well screen volumes has been removed.

If a well cannot sustain a pumping rate of 0.2 L/minute, and can be purged dry at that flow rate, the well will be purged dry and allowed to recover prior to sampling. The sample will be collected within 24 hours after purging.

Disposable HDPE or reusable stainless steel bailers may be used as a "last resort" to purge and sample wells in the event that a well cannot be successfully sampled by any other means. When wells are purged with a bailer, a minimum of four well volumes will be removed prior to sampling.

4.3.4 PFAS Sampling – Monitoring Wells

Samples for PFAS analysis will be collected concurrently with the routine VOC sampling. The samples will be collected using the existing dedicated pump systems, where installed. The dedicated equipment may include materials or components that contain or have historically contained PFAS compounds, such as polytetrafluoroethylene (PTFE) or low-density polyethylene (LDPE). These systems have been in contact with the well water for an extended period of time; however, adequate purging of the wells prior to sampling should significantly reduce any impact seen from sampling materials and equipment.

For wells where no dedicated pump system is present (e.g., wells P-16D and P-24D), the wells will be sampled using equipment and materials appropriate for PFAS sampling (e.g., HDPE and silicon tubing or HDPE bailers and polyethylene rope).

The sampling procedures for collecting samples for PFAS analysis will be identical to sampling for other parameters with the following exceptions:

- Sampling staff will be directed to avoid using equipment or materials containing PTFE or LDPE during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/water resistant paper products, post-it notes, aluminum foil, certain personal protective equipment (PPE), and PTFE tape.
- Equipment decontamination will include a final rinse with laboratory certified PFAS-free water in a new, clean 5-gallon bucket, or dispensed from an HDPE spray bottle.
- VOC vials will be kept in separate sample coolers from PFAS sample containers unless separated with resealable zipper top bags (Ziploc® or equivalent) due to the presence of PTFE septa in the VOC vials.
- Sampling staff will wash hands with an Alconox/Liquinox solution and deionized water after leaving the field vehicle and before setting up to sample a well.
- Sampling staff will wear nitrile gloves at all times while prepping sample containers, collecting samples, or handling samples. Avoid handling unnecessary items between donning gloves and handling or collecting the sample/sample containers, including pens, field forms/clipboards, and field tablet computer. Don new gloves at any time during the sampling process if unnecessary items are contacted.
- Field notes will be recorded on loose paper field forms maintained in aluminum or Masonite clipboards, or on a field tablet computer. Waterproof field books, plastic clipboards and spiral bound notebooks will not be used. Don new nitrile gloves between contacting the note-taking materials and handling the samples or sample containers.

- Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn (including rain gear). Polyurethane and polyvinyl chloride (PVC) are acceptable.
- Staff should avoid wearing clothing laundered with fabric softeners, new clothing, stain resistant clothing, or clothing treated with insect repellant chemicals. Clothing made of cotton is preferred.
- Staff should avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling.
- Staff should avoid using sunscreens or insect repellants that are not naturally derived.

4.3.5 Groundwater Sampling Procedures – Residential Wells

Groundwater samples will be collected from residential wells from a standard residential tap located as close to the well, and before any treatment systems or pressure tanks, as possible. Aeration devices will be removed, if possible. The location of the sample will be recorded in the field notes. The tap will be purged for a minimum of 5 minutes prior to collecting the groundwater sample.

4.4 Landfill Gas Monitoring Procedures

Gas probe monitoring will be performed in the field with the portable instruments such as the Landtech GEM 500 portable gas sensor (or equivalent). The following sampling protocol will be followed to monitor pressure, barometric pressure, percent methane, methane as percent of the lower explosive limit (LEL), percent oxygen, and percent carbon dioxide at each of the gas probes:

- Calibrate the gas monitoring instrument in an area where ambient concentrations of gases of concern are not present. Calibrate the oxygen sensor to 21 percent, and set the methane sensor to zero. Check the calibration of the methane sensor using appropriate concentrations of sample gas following the manufacturer's recommended procedures.
- With the gas analysis instrument running and zeroed, first attach a pressure gauge to the valve prior to opening the valve. Open the valve and record the highest pressure that the gauge measured. Close the valve and disconnect the gauge.
- Attach the inlet hose of the gas analysis instrument to the valve prior to opening the valve. Open the valve and record the highest concentration that the instrument detects and note if the concentration decreases or remains steady. Sample the gas for a minimum period of 30 seconds and a maximum of 1 minute. After analyzing the gas, close the valve prior to removing the hose of the instrument.
- Prior to proceeding with sampling and analyzing gas in the next probe, let the monitoring instrument purge itself with ambient air such that it reads zero, or the reading is representative of the atmospheric air.
- If readings are recorded that differ greatly from other probes on-site, or from previous readings at a specific probe, recalibrate the monitoring instrument and recheck the anomalous gas probe.
- Record all monitoring data on a field data sheet.

4.5 Field Parameter Monitoring Equipment Operation, Calibration, and Maintenance

Field analytical measurements to be taken during the fieldwork program will use equipment that is suitable for the analytical method to be used and is properly calibrated. In addition to being accurate, field analyses will be conducted on a sample that is representative of the source from which it was collected. Therefore, the type of sample and the location of the sampling site are critical.

The equipment used for in-field measurement will be maintained, calibrated, and used in the field according to the procedures described in this section. The process will be documented, and the field team leader will periodically review the documentation and inspect the equipment to ensure that the procedures are followed by the personnel collecting the samples. Significant deviations from the QA/QC Plan, errors, equipment failures, or other problems will be recorded in the field notes and reported to the Project Manager. Corrective actions and additional notifications will be coordinated by the Project Manager.

4.5.1 Calibration Procedures

Groundwater level measurement devices will be prepared according to the appropriate manufacturer's instructions (Attachment 3) and checked for visual damage or defects prior to use at the site. The groundwater level measuring device will be calibrated by comparing measurements adjacent to a new measuring tape graduated in hundredths of a foot. If the measuring device does not correspond to the measuring tape within 0.01 foot, the device will be replaced.

The pH and specific conductance meter will be calibrated daily in accordance with manufacturer's instructions (Attachment 3). Calibration will include a minimum of one calibration at the beginning of each sampling day, and a calibration check will be performed at the end of each sampling day.

The Landtech meter will be calibrated once per sampling day as described in Section 4.4. Calibration information will be recorded in the field notes.

4.5.2 Operation Procedures

The sampling meters will be operated according to the manufacturer's instructions (Attachment 3).

4.5.3 Maintenance Procedures

The sampling meters will be maintained according to the manufacturer's instructions (Attachment 3). Maintenance activities performed during the fieldwork will be recorded in the field notes.

4.6 Sampling QA Procedures

4.6.1 General

The sample collection procedures presented in this QA/QC Plan are designed to provide samples of the required quality for the purposes of routine groundwater monitoring. All field personnel will be required to understand the requirements of this Plan and will be trained in the use of the specified equipment and techniques. Specific site activities that will be implemented include the following:

- Convene a meeting of field personnel at the start of a specific monitoring event to review health and safety requirements, the sampling requirements of the QA/QC Plan, review the necessary equipment and decontamination requirements and use, and review the required documentation.
- Review all documentation for completeness, errors, problems, and corrective actions taken.
- Convene daily project team meetings at the start of the day to review health and safety protocol, address any problems developed during the previous day's work, and to review the work to be completed that day.
- Manage the implementation of in-field corrective actions. The Project Manager will be notified of significant problems and, if necessary, will work with the Technical Coordinator to develop corrective actions. The project manager will be responsible for implementing corrective actions that need to be applied to areas other than field activities.

4.6.2 Sample Collection

Personnel involved in the collection of samples are required to read, understand, and follow the health and safety plan and sampling procedures specified in this QA/QC Plan. Problems that may affect the quality of the sampling effort will be recorded by the field personnel most directly involved with the problem, and the Technical Coordinator will be notified and responsible for coordinating the development and implementation of corrective actions with the Project Manager.

4.6.3 Analytical Quality Assurance Considerations

Analytical quality assurance will be assessed through the collection of field QA/QC samples, such as blank and duplicate samples. The frequencies for collection of field duplicate, field blank, trip blank, and matrix spike/matrix spike duplicate samples are specified below:

4.6.3.1 Field Duplicates

Blind field duplicate samples, prepared by splitting a single sample into two separate sets of laboratory containers, will be used to evaluate sampling precision. Points where duplicate samples are to be collected will be selected by the field personnel and will be submitted as single-blind duplicates to the laboratory. Field duplicates will be collected at a rate of one for every 10 (or fewer) primary samples.

4.6.3.2 Field Blanks

Two types of field blanks (equipment blanks and reagent blanks) may be collected as a part of the field sampling program.

4.6.3.2.1 Equipment Blanks

Equipment blanks (or "rinsate blanks") will be collected only if non-dedicated, non-disposable equipment is used to collect groundwater samples, or if samples are to be analyzed for PFAS during the event. Field equipment blanks are analyzed to check for procedural contamination at the site that may cause sample contamination. In most cases, field equipment blanks are samples collected in the field by rinsing a piece of non-dedicated sampling equipment (e.g., steel bailers or portable sampling pumps) that has just been decontaminated with analyte-free water or other blank matrix, and then transferring this water to the proper sample bottles. The water source for the blanks will consist of deionized or distilled water from an off-site source, or from the analytical laboratory. Field equipment blanks will be collected at a frequency of one for every 10 (or fewer) primary samples that are collected with the non-dedicated, non-disposable equipment. Equipment blanks will not be collected from dedicated field equipment.

Equipment blanks will be collected from single-use disposable field equipment only when sampling for PFAS. During PFAS sampling, one equipment blank will be collected from each type of single-use (disposable) sampling equipment used, and at a frequency of at least one for every 10 (or fewer) primary PFAS samples collected with the disposable equipment. For example, if the PFAS sampling requires disposable HDPE bailers at some locations and HDPE tubing at others, at least one field blank will be collected from a bailer, and at least one field blank will be collected from the tubing. New, clean materials will be selected for the collection of the equipment blanks. Laboratory certified PFAS-free water will be obtained for the collection of blanks for PFAS analysis.

4.6.3.2.2 Reagent Blanks

Reagent blanks consist of laboratory grade reagent water poured into the sample containers while at the sampling site. Reagent blanks will be collected as required by the analytical methods. For PFAS sampling, one reagent blank, consisting of laboratory-certified PFAS-free water will be collected per PFAS sampling event.

4.6.3.3 Trip Blanks

Trip blanks will be analyzed to assess whether cross-contamination of VOCs resulting from diffusion through sample container seals may have occurred during sample shipment. Trip blanks, consisting of 40-mL VOA vials with laboratory-grade deionized water, are generated in the laboratory and will accompany VOC sample coolers from the laboratory to the field and back to the laboratory. Trip blank containers are not opened in the field. Trip blanks prepared by the laboratory will meet holding time requirements. One trip blank, consisting of two VOA vials, will be shipped with each cooler containing VOC sample containers.

4.6.3.4 Matrix Spikes/Matrix Spike Duplicates (MSs/MSDs)

MS/MSD samples provide information about the effect of the sample matrix on the sample preparation and measurement methodology. MS/MSD samples will be analyzed in accordance with the laboratory operating procedures. In conjunction with other QC data, the spikes and duplicates give information on the precision and accuracy of the analytical methods for the various sample matrices. One MS/MSD sample will be collected and prepared for every 20 (or fewer) primary samples collected during a monitoring event. The MS/MSD samples will consist of triple the normal sample volume, provided adequate sample volume is available. Field personnel will select the locations where MS/MSD samples are collected and will use care to select locations where adequate sample volumes are obtainable.

5.0 Sample Handling and Analysis

This section presents general sample handling and analysis protocols.

5.1 Sample Containers and Shipping

Sample containers, preservation methods, and holding times that meet USEPA standards for liquid samples intended for chemical analyses are summarized in Table 1. Sample containers are prepared by the laboratory (CT Laboratories in Baraboo, Wisconsin) and shipped directly to the Madison office for transport to the site. PFAS sample containers will be kept separate from the VOC sample containers to prevent cross-contamination. Additional containers of laboratory certified PFAS-free water will accompany the PFAS sample containers for use in collecting field blanks and equipment decontamination. For samples intended for VOC analysis, the sample containers will be filled completely to eliminate airspace. Samples will be kept out of direct sunlight and on ice in a metal or hard-plastic ice chest or cooler from the time the samples are collected until delivery to the laboratory.

For delivery of samples to the laboratory, the following procedures will be implemented:

1. Collect and preserve the samples as described in Table 1.
2. Place sample containers (including field duplicates, field equipment blanks, and matrix spike samples) in a laboratory shipping container(s). Pack samples securely with packing material to protect sample containers from accidental breakage and from leaks or spills during shipment. PFAS and VOC sample containers will be kept in separate coolers. A trip blank will be included with each shipping container that contains VOC samples.
3. Fill shipping containers with enough ice to last the duration of the trip. Double-bag the ice to ensure sample integrity. Do not use dry ice and/or blue ice (ice packs).
4. Complete the Chain-of-Custody form as described in Section 3.2. An example form is included in Attachment 2.
5. Seal the Chain-of-Custody form in a zipper top bag and place inside the top of the cooler.
6. Seal shipping container with packaging tape, and place a custody seal (provided by the laboratory) on the shipping container prior to shipping.
7. Deliver or ship to the laboratory using an overnight shipping service or directly via a courier.

The field team leader will be responsible for the proper use of containers and preservatives.

5.2 Selection of Parameters for Analysis

The samples to be collected for this monitoring program will be analyzed for the parameters as listed in the tables included in Attachment 1, Tables 5 and 6.

5.3 Laboratory Analytical Procedures

The selection of analytical procedures will reflect USEPA-approved methodology from SW-846, and USEPA 500 methods, where applicable, as stated in Table 1.

6.0 Management of Waste Materials From Fieldwork Program

6.1 Investigative-Derived Waste

Purge water from contaminated wells, or wells that have not previously been sampled, will be collected in truck- or trailer-mounted polyethylene tanks and transferred to the on-site leachate tank. Contaminated wells include any well with a Wisconsin Administrative Code Chapter NR 140 Enforcement Standard (ES) exceedance for any reported parameter over the last five years. The current list of contaminated wells is included in Table 2. The list of contaminated wells will be reviewed and revised periodically as additional groundwater data are generated. Water from uncontaminated wells and decontamination water will be discharged to the ground surface.

6.2 Used Personal Protective Equipment and Uncontaminated Refuse

Used personal protective equipment and other types of general uncontaminated debris or waste materials produced during the fieldwork will be collected daily in sealed plastic bags and placed in a waste dumpster at the TRC Madison office.

7.0 References

TRC. 2019. Quality Assurance/Quality Control Plan, Refuse Hideaway Landfill, Town of Middleton, Dane County, Wisconsin. May 2019. Revision 1.

United States Environmental Protection Agency (USEPA) Region 1. 1996. Low stress (low flow) purging and sampling procedure for the collection of groundwater samples from monitoring wells. July 30, 1996. Revision 2.

Table 1: Analytical Sampling Requirements

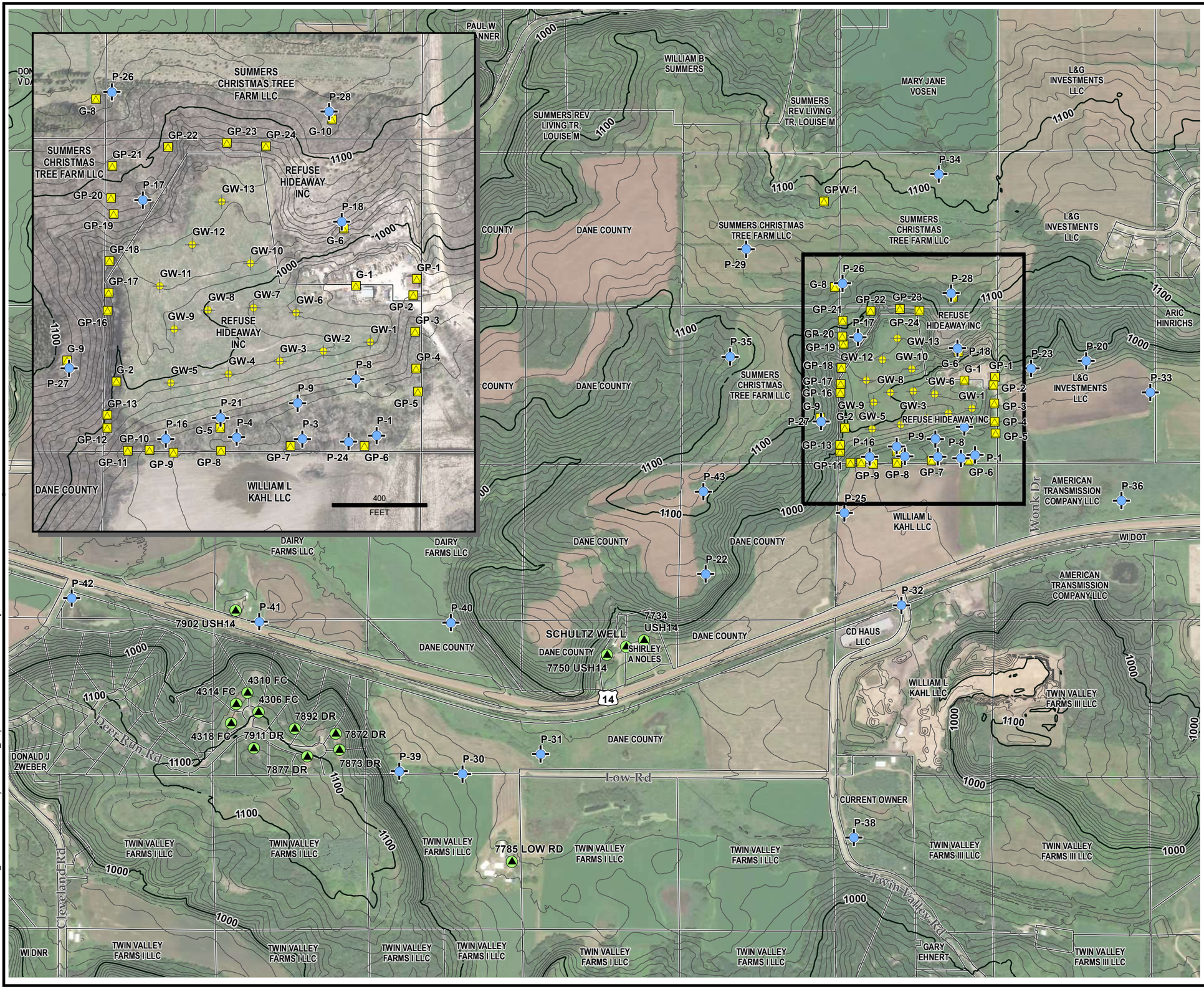
Analytical Group[(1)]	Analytical and Preparation Method	Sample Volume[(1)]	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
VOC (Monitoring Wells)	SW-846 8260B	120 mL	(3) 40-mL glass vials, no headspace	Cool to 4 ± 2 °C HCl to pH <2	14 days
VOC (Residential Wells)	USEPA 524.2	120 mL	(3) 40-mL glass vials, no headspace	Cool to 4 ± 2 °C HCl to pH <2	14 days
Per- and polyfluoroalkyl substances (PFAS)	USEPA 537.1	250 mL	(2) 125-mL HDPE Plastic	Cool to 4 ± 2 °C	14 days

Footnotes:

(1) Analytical lists are included in Attachment 1.

Table 2: List of Wells with History of ES Exceedances – 2014 to 2019

Well Name	Sampling Frequency
P-17S	Semi-annual
P-18S	Semi-annual
P-20SR	Semi-annual
P-22S	Semi-annual
P-22D	Semi-annual
P-22E	Semi-annual
P-23S	Semi-annual
P-23D	Semi-annual
P-8D	Annual
P-16D	Annual
P-21D	Annual
P-21BR	Annual
P-24D	Annual
P-24E	Annual



LEGEND

- GAS PROBE
- GAS WELL
- MONITORING WELL
- PRIVATE WELL
- PARCEL BOUNDARY

NOTES

1. BASE MAP IMAGERY FROM ESRI/DANE COUNTY, 2017.
2. TOPOGRAPHY FROM DANE COUNTY LIDAR SURVEY, 2017.
3. PARCELS FROM WISCONSIN STATE CARTOGRAPHER'S OFFICE, 2018.
4. SITE FEATURES SHOWN ARE APPROXIMATE.

0 800 1,600 Feet

1 " = 800 '

1:9,600

PROJECT:

WISCONSIN DNR
REFUSE HIDEAWAY LANDFILL

TITLE:

SITE OVERVIEW

DRAWN BY:	J. PAPEZ	PROJ NO.:	335719.9990
CHECKED BY:	M. WESTOVER		
APPROVED BY:	K. VATER		**FIGURE 1**
DATE:	APRIL 2019		

TRC
708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 335719-001.mxd

Plot Date: 4/17/2019, 10:51:57 AM by JPAPEZ -- LAYOUT: ANSI B (11"x17")
Path: S:\1-PROJECTS\WI_DNR\RefuseHideaway\335719-GW_Proposal\335719-001.mxd
Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet (Foot US)
Map Rotation: 0

TRC - GIS

Attachment 1: Groundwater Monitoring Program Summary Tables

Attachment 1

Table 1: Monitoring Wells Included in Semi-Annual Sampling

Well Number	Well Depth (Feet)[1]	Depth to Groundwater (Feet)[1]	Approximate Purge Vol. (Gal)[2]	Dedicated QED System[3]	Analytical Method
P-17S	158.8	148.3	7	Yes	SW846-8260
P-18S	107.2	101.97	4	Yes	SW846-8260
P-20SR	66.3	41.0	17	No	SW846-8260
P-22S	184.7	174.9	7	Yes	SW846-8260
P-22D	217.2	175.9	27	Yes, p.m.	SW846-8260
P-22E	273.0	179.00	57	Yes	SW846-8260
P-23S	48.1	43.61	3	No	SW846-8260
P-23D	80.1	43.36	23	Yes	SW846-8260
P-25D	96.3	28.6	44	Yes	SW846-8260
P-25BR	140.3	27.6	73	Yes	SW846-8260
P-26S	237.6	221.9	10	Yes	SW846-8260
P-27S	188.8	177.0	8	Yes	SW846-8260
P-27D	204.3	177.6	18	Yes, p.m.	SW846-8260
P-30I	142.3	21.9	79	Yes, p.m.	SW846-8260
P-30D	289.5	23.9	173	Yes, p.m.	SW846-8260
P-31IA[4]	95.6	11.3	55	Yes, p.m.	SW846-8260
P-31IB[4]	135.7	10.6	81	Yes, p.m.	SW846-8260
P-31D[4]	258.2	9.8	162	Yes, p.m.	SW846-8260
P-40I	104.8	12.6	60	Yes, p.m.	SW846-8260
P-40D	255.2	13.7	158	Yes, p.m.	SW846-8260
P-43S	205.7	197.08	5	Yes	SW846-8260
P-43I	233.3	196.70	22	Yes	SW846-8260
P-43D	283.6	196.39	53	Yes	SW846-8260

NOTES (4 are listed below):

1 Well depths are from the top of the casing. Depth in feet below top of well casing, based on February or May, 1998 data, except for wells P-22E, P-43S, P-43I, and P-43D for which depths are based on November 2003 data. Depths may vary seasonally.

2 4x the estimated casing volume, from Wisconsin Department of Natural Resources “Groundwater Sampling Field Manual”, September 1996, Publication Number PUBL-DG-038 96, p.11, Equation 1.

3 Yes indicates a bladder pump only; Yes, p.m. indicates a bladder pump and purge-mizer system. The bladder pumps are “QED” brand pumps, except the pumps in P-22E, P-43S, P-43I, and P-43D, which are “Geo-Pump” brand pumps

4 Wells equipped with mechanical packers in the QED equipment (P-31IA, P-31IB, P-31D)

Attachment 1

Table 2: Monitoring Wells Included in Annual Sampling

Well Number	Well Depth (Feet)[1]	Depth to Groundwater (Feet)[1]	Approximate Purge Vol. (Gal)[2]	Dedicated QED System[3]	Analytical Method
P-8S	20.5	8.76	8	No	SW846-8260
P-8D	42.2	11.53	19	No	SW846-8260
P-9S	16.0	11.83	3	No	SW846-8260
P-9D	43.0	11.57	20	No	SW846-8260
P-16S	17.2	10.1	5	No	SW846-8260
P-16D	42.9	17.7	17	No	SW846-8260
P-21S	19.7	13.5	4	No	SW846-8260
P-21D	41.6	15.9	17	No	SW846-8260
P-21BR	148.3	16.4	86	Yes	SW846-8260
P-24D	25.2	3.8	14	No	SW846-8260
P-24E	52.5	8.8	29	No	SW846-8260
P-25S	29.4	24.6	3	No	SW846-8260
P-28S	207.4	204.35	2	Yes	SW846-8260
P-29S	257.2	239.8	11	Yes	SW846-8260
P-31S	28.8	6.2	15	Yes	SW846-8260
P-32S	39.5	24.2	10	No	SW846-8260
P-32D	176.2	24.6	99	Yes	SW846-8260
P-33D	103.4	9.8	57	Yes	SW846-8260
P-34S	186.0	164.3	14	Yes	SW846-8260
P-34D	276.1	167.3	71	Yes, p.m.	SW846-8260
P-41D	104.5	19.0	56	Yes, p.m.	SW846-8260

NOTES (3 are listed below):

[1] Well depths are from the top of the casing. Depth in feet below top of well casing, based on February or May, 1998 data, or November 2003 data. Depths may vary seasonally.

[2] 4x the estimated casing volume, from Wisconsin Department of Natural Resources “Groundwater Sampling Field Manual”, September 1996, Publication Number PUBL-DG-038 96, p.11, Equation 1.

[3] Yes indicates a bladder pump only; Yes, p.m. indicates a bladder pump and purge-mizer system

Attachment 1

Table 3: Monitoring Wells to be Sampled on a Three-Year Frequency (in May 2019)

Well Number	Well Depth (Feet)[1]	Depth to Groundwater (Feet)[1]	Approximate Purge Vol. (Gal)[2]	Dedicated QED System[3]	Analytical Method
P-8BR	111.5	11.6	61	Yes	SW846-8260
P-33S	27.6	7.7	12	No	SW846-8260
P-35S	184.0	167.6	11	Yes	SW846-8260
P-35D	252.6	168.7	55	Yes, p.m.	SW846-8260

NOTES (3 are listed below):

1 Well depths are from the top of the casing. Depth in feet below top of well casing, based on February or May, 1998 data, or November, 2003 data. Depths may vary seasonally.

2 4x the estimated casing volume, from Wisconsin Department of Natural Resources "Groundwater Sampling Field Manual", September 1996, Publication Number PUBL-DG-038 96, p.11, Equation 1.

3 Yes indicates a bladder pump only; Yes, p.m. indicates a bladder pump and purge-mizer system

Attachment 1

Table 5: PFAS Compounds

#	Acronym (EPA Dashboard)	Free Acid Name (EPA Dashboard)	Free Acid CAS #
Carboxylic Acids			
1	PFBA	Perfluorobutanoic acid	375-22-4
2	PFPeA	Perfluoropentanoic acid	2706-90-3
3	PFHxA	Perfluorohexanoic acid	307-24-4
4	PFHpA	Perfluoroheptanoic acid	375-85-9
5	PFOA	Perfluorooctanoic acid	335-67-1
6	PFNA	Perfluorononanoic acid	375-95-1
7	PFDA	Perfluorodecanoic acid	335-76-2
8	PFUnA	Perfluoroundecanoic acid	2058-94-8
9	PFDoA	Perfluorododecanoic acid	307-55-1
10	PFTriA	Perfluorotridecanoic acid	72629-94-8
11	PFTeDA	Perfluorotetradecanoic acid	376-06-7
12	PFHxDA	Perfluorohexadecanoic acid	67905-19-5
13	PFODA	Perfluorooctadecanoic acid	16517-11-6
Sulfonic Acids			
14	PFBS	Perfluorobutanesulfonic acid	375-73-5
15	PFPeS	Perfluoropentanesulfonic acid	2706-91-4
16	PFHxS	Perfluorohexanesulfonic acid	355-46-4
17	PFHpS	Perfluoroheptanesulfonic acid	375-92-8
18	PFOS	Perfluorooctanesulfonic acid	1763-23-1
19	PFNS	Perfluorononanesulfonic acid	68259-12-1
20	PFDS	Perfluorodecanesulfonic acid	335-77-3
21	PFDoS	Perfluorododecanesulfonic acid	79780-39-5
22	4:2 FTS	4:2 Fluorotelomer sulfonic acid	757124-72-4
23	6:2 FTS	6:2 Fluorotelomer sulfonic acid	27619-97-2
24	8:2 FTS	8:2 Fluorotelomer sulfonic acid	39108-34-4
25	10:2 FTS	10:2 Fluorotelomer sulfonic acid	120226-60-0
Sulfonamides, Sulfomidoacetic acids, Sulfonamidoethanols			
26	PFOSA	Perfluorooctanesulfonamide	754-91-6
27	N-MeFOSA	N-Methylperfluorooctanesulfonamide	31506-32-8
28	N-EtFOSA	N-Ethylperfluorooctanesulfonamide	4151-50-2
29	N-MeFOSAA	2-(N-Methylperfluorooctanesulfonamido)acetic acid	2355-31-9
30	N-EtFOSAA	2-(N-Ethylperfluorooctanesulfonamido)acetic acid	2991-50-6
31	N-MeFOSE	N-Methyl perfluorooctanesulfonamidoethanol	24448-09-7
32	N-EtFOSE	N-Ethyl perfluorooctanesulfonamidoethanol	1691-99-2

Attachment 1

Table 5: PFAS Compounds

#	Acronym (EPA Dashboard)	Free Acid Name (EPA Dashboard)	Free Acid CAS #
Replacement Chemicals			
33	GenX (parent acid/non-salted)	Perfluoro-2-methyl-3-oxahexanoic acid	13252-13-6
34	ADONA (parent acid)	4,8-Dioxa-3H-perfluorononanoic acid	919005-14-4
35	F-53B Major	Perfluoro(2-((6-chlorohexyl)oxy)ethanesulfonic acid)	756426-58-1
36	F-53B Minor	2-[(8-Chloro-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8-hexadecafluorooctyl)oxy]-1,1,2,2-tetrafluoroethanesulfonic acid	763051-92-9

MDL Update Request

Changes Requested by / Date: _____ ***Date Needed:*** _____ ***Changed***

TESTCODE: 244 **MATRIX:** DRINKING WATER

TEST NAME: VOC 524 SDWA **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
1,1,1,2-Tetrachloroethane	0.3		0.3				1.0
1,1,1-Trichloroethane	0.28		0.28				0.93
1,1,2,2-Tetrachloroethane	0.5		0.5				1.6
1,1,2-Trichloroethane	0.4		0.4				1.3
1,1-Dichloroethane	0.28		0.28				0.95
1,1-Dichloroethene	0.3		0.3				1.1
1,1-Dichloropropene	0.3		0.3				1.1
1,2,3-Trichlorobenzene	0.5		0.5				1.6
1,2,3-Trichloropropane	0.25		0.25				0.83
1,2,4-Trichlorobenzene	0.4		0.4				1.4
1,2,4-Trimethylbenzene	0.3		0.3				1.1
1,2-Dichlorobenzene	0.4		0.4				1.2
1,2-Dichlorobenzene-d4			80				120
1,2-Dichloroethane	0.23		0.23				0.76
1,2-Dichloropropane	0.3		0.3				1.0
1,3,5-Trimethylbenzene	0.29		0.29				0.98
1,3-Dichlorobenzene	0.26		0.26				0.87
1,3-Dichloropropane	0.3		0.3				1.1
1,4-Dichlorobenzene	0.29		0.29				0.98
2,2-Dichloropropane	0.4		0.4				1.2
2-Chlorotoluene	0.3		0.3				1.0
4-Chlorotoluene	0.4		0.4				1.2
Benzene	0.26		0.26				0.87
Bromobenzene	0.4		0.4				1.4
Bromochloromethane	0.4		0.4				1.2

TESTCODE: 244 **MATRIX:** DRINKING WATER

TEST NAME: VOC 524 SDWA **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
Bromodichloromethane	0.24		0.24				0.81
Bromofluorobenzene			80				120
Bromoform	0.4		0.4				1.2
Bromomethane	0.4		0.4				1.4
Carbon tetrachloride	0.28		0.28				0.94
Chlorobenzene	0.25		0.25				0.84
Chlorodibromomethane	0.4		0.4				1.4
Chloroethane	0.3		0.3				1.3
Chloroform	0.23		0.23				0.78
Chloromethane	0.19		0.19				0.63
cis-1,2-Dichloroethene	0.28		0.28				0.94
cis-1,3-Dichloropropene	0.22		0.22				0.73
Dibromomethane	0.3		0.3				1.0
Dichlorodifluoromethane	0.3		0.3				1.0
Ethylbenzene	0.27		0.27				0.89
Hexachlorobutadiene	0.4		0.4				1.4
Isopropylbenzene	0.29		0.29				0.98
m & p-Xylene	0.5		0.5				1.5
Methyl tert-butyl ether	0.26		0.26				0.86
Methylene chloride	0.30		0.30				0.99
n-Butylbenzene	0.3		0.3				1.0
n-Propylbenzene	0.26		0.26				0.85
Naphthalene	0.5		0.5				1.5
o-Xylene	0.26		0.26				0.88
p-Isopropyltoluene	0.25		0.25				0.82
sec-Butylbenzene	0.26		0.26				0.85
Styrene	0.3		0.3				1.0
tert-Butylbenzene	0.24		0.24				0.80
Tetrachloroethene	0.26		0.26				0.87
Toluene	0.25		0.25				0.84

TESTCODE: 244 **MATRIX:** DRINKING WATER ☐

TEST NAME: VOC 524 SDWA **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
Total Xylene	0.26		0.26				0.88
trans-1,2-Dichloroethene	0.23		0.23				0.75
trans-1,3-Dichloropropene	0.28		0.28				0.93
Trichloroethene	0.3		0.3				1.0
Trichlorofluoromethane	0.24		0.24				0.80
Vinyl chloride	0.17		0.17				0.58

Please copy the above changes to the following matrices :

☐ Groundwater	☐ Leachate	☐ MeOH Blank	☐ ASTM Leach
☐ Drinking Water	☐ Trip Blank	☐ Air	☐ Waste
☐ Surface Water	☐ Soil	☐ TCLP	
☐ Wastewater	☐ Sludge	☐ SPLP	

Please copy the above changes to the following Tests :

CT LABORATORIES
delivering more than data from your environmental analyses
1230 Lange C

MDL Update Request

Changes Requested by / Date: _____ ***Date Needed:*** _____ ***Changed***

TESTCODE: 60 **MATRIX:** GROUND WATER

TEST NAME: VOC 8260LANDFILL **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
1,1,1,2-Tetrachloroethane	0.6		0.6				1.9
1,1,1-Trichloroethane	0.5		0.5				1.8
1,1,2,2-Tetrachloroethane	0.7		0.7				2.4
1,1,2-Trichloroethane	0.4		0.4				1.5
1,1-Dichloroethane	0.3		0.3				1.1
1,1-Dichloroethene	0.4		0.4				1.5
1,1-Dichloropropene	0.7		0.7				2.2
1,2 Dichloroethane-d4			89				111
1,2,3-Trichlorobenzene	0.8		0.8				2.6
1,2,3-Trichloropropane	0.6		0.6				1.9
1,2,4-Trichlorobenzene	0.5		0.5				1.7
1,2,4-Trimethylbenzene	0.4		0.4				1.2
1,2-Dibromo-3-chloropropane	0.7		0.7				2.4
1,2-Dibromoethane	0.6		0.6				1.8
1,2-Dichlorobenzene	0.6		0.6				1.9
1,2-Dichloroethane	0.26		0.26				0.87
1,2-Dichloropropane	0.4		0.4				1.4
1,3,5-Trimethylbenzene	0.4		0.4				1.3
1,3-Dichlorobenzene	0.5		0.5				1.8
1,3-Dichloropropane	0.5		0.5				1.6
1,4-Dichlorobenzene	0.6		0.6				2.0
2,2-Dichloropropane	0.5		0.5				1.6
2-Butanone	4		4				14
2-Chlorotoluene	0.4		0.4				1.4
2-Hexanone	7		7				24

TESTCODE: 60 **MATRIX:** GROUND WATER

TEST NAME: VOC 8260LANDFILL **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
4-Chlorotoluene	0.4		0.4				1.5
4-Methyl-2-pentanone	6		6				19
Acetone	9		9				30
Benzene	0.24		0.24				0.81
Bromobenzene	0.6		0.6				1.9
Bromochloromethane	0.8		0.8				2.5
Bromodichloromethane	0.4		0.4				1.4
Bromofluorobenzene			83				111
Bromoform	0.7		0.7				2.3
Bromomethane	0.7		0.7				2.4
Carbon disulfide	0.5		0.5				1.6
Carbon tetrachloride	0.5		0.5				1.6
Chlorobenzene	0.5		0.5				1.5
Chloroethane	0.5		0.5				1.6
Chloroform	0.3		0.3				0.9
Chloromethane	0.7		0.7				2.5
cis-1,2-Dichloroethene	0.3		0.3				1.0
cis-1,3-Dichloropropene	0.4		0.4				1.2
d8-Toluene			93				107
Dibromochloromethane	0.4		0.4				1.4
Dibromofluoromethane			90				110
Dibromomethane	0.8		0.8				2.5
Dichlorodifluoromethane	0.4		0.4				1.5
Diisopropyl ether	0.29		0.29				0.97
Ethylbenzene	0.3		0.3				1.1
Hexachlorobutadiene	0.9		0.9				2.9
Isopropylbenzene	0.4		0.4				1.4
m & p-Xylene	0.5		0.5				1.8
Methyl tert-butyl ether	0.3		0.3				1.1
Methylene chloride	0.5		0.5				1.7

TESTCODE: 60 **MATRIX:** GROUND WATER ☐

TEST NAME: VOC 8260LANDFILL **REPORTED UNITS:** ug/L

ANALYTES:	CURRENT REPORTING LIMIT	NEW REPORTING LIMIT	CURRENT LOD	NEW LOD	CURRENT DOD LOD	NEW DOD LOD	CURRENT LOQ
n-Butylbenzene	0.4		0.4				1.2
n-Propylbenzene	0.5		0.5				1.8
Naphthalene	0.7		0.7				2.2
o-Xylene	0.4		0.4				1.4
p-Isopropyltoluene	0.5		0.5				1.5
sec-Butylbenzene	0.4		0.4				1.3
Styrene	0.5		0.5				1.7
tert-Butylbenzene	0.4		0.4				1.4
Tetrachloroethene	0.5		0.5				1.8
Tetrahydrofuran	3.0		3.0				10.0
Toluene	0.3		0.3				1.1
trans-1,2-Dichloroethene	0.6		0.6				1.9
trans-1,3-Dichloropropene	0.4		0.4				1.4
Trichloroethene	0.3		0.3				1.0
Trichlorofluoromethane	0.3		0.3				1.1
Vinyl chloride	0.19		0.19				0.64

Please copy the above changes to the following matrices :

☐ Groundwater ☐ Leachate ☐ MeOH Blank ☐ ASTM Leach

☐ Drinking Water ☐ Trip Blank ☐ Air ☐ Waste

☐ Surface Water ☐ Soil ☐ TCLP

☐ Wastewater ☐ Sludge ☐ SPLP

Please copy the above changes to the following Tests :

Attachment 2: Example Forms

TRC

PROJECT NAME: Refuse Hideaway Landfill

PROJECT NUMBER:

PROJECT MANAGER:

SITE LOCATION:

DATES OF FIELDWORK: TO

PURPOSE OF FIELDWORK:

WORK PERFORMED BY:

SIGNED DATE

CHECKED BY DATE

TRC

WELL INSPECTION REPORT

PROJECT NAME:	Refuse Hideaway Landfill
PROJECT NO.:	0.00

SAMPLER NAME:	
DATE:	

WELL ID	PROTECTIVE CASING	SURFACE SEAL	DEGREE OF IMMOBILITY OF PROTECTIVE CASING	PERMANENT LEGIBLE LABELS	LOCK	WELL CAP	EASE OF INSERTING / REMOVING BAILER	SEDIMENT IN WELL	COMMENT

SIGNED DATE

CHECKED BY DATE

REVISED 03/2008

TRC

GENERAL NOTES

PROJECT NAME: Refuse Hideaway Landfill	DATE:	TIME ARRIVED:
PROJECT NUMBER: 0.00	AUTHOR:	TIME LEFT:

WEATHER		
TEMPERATURE: _____ °F	WIND: _____ MPH	VISIBILITY: _____

WORK / SAMPLING PERFORMED

PROBLEMS ENCOUNTERED	CORRECTIVE ACTION TAKEN

COMMUNICATION		
NAME	REPRESENTING	SUBJECT / COMMENTS

SIGNED DATE

CHECKED BY DATE

TRC

WATER QUALITY METER CALIBRATION LOG

PROJECT NAME:	Refuse Hideaway Landfill	MODEL:	SAMPLER:
PROJECT NO.:	0.00	SERIAL #:	DATE: -

PH METER

CALIBRATION			POST SAMPLING CALIBRATION CHECK			
pH 4	pH 7	TIME	pH 4	pH 7	TIME	DATE
☐ WITHIN RANGE	☐ WITHIN RANGE					
☐ WITHIN RANGE	☐ WITHIN RANGE					
☐ WITHIN RANGE	☐ WITHIN RANGE					
☐ WITHIN RANGE	☐ WITHIN RANGE					
☐ WITHIN RANGE	☐ WITHIN RANGE					

CONDUCTIVITY METER

CALIBRATION			POST SAMPLING CALIBRATION CHECK			
STANDARD		TIME	SOLUTION CHECK	SOLUTION TEMP	TIME	DATE
µmhos/cm	☐ WITHIN RANGE		µmhos/cm	°C		
µmhos/cm	☐ WITHIN RANGE		µmhos/cm	°C		
µmhos/cm	☐ WITHIN RANGE		µmhos/cm	°C		
µmhos/cm	☐ WITHIN RANGE		µmhos/cm	°C		
µmhos/cm	☐ WITHIN RANGE		µmhos/cm	°C		

Autocal Solution Lot#: _____ Exp Date: _____

pH 7 Soultion Lot#: _____ Exp Date: _____

Parameters Calibrated: ☐ pH ☐ Conductivity

NOTES

DATE	PROBLEMS ENCOUNTERED	CORRECTIVE ACTIONS

SIGNED _____ DATE _____

Checked _____ DATE _____

TRC

WATER LEVEL DATA

PROJECT NAME:	Refuse Hideaway Landfill	DATE:
PROJECT NUMBER:	0.00	AUTHOR:

WELL LOCATION	TIME	REFERENCE	DEPTH TO WATER (FEET)	DEPTH TO BOTTOM (FEET)	SCREENED INTERVAL (FEET)	WATER ELEVATION

SIGNED DATE

CHECKED DATE

TRC

WATER SAMPLE LOG

PROJECT NAME: **Refuse Hideaway Landfill**	PREPARED		CHECKED	
PROJECT NUMBER: **0.00**	BY:	DATE:	BY:	DATE:

SAMPLE ID:	WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6" ☐ OTHER
WELL MATERIAL: ☐ PVC ☐ SS ☐ IRON ☐	☐ OTHER
SAMPLE TYPE: ☐ GW ☐ WW ☐ SW ☐ DI ☐ LEACHATE	☐ OTHER

PURGING	TIME:	DATE:

PURGE METHOD: ☐ PUMP _____ ☐ BAILER _____	PH: SU	CONDUCTIVITY: umhos/cm
DEPTH TO WATER: T/ PVC	TURBIDITY: ☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY	
DEPTH TO BOTTOM: T/ PVC		
WELL VOLUME: ☐ LITERS ☑ GALLONS	TEMPERATURE: °C	OTHER: --
WELL PURGED DRY: ☐ NO ☐ YES	COLOR:	ODOR:
VOLUME REMOVED: ☐ LITERS ☐ GALLONS	FILTRATE (0.45 um) ☐ YES ☐ NO	
COLOR: ODOR	COLOR: FILT ODOR:	
TURBIDITY ☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY	QC SAMPLE: ☐ MS/MSD ☐ DUP-	
DISPOSAL METHOD ☐ GROUND ☐ LEACHATE TANK	COMMENTS:	

SAMPLE	TIME:	DATE:

BOTTLES FILLED — PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F -

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD:	DATE SHIPPED:	
	SIGNATURE: _____	DATE SIGNED: _____

Rev. 02/2017

CHAIN OF CUSTODY

Page _____ of _____

Company:
Project Contact:
Telephone:
Project Name:
Project #:
Location:
Sampled By:

CT LABORATORIES

1230 Lange Court, Baraboo, WI 53913
608-356-2760 Fax 608-356-2766
www.ctlaboratories.com

Lab Use Only
Place Header Sticker Here:

Program:
QSM RCRA SDWA NPDES
Solid Waste Other _____

PO #

Report To:
EMAIL:
Company:
Address:

Invoice To:*
EMAIL:
Company:
Address:

****Party listed is responsible for payment of invoice as per CT Laboratories' terms and conditions***

Client Special Instructions

Matrix:
GW – groundwater **SW** - surface water **WW** - wastewater **DW** - drinking water
S - soil/sediment **SL** - sludge **A** - air **M** - misc/waste

Filtered? Y/N

ANALYSES REQUESTED

Total # Containers

Designated MS/MSD

Turnaround Time
Normal RUSH*
Date Needed: _____
Rush analysis requires prior CT Laboratories' approval
Surcharges:
24 hr 200%
2-3 days 100%
4-9 days 50%

Collection Date	Collection Time	Matrix	Grab/ Comp	Sample #	Sample ID Description	Filtered? Y/N	Fill in Spaces with Bottles per Test	Total # Containers	Designated MS/MSD	CT Lab ID # (Lab use only)

Relinquished By:	Date/Time	Received By:	Date/Time
Received by:	Date/Time	Received for Laboratory by:	Date/Time

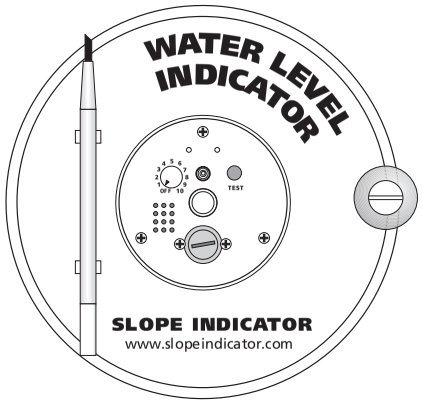
Lab Use Only
Ice Present Yes No
Temp _____ IR Gun _____
Cooler # _____

Attachment 3: Instrument Manufacturers' Instructions/Manuals

- Slope Indicator (or equivalent) – Water Level Indicator
- In-Situ SmarTroll (includes calibration and maintenance of pH, temperature, and conductivity)
- GEM-500 Operations Manual

Slope Indicator (or equivalent) – Water Level Indicator

Water Level Indicator

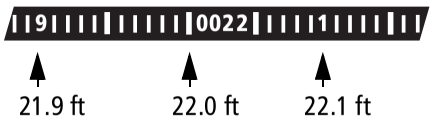


Taking Readings

1. Switch on. Set sensitivity to 5 or 6.
2. Lower probe into well. When probe touches water, light turns on and beeper sounds.
3. Read depth to water from cable mark that aligns with your reference (such as the top of the well).
4. Switch off.

Reading Cable Marks

Cable is graduated with 1/100 ft marks. White numbers are 1/10 ft. Yellow numbers are feet. Read as shown below:



Indicator Controls

On/Off/Sensitivity: The on/off switch also adjusts sensitivity. Sensitivity is set properly if beeper and light turn off immediately when probe is removed from contact with water. Use lower setting for very conductive water or to eliminate false triggering. Use higher setting for less conductive water.

Battery Test Button: Push the button to check the batteries. Light and beeper activate when batteries are good.

Replacing Batteries

The indicator uses two AA-size batteries. Press Test button to check batteries. Replace batteries if light and beeper do not activate.

1. Use coin or screwdriver to open battery holder. (¼ turn counter-clockwise)
2. Remove the two AA batteries. Insert new batteries with + terminals up, toward the cap.
3. Replace cap.

Cleaning the Indicator

Probe: Wash probe with detergent.

Reel: Wipe off the reel with a damp cloth. Do not immerse in water.

Cable: Wash the cable with a laboratory-grade detergent such as Alconox or Liquinox. Rinse with distilled water as required. Remove oily deposits with dish-washing detergent. Do not leave the cable immersed in detergent for a long time. Rinse in distilled water.

Do not use nitric acid, hydrochloric acid, MEK, Acetone, Toluene, or alcohol to clean the cable. Even short-term exposure to these substances can damage the polyurethane cable jacket.

Repairs

If your water level indicator is damaged, you can order replacement parts to fix it yourself or you can return it to the factory for repair.

To order replacement parts, please visit www.slopeindicator.com. Click on Support, then click on Water Level Indicator Parts.

To return the water level indicator to the factory for repair, contact the Slope Indicator factory for a return authorization:

Tel: 425-493-6200
Fax: 425- 493-6250
Email: solutions@slope.com

Check that the indicator is clean and dry, then package it, write the return authorization number on the outside, and send to:

Slope Indicator
12123 Harbour Reach Drive
Mukilteo, WA, USA
98275

Limited Warranty

Slope Indicator warrants all products manufactured by it to be free of defects of workmanship and material for a period of one year from the date of delivery to the customer, unless the customer is an authorized distributor of Slope Indicator products, in which case the warranty shall be for a period of one year from the date of delivery to the authorized distributor's customer. The obligation of Slope Indicator Company is hereafter limited to replacement or, at its option, repair of products returned to it with transportation charges to and from the Company paid by the customer (including prepayment of transportation charges to the Company) and which the company's examination shall disclose, to its satisfaction, were not free from such defects.

In no event shall Slope Indicator be liable for consequential or special damages, or for installation, adjustment or other expenses which may arise in connection with such products. This warranty extends only to the original customer of the company or its authorized distributor, as the case may be, and is expressly in lieu of all other warranties, express or implied, whether of merchantability or fitness for any particular purpose or use and of all other obligations and liabilities of any kind and character. Except for the warranty described on the face hereof, seller makes no warranty of merchantability of the goods or of the fitness of the goods for any purpose. There are no warranties which extend beyond the description on the face hereof.

SLOPE INDICATOR
www.slopeindicator.com

In-Situ SmarTroll
(includes calibration and maintenance of pH, temperature, and conductivity)

Innovations in **Water Monitoring**

Operator's Manual

SMARTROLL™ MP Handheld Instrument for Android

0099552 | 2019-03-18

Mailing and Shipping Address:

In-Situ
221 East Lincoln Avenue
Fort Collins, CO 80524
U.S.A.

Phone: 970-498-1500 (international & domestic)

Fax: 970-498-1598

Internet: *www.in-situ.com*

Support: 800-446-7488 (U.S.A. & Canada)

The presence of the Waste Electrical and Electronic Equipment (WEEE) marking on the product indicates that the device is not to be disposed via the municipal waste collection system of any member state of the European Union.

For products under the requirement of WEEE directive, please contact your distributor or local In-Situ office for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.

0099552 | 2019-03-18

Table of Contents

Introduction

This manual is intended to describe the characteristics, operation, calibration, and maintenance of the SmarTROLL™ MP Instrument.

Serial Number Location

The probe serial number is on the product label affixed to the probe body.

The Power Pack serial number is under the flap that protects the USB charging connector.

Safety

- Do not submerge the Power Pack or the mobile display device in liquid.
- Ensure that the pH/ORP sensor is completely inserted into the port, so that no liquid can enter the instrument. The storage plug is not intended to be used when the instrument is deployed in water.
- Ensure that the RDO Sensor Cap is pressed firmly over the sensor lens and is flush with the instrument before submerging in liquid.
- Replace the cable if insulation or connectors are damaged.
- Make sure the probe and sensor O-rings are clean and free of damage.

General Specifications

Operating temperature	-5 to 50° C (23 to 122° F)
Storage temperature	-40 to 65° C (-40 to 149° F)
Dimensions	4.7 cm (1.85 in.) OD x 26.9 cm (10.6 in.) with restrictor installed (does not include connector)
Weight	694 g (1.53 lbs)
Wetted materials	PVC, 316 stainless steel, titanium, Acetal, Viton®, PC/PMMA
Environmental rating	IP68 with all sensors and cable attached. IP67 with sensors removed and cable detached.
Reading rate	1 reading every 10 seconds; data logged to mobile device.
Power	5 VDC from Power Pack
Interface	Android™ platform 4.4 (requires *Bluetooth*® 2.0) Download VuSitu for free on the Google Play store. Used with Android Power Pack
Cable	Black polyurethane. Standard lengths available: 1.5 m, 4.6 m, 9.1 m, 30.5 m, 76.2 m (5 ft, 15 ft, 30 ft, 100 ft, 250 ft)
Warranty	2-years
Notes	Specifications are subject to change without notice. Bluetooth is a registered trademark of Bluetooth SIG, Inc. Viton is a registered trademark of DuPont Performance Elastomers L.L.C.

Sensor Specifications

Level, Depth, Pressure Sensor Specifications

Accuracy	Typical ±0.1% FS @ 15° C; ±0.3% FS max. from 0 to 50° C
Range	76 m (250 ft); absolute (non-vented)
Resolution	±0.01% FS or better
Sensor Type	Fixed
Response Time	Instantaneous in thermal equilibrium
Units of Measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg Level: mm, cm, m, in, ft
Methodology	Piezoresistive; ceramic

Barometric Pressure Sensor Specifications (Power Pack)

Accuracy	±3 mbar max.
Range	300 to 1100 mbar
Resolution	0.01 mbar
Sensor Type	Fixed
Response Time	Instantaneous in thermal equilibrium
Units of Measure	psi, kPa, bar, mbar, mmHg, inHg, Torr, atm
Methodology	Piezoresistive pressure sensor

Conductivity Sensor Specifications

Accuracy	Typical ±0.5% + 1 µS/cm; ±1% max.
Range	5 to 100,000 µS/cm
Resolution	0.1 µS/cm
Sensor Type	Fixed
Response Time	Instantaneous in thermal equilibrium
Units of Measure	Actual conductivity (µS/cm, mS/cm) Specific conductivity (µS/cm, mS/cm) Salinity (PSU) Total dissolved solids (ppt, ppm) Resistivity (Ohms-cm) Density (g/cm3)
Methodology	Std. Methods 2510 EPA 120.1

Dissolved Oxygen RDO Cap (Optical Sensor) Specifications

Accuracy	±0.1 mg/L; ±0.2 mg/L; ±10% of reading
Range	0 to 8 mg/L; 8 to 20 mg/L; 20 to 50 mg/L; Full operating range: 0 to 50 mg/L
Resolution	0.01 mg/L
Sensor Type	Fixed with replaceable RDO Cap (life: 1 year typical)
Response Time	T90: <30 sec. T95: <45 sec.
Units of Measure	mg/L, % saturation, ppm
Methodology	EPA-approved In-Situ Methods 1002-8-2009 1003-8-2009 1004-8-2009

ORP Sensor Specifications

Accuracy	±5.0 mV
Range	±1400 mV
Resolution	0.1 mV
Sensor Type	Replaceable pH/ORP combo sensor
Response Time	<15 sec.
Units of Measure	mV
Methodology	Std. Methods 2580

pH Sensor Specifications

Accuracy	±0.1 pH unit from 0 to 12 pH units
Range	0 to 14 pH units
Resolution	0.01 pH unit
Sensor Type	Replaceable pH/ORP combo sensor
Response Time	<15 sec., pH 7 to pH 4
Units of Measure	pH units
Methodology	Std. Methods 4500-H+ EPA 150.2

Air Temperature Sensor Specifications (Power Pack)

Accuracy	±2° C
Range	-20 to 70° C (-4 to 158° F)
Resolution	0.1° C
Sensor Type	Fixed
Response Time	<30 sec.
Units of Measure	Celsius, Fahrenheit
Methodology	EPA 170.1

Temperature Sensor Specifications (Probe)

Accuracy	±0.1° C
Range	-5 to 50° C (23 to 122° F)
Resolution	0.01° C or better
Sensor Type	Fixed
Response Time	<30 sec.; temperature sensor only
Units of Measure	Celsius, Fahrenheit
Methodology	EPA 170.1

Power Pack Specifications

Operating temperature	-5 to 50° C (23 to 122° F); 95% relative humidity, non-condensing
Storage temperature	-20 to 50° C (-4 to 122° F); 95% relative humidity, non-condensing
Dimensions	14.4 x 4.3 x 3 cm (5.7 x 1.7 x 1.2 in.)
Weight	145 g (0.32 lb)
Materials	PC / ABS blend, Silicon, Urethane, Stainless steel, Brass, Santoprene, Poron®, Polyethylene, Versapor®, Titanium, PEEK, Viton®

Environmental rating	IP67
Output options	***Bluetooth***®, USB
Communication protocol	Android®: SPP Windows®: SPP or USB
Battery type	3.7 V 8600 MWh Lithium rechargeable cell (UBBL19-FL)
Charging requirements	5 VDC USB charger (1 A or 500 mA)
Warranty	1 year
Certifications	CE, FCC (SSSBC127-X), WEEE

Sensor	**Temperature**	**Barometric Pressure**
Accuracy	±2° C max	±3 mbar max
Range	-20 to 70° C (-4 to 158° F)	300 to 1100 mbar
Resolution	0.1° C	0.01 mbar
Sensor type	Fixed	Fixed
Response time	< 30 seconds	Instantaneous in thermal equilibrium
Units of measure	Celsius or Fahrenheit	psi, kPa, bar, mbar, mmHg, inHg, Torr, atm
Method	EPA 170.1	Piezoresistive

Instrument Overview

Instrument Description

The smarTROLL MP Handheld Instrument is comprised of a mobile display, Power Pack, cable, and multiparameter water quality probe. The optical Rugged Dissolved Oxygen (RDO®), conductivity, pressure, and temperature sensors are integrated into the probe. The pH/ORP and the RDO Sensor Cap are replaceable.

System Components

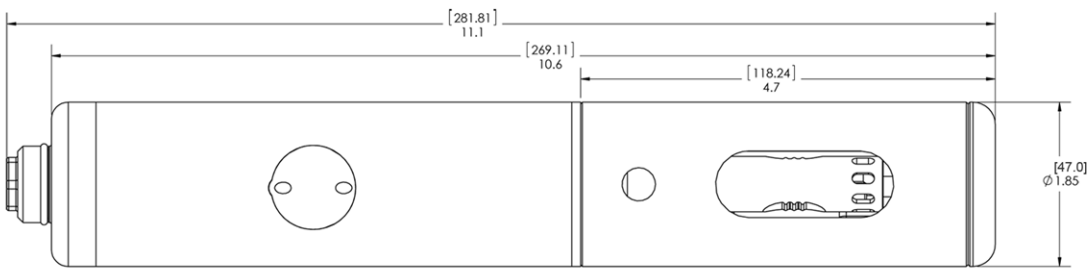
The system includes the following components.

- Integrated sensors: RDO, conductivity, pressure, and temperature
- Plug-in pH/ORP sensor
- Classic Cap, Fast Cap, or RDO-X Sensor Cap. The Fast Cap ships with the instrument.
- Stainless steel restrictor
- Calibration and storage cup
- Power Pack and cable

Accessories purchased separately

- Replacement RDO Sensor Cap
- Replacement pH/ORP sensor
- Calibration Kit (includes calibration cup, 3 sponge wafers, vented cap, and storage cap)
- Cable 1.5 m (5 ft), 4.6 m (15 ft), 9.1 m (30 ft), 30.5 m (100 ft), 76.2 m (250 ft).
- Maintenance kit (instrument and Power Pack)
- Replacement Power Pack
- Storage/Calibration cup
- Android platform 4.4 (requires Bluetooth 2.0). Download VuSitu for free on the Google Play™ store. Used with Power Pack
- Universal wall charger and cable
- Replacement wall charger and cable

Probe Dimensions with Restrictor On



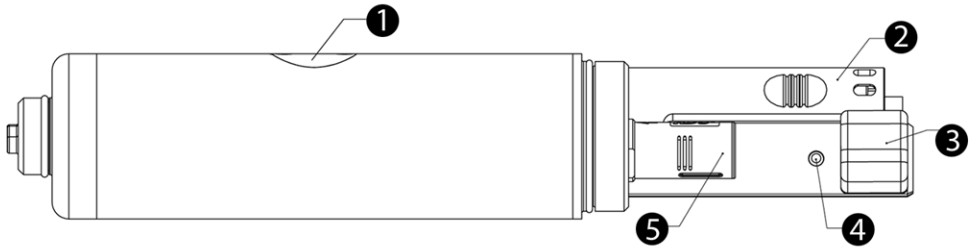
Total length with connector	281.81 mm (11.1 in.)
Total length without connector	269.11 mm (10.6 in.)
Restrictor length	118.24 mm (4.7 in.)
Diameter	47 mm (1.85 in.)

Probe Dimensions with Restrictor Off

Sensor length	81.09 mm (3.2 in.)

Sensors

Sensors include optical RDO (Rugged Dissolved Oxygen), pH/ORP, conductivity, pressure, and temperature.



1	Pressure sensor 76 m (250 ft)
2	pH/ORP sensor
3	Conductivity sensor
4	Temperature sensor
5	RDO Sensor

Probe Setup

The probe is shipped with a storage plug and protective dust caps in place.

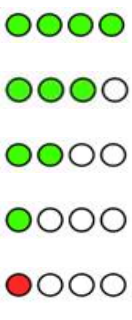
1	Dust cap protector on the RDO Sensor. (Install the RDO Cap before deploying the instrument.)
2	pH/ORP storage plug. (Remove the storage plug and install the pH/ORP sensor before deploying the instrument.)

Power Pack Description

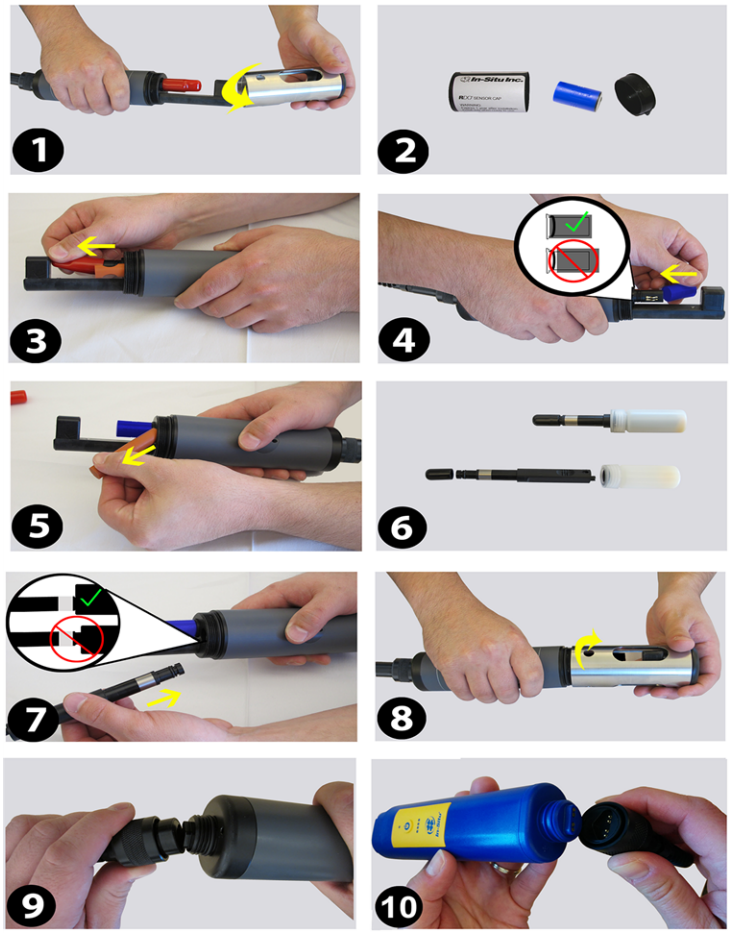
The Power Pack enables wireless communication between the Android device and the probe and supplies power to the probe. The Power Pack provides a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements. The ambient temperature measurement is also provided by the Power Pack.

A fully-charged Power Pack will run for approximately 40 continuous hours.

1	Dust cover for the USB connection
2	Connection status **Red (flashing)** = The communication device, instrument, and Bluetooth-enabled device are not connected. **Red (continuous)** = The communication device and instrument are connected, but the communication device is not connected to the Bluetooth-enabled device. -OR- The communication device is connected via USB cable. **Green (flashing)** = The communication device is connected to the Bluetooth-enabled device, but is not connected to the instrument. **Green (continuous)** = The communication device, instrument, and Bluetooth-enabled device are connected.
3	On/Off button

4	Battery charge status:  100% -90% 90% - 75% 75% - 50% 50% - 25% Less than 25%
5	Cable connector to the instrument
6	Lanyard connector
7	USB connection to a power source for charging the internal battery

Installing the Sensors



1. Twist the restrictor off the probe.
2. Locate the RDO Sensor Cap container and remove the cap.
3. Remove the dust cap from the RDO Sensor.
4. Align the flat edge of the RDO Sensor with the slotted edge of the RDO Cap and press the cap into position. Push until the cap is firmly in place.

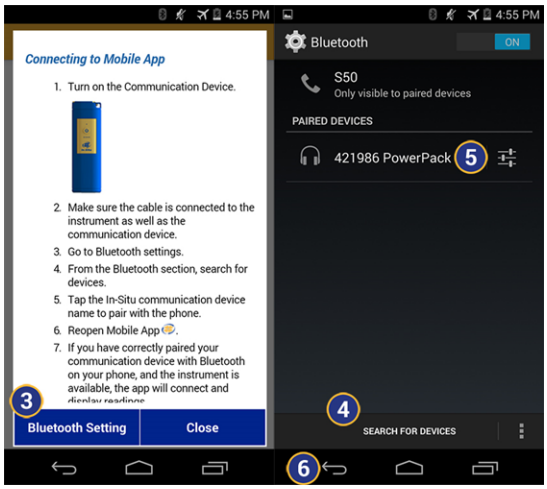
   > ⚠ Important: Avoid touching the sensor lens and the sensing material on the top of the cap.

5. Remove the orange plug from the pH/ORP port.
6. Remove the pH/ORP sensor from the storage bottle. Keep the bottle for future sensor storage.
7. Use the alignment marks to properly align the pH/ORP sensor with the port connection, and press firmly into place. Push until the sensor is completely inserted into the port.
8. Twist the restrictor onto the probe.
9. Align the pins on the cable with the pins on the probe, then twist the outer portion of the connector until the connection is secure.
10. Align the pins on the cable with the pins on the Power Pack, then twist the outer portion of the connector until the connection is secure.

> ⚠ Important: The RDO Sensor Cap and pH/ORP sensor must be installed firmly in place to prevent water from entering the instrument.

Connecting to VuSitu

1. Turn on the Power PackWireless TROLL Com.
2. Make sure the cable is connected to the instrument as well as the communication device.
3. Go to Bluetooth settings on the phone.



4. From the Bluetooth section, search for devices.
5. Tap the In-Situ Power PackWireless TROLL Com name to pair with the phone.
6. Tap the back arrow to return to the app.
7. If you have correctly paired your communication device with Bluetooth on your phone, and the instrument is available, the app will connect and display readings.

> ✔ In general, it is necessary to pair the devices only the first time you use them. After you have paired the first time, turn on the communication device and open the app for direct communication with the instrument.

VuSitu Overview

About VuSitu

VuSitu is the mobile user interface and control application for In-Situ water quality instruments. You can use VuSitu on mobile devices with Android operating system 4.4, *Bluetooth* 2.0 and newer. Download the latest version of the app from the Google Play Store at play.google.com.

VuSitu allows you to accomplish the following tasks.

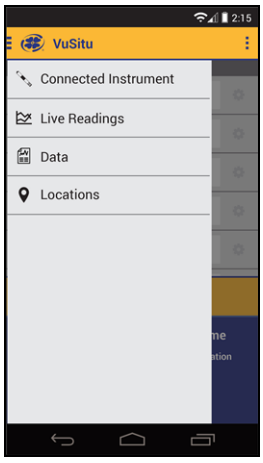
- View live readings that update every 10 seconds
- Change parameters and units
- Set up a data log
- Record data
- Email data in spreadsheet format
- Download data to mobile device
- Transfer data from mobile device to a computer
- Organize data by Location
- Calibrate Sensors and View Reports

VuSitu Menu Options

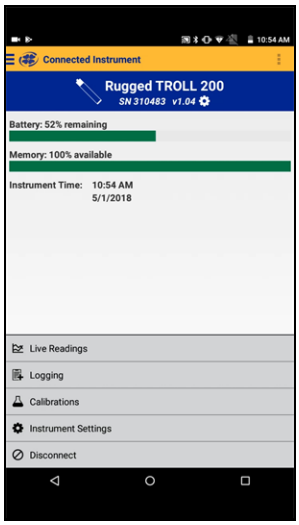
The features available in the VuSitu mobile app vary slightly depending on the instrument to which it is connected. Tap the menu icon in the upper left portion of the screen to view the features included in VuSitu. Tap the menu icon again to close the menu.

Menu Options when Connected to Instrument

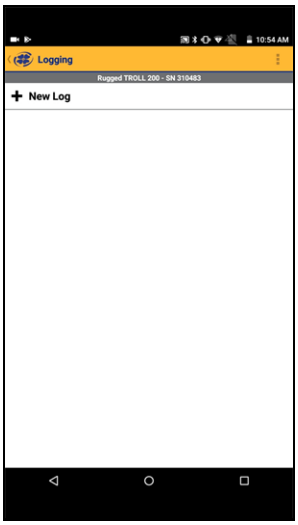
Some features, such as sensor calibration, are not available when you are not connected to an instrument.



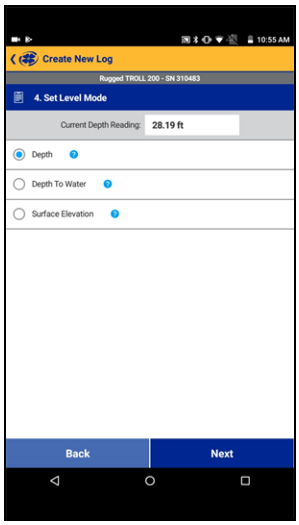
Setting Up a Log



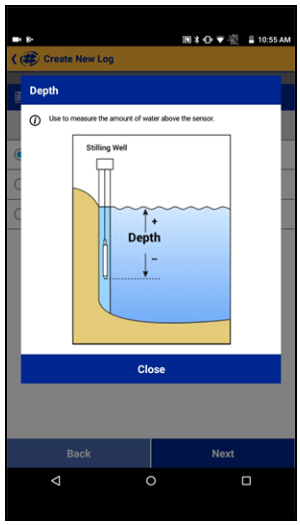
From the Connected Instrument screen, select **Logging**.



Tap **New Log** and follow the prompts to create a name, select a location and choose the parameters you wish to monitor.



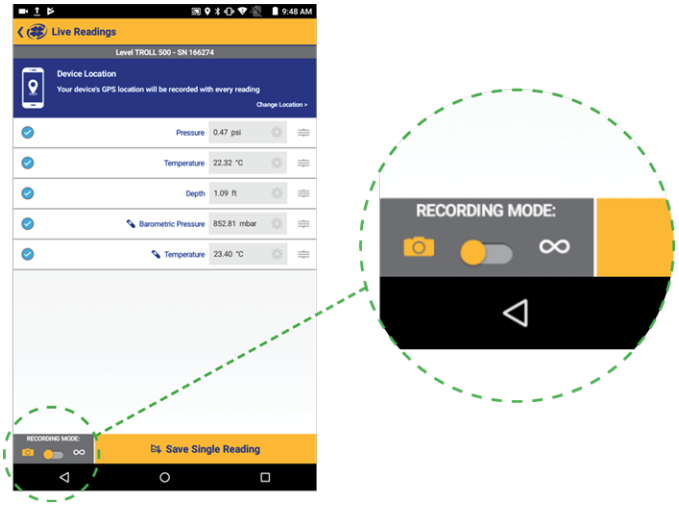
Select a level mode in step 4. Tap the blue circle to the right of each option for an explanation of how the mode works.

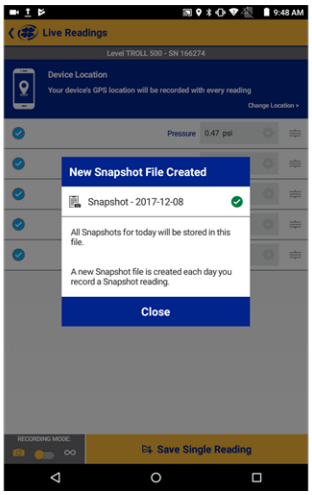


For Depth to Water and Surface Elevation modes, enter a level reference. See "About the Level Reference" on page 1 of this manual for complete information about level modes and level references.

Taking live readings in VuSitu

Snapshot Mode

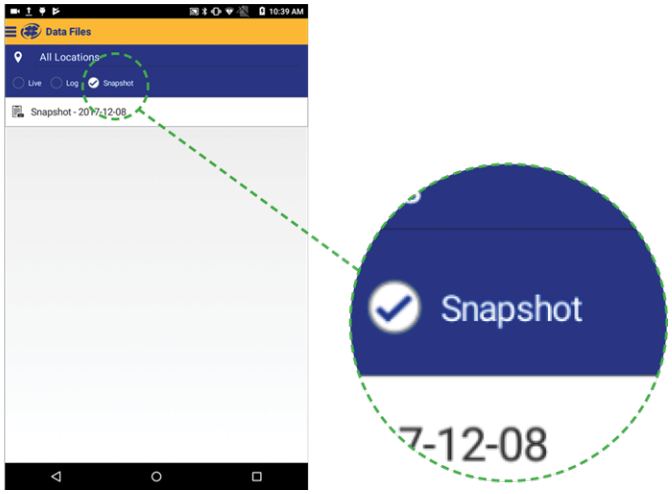




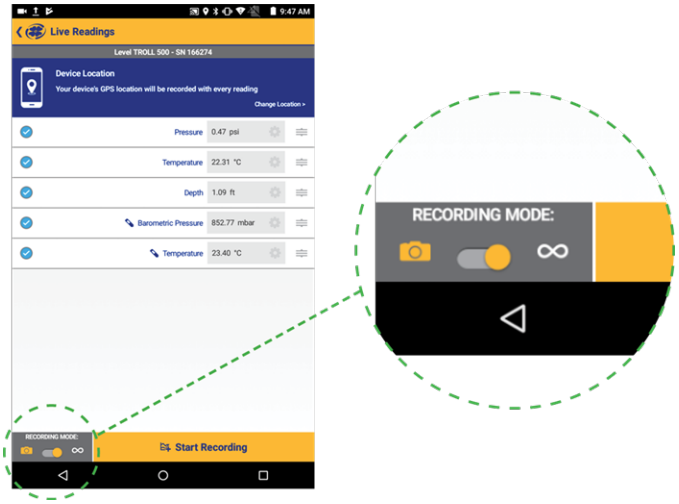
Take a single reading and save to Snapshot file.

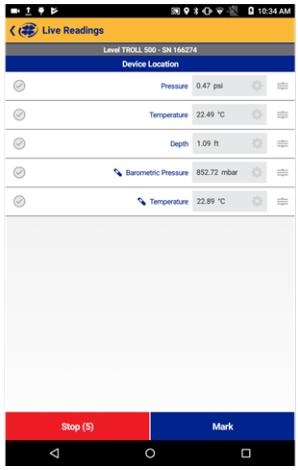
View Snapshot file from Menu > Data Files.

Check Snapshot option.



Live Readings Mode

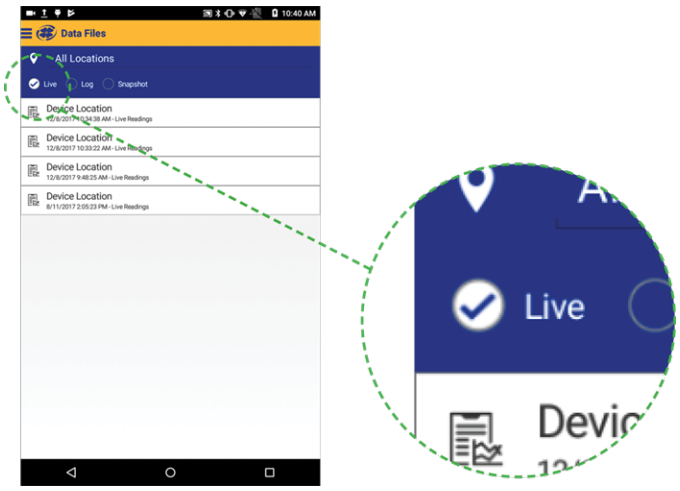




Take readings at two-second intervals.

View readings from Menu > Data Files.

Check Live option.



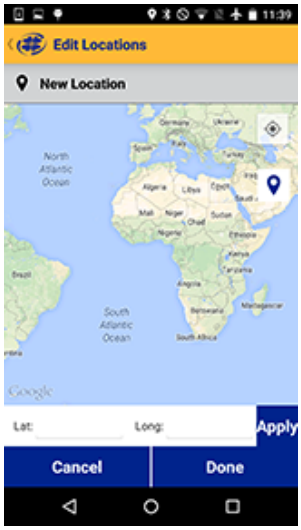
VuSitu Locations

About VuSitu Locations

A Location represents the physical location at which an instrument collects data. For example, you can create a Location to represent a lake, gauging station, well, tank, number, or nearby landmark. If you do not set up a Location, your data will be associated with Default Location. The Location name is displayed on the Live Readings screen. You can access Locations through the Main Menu or by tapping the Location displayed in the lower portion of the Live Readings screen.

Create a New Location

1. You can create a new Location with which to associate your data by selecting Locations from the main menu, or by tapping the location shown on the Live Readings screen.
2. Tap Add New Location.
3. Enter a name for the Location.
4. It is optional to add a photo to the Location. Tap the camera icon, take a photo and select the check mark to select the photo.
5. It is optional to add notes to the Location. Tap the Notes field to enter additional information about the Location.
6. It is optional to associate latitude and longitude coordinates with the Location. Tap the map to activate the mapping feature.



7. Tap the GPS icon in the upper-right portion of the screen to navigate to your current physical location.
8. Tap the Location icon to select the point on the map as the Location.
9. To manually set a Location, tap and hold to drop a pin on a specific area of the map. This associates latitude and longitude with your Location.

> As an alternative, you can manually enter latitude and longitude values and tap Apply.

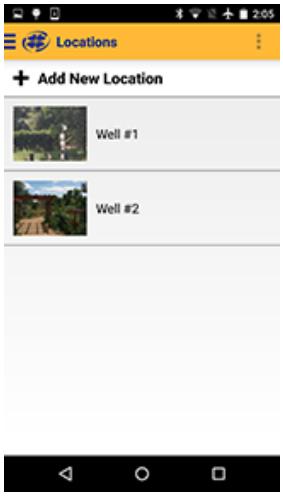
10. Tap Save.

Select a Location

Data is associated with the Location that is displayed on the Live readings screen.

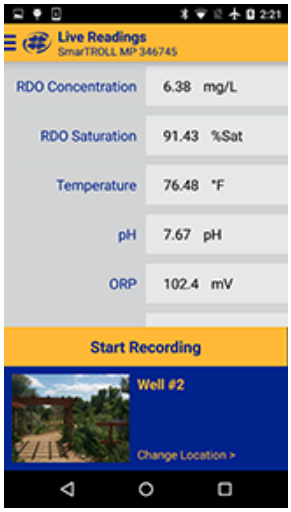
After you have created a Location, you must select it in order for your data to be associated with the Location.

1. To Select a Location, tap the current Location displayed on the Live Readings screen. The list of Locations appears.



2. The active Location is marked with a green check mark. If no Location has been selected data will be associated with the Default Location.
3. Tap the desired location in the list.

4. The Live Readings screen appears with the site selected.



Edit or Delete a Location

1. From the Main Menu, tap Locations.
2. Tap the Location you want to edit.

3. Tap the Overflow Menu ⋮ in the upper-right portion of the screen.
4. Select Edit Location to make changes, or Archive Location to remove it from the list.

> ✔ Archived Locations can be restored at any time by tapping the Location, accessing the Overflow Menu ⋮ and tapping Restore Location.

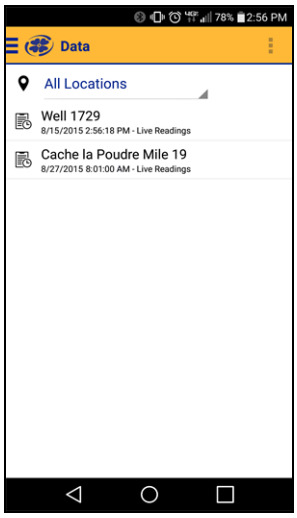
VuSitu Reports

About Data

Recorded data from the Live Readings screen is stored in the VuSitu Data section of the app. Data is organized by the Location that was active when the data was recorded. You can view data on the device, delete the data, send the data through email, or save the data to the VuSitu Folder so that it can be downloaded to your computer via USB connection.

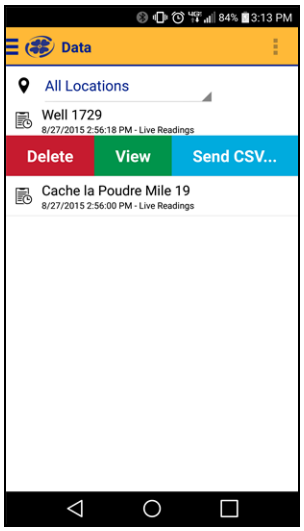
View, Send, Delete Data

1. From the Main Menu, select Data.



> ✔ It is optional to filter results by Location. Tap the drop-down list and select a Location.

2. Tap the desired data.



- Tap Delete to remove the data from the data list.
- Tap View to see the data on the mobile device.
- Tap Send CSV to send an Excel-compatible file to email or the VuSitu Folder. (When you send the report to the VuSitu Folder, you can later download the data to a computer via USB cable.)

VuSitu Calibration & Settings

About Calibration and Settings

You can perform sensor calibrations, view a calibration report, or restore factory calibration defaults when the instrument is connected to VuSitu.

1. Tap the VuSitu menu icon, and select Connected Instrument from the list.
2. Tap Calibrations.
3. Calibrations and settings for all connected sensors will appear. Ammonium, chloride and nitrate parameters are not shown in the image below but are displayed when the corresponding sensors are installed.

4. Tap the calibration you want to perform.

> ✔ You can also access the full Calibration Report from this menu.

Calibrate the Rugged Dissolved Oxygen Sensor (1-Point)

The optical Rugged Dissolved Oxygen sensor is very stable. The factory calibration should produce readings within 3% accuracy. If you require readings with greater accuracy we recommend that you perform a 1-point, 100% water-saturated air calibration as described below.

100% Water-saturated Air Calibration

1. From the main menu, select **Calibration & Settings**.
2. From the Calibrations menu select **RDO Saturation**.
3. For a 1-point calibration, select **100% Saturation**.
4. Make sure the vented cap is installed on the calibration cup and a water-saturated sponge is placed in the bottom of the cup.

5. After the calibration is stable, select **Accept**.
6. The calibration values are applied to the sensor and appear on screen. You can view a full calibration report for all sensors, or select **Done** to return to the Calibration Menu.
7. Remove the sponge from the calibration cup.

Calibrate the Rugged Dissolved Oxygen Sensor (2-Point)

We recommend that you perform the 0 % oxygen calibration only if you intend to measure dissolved oxygen at a concentration of less than 4 mg/L.

100% Water-saturated Air Calibration

1. From the main menu, select **Calibration & Settings**.
2. From the Calibrations menu select **RDO Saturation**.
3. For a 2-point calibration, select **100% and 0% Saturation**.
4. Make sure the vented cap is installed on the calibration cup and a water-saturated sponge is placed in the bottom of the cup.
5. After the calibration is stable, a prompt to prepare for the next calibration point appears.

0-point Calibration

1. Remove the sponge from the calibration cup.
2. Fill the calibration cup to the fill line with sodium sulfite. Place the instrument in the calibration cup.

3. Select **Next**.
4. After the calibration is stable, select **Accept**.
5. The calibration values are applied to the sensor and appear on screen. You can view a full calibration report for all sensors, or select **Done** to return to the Calibration Menu.
6. Rinse the sensors and restrictor with DI water.

Calibrating the Rugged Dissolved Oxygen Sensor Using Concentration

The preferred method of calibrating the RDO sensor is using the 1-point 100% Saturation calibration. However, you can also calibrate the sensor using a concentration method.

1. From the main menu, select **Connected Instrument**.
2. Select **Calibrations**.
3. Tap **RDO Concentration**.
4. Place the instrument in reference solution and tap **Next**.
5. Enter the value of the reference solution.
6. After the calibration is stable, select **Accept**.
7. The calibration values are applied to the sensor and appear on screen. You can view a full calibration report for all sensors, or select **Done** to return to the Calibration Menu.

RDO Salinity Setting

The smarTROLL MP for Android…… does not include automatic salinity compensation, so you must set it manually.

1. From the main menu, select **Connected Instrument**.
2. Select **Instrument Settings**.
3. From the Instrument Settings menu select **Salinity Setting**.
4. Select the appropriate setting for your sampling environment.

Calibrate the Level Sensor

The factory calibration of the level sensor is very accurate. In-Situ does not recommend calibrating the Level sensor unless your SOP specifically requires you to do so.

1. From the main menu, select **Connected Instrument**.
2. Select **Calibrations**.
3. From the Calibrations menu select **Level**.
4. Make sure that the pressure sensor is open to air and not submersed in water.
5. Select **Next**.
6. After the calibration is stable, select **Accept**.

Care and Maintenance

Maintenance Schedule

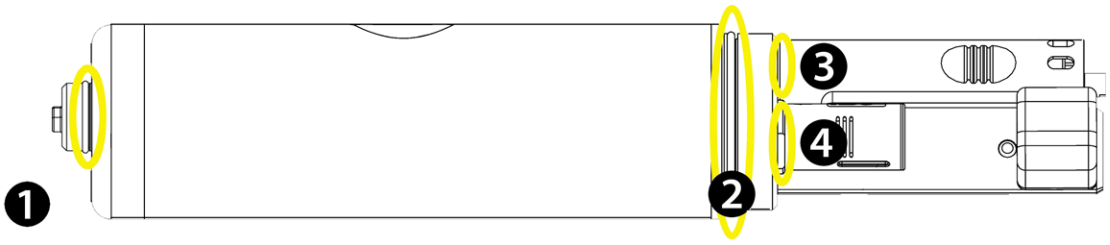
For best results, send the instrument to the manufacturer for factory calibration every 12 to 18 months.

User-Serviceable Parts

The user-serviceable parts on the instrument include the O-rings, the pH/ORP sensor, and the RDO Sensor Cap.

O-rings

The instrument has several O-rings that can be maintained by the user in order to keep moisture from entering the instrument and damaging the electronics. Apply a very thin layer of vacuum grease to new O-rings upon installation. The O-rings are located in the following areas.



1	Connector
2	Instrument housing
3	pH sensor
4	RDO Sensor

RDO Sensor Cap Replacement

The RDO Sensor Cap has a 1-year typical life (15 months of total usage) after the sensor takes its first reading, or 36 months from the date of manufacture. Follow the instructions included in the RDO Sensor Cap Replacement Kit. Replacement caps are available from In-Situ Inc. or your authorized In-Situ distributor.

pH/ORP Sensor Replacement

To replace the pH/ORP sensor or to refill the reference junction, follow the instructions in the pH/ORP Sensor Instruction Sheet that is included with the replacement sensor.

Instrument Storage

To store the probe for a week or less, place the probe in the calibration cup with at least 10 mL of clean water to maintain a moist storage environment.

To store the probe for more than a week, perform the following procedure.

1. Remove the pH/ORP sensor and place the orange pH port plug into the empty pH/ORP port to prevent any humidity from entering the probe.
2. Locate the sensor storage bottle in which the pH sensor was originally shipped.
3. Open the bottle and remove the O-ring.
4. Add enough pH storage solution or pH 4 solution to cover the sensor bulb (about 10 mL).
5. Slide the O-ring onto the sensor, and then slide the bottle cap over the sensor as shown.

6. Place the sensor tip in the buffer and tighten the cap to prevent the glass bulb from drying.

Cleaning the pH/ORP Sensor

Begin with the gentlest cleaning method and continue to the other methods only if necessary. Do not directly touch or wipe the glass bulb.

To clean the pH sensor, gently rinse with cold water. If further cleaning is required, consider the nature of the debris to determine the appropriate method.

Remove Crystalline Deposits

1. Clean the sensor with warm water and mild soap.
2. Soak the sensor in 5% HCl solution for 10 to 30 minutes.
3. If deposits persist, alternate soaking in 5% HCl and 5% NaOH solutions.

Remove Oily or Greasy Residue

1. Clean the sensor with warm water and mild soap.
2. Methanol or isopropyl alcohol may be used for short soaking periods, up to 1 hour.
3. Do not soak the sensor in strong solvents, such as chlorinated solvents, ethers, or ketones, including acetone.

Remove Protein-Like Material or Slimy Film

1. Clean the sensor with warm water and mild soap.
2. Soak the sensor in 0.1M HCl solution for 10 minutes and then rinse with deionized water.

> ✔ Note: After performing any of these cleaning methods, rinse the sensor with water and then soak overnight in pH 4 buffer.

Cleaning the RDO Sensor

Clean the Sensor Cap

1. Leave the cap on the sensor.
2. Rinse the sensor with clean water from a squirt bottle or spray bottle.
3. Gently wipe with a soft cloth or brush if biofouling is present.
4. If extensive fouling or mineral build-up is present, soak the RDO Cap end (while the cap is still installed on the sensor) in commercially available household vinegar for 15 minutes, then soak in deionized water for 15 minutes.

> ✔ Note: Vinegar is safe for all of the sensors on the probe including the RDO Sensor if the sensor cap is on.

5. Do not use organic solvents because they will damage the sensing material. Do not remove the cap from the sensor prior to wiping.
6. After cleaning the sensor cap, perform a 2-point calibration.

Clean the Optical Window

1. Perform this task only once per year when you replace the sensor cap.
2. Pull to remove the sensor cap.
3. Gently wipe the optical window with the supplied lens wipe.

> ⚠ Important: Do not wet the interior lens area with water or any solution.

Cleaning the Conductivity Sensor

1. Before you begin, ensure that the RDO Cap and any removable sensors are in place. Rinse the conductivity sensor under running water to remove loose material.
2. Follow Cleaning Procedure 1. If debris is still present, progress to the next cleaning procedure. If the debris is removed, skip to the last step.

Cleaning Procedure 1

Avoid damaging the plastic material of the conductivity cell. Gently scrub the conductivity cell with a soft swab and mild soap such as a dilute solution of dish detergent. The probe is shipped with polyurethane foam swabs for this purpose. You can also achieve good results using a gentle back-and-forth motion with a thin cotton pipe cleaner. If debris is still present, continue to Cleaning Procedure 2. If the sensor is clean, skip to the last step.

Cleaning Procedure 2

Avoid damaging the plastic material of the conductivity cell. Gently scrub the conductivity cell with a foam swab and an aggressive soap such as Alconox cleaner. If debris is still present, continue to Cleaning Procedure 3. If the sensor is clean,

skip to the last step.

Cleaning Procedure 3

Soak the sensor with dilute acetic acid (10:1 solution) or commercially available household vinegar to pre-soften calcium deposits. Follow this with Cleaning Procedure 1 or Cleaning Procedure 2, depending on the degree of residual contamination. The probe can soak for any length of time in household vinegar. If debris is still present, continue to Cleaning Procedure 4. If the sensor is clean, skip to the last step.

Cleaning Procedure 4

Topically apply dilute phosphoric acid (< 27 %) or the consumer product LIME-A-WAY with a soft swab to remove iron or calcium deposits that remain after using Process 3. Do not allow the cleaner to be in contact with the sensor for more than 10 minutes. Rinse well with clean water and continue to the last step.

Check the sensor calibration before redeployment. Recalibrate the sensor when necessary.

GEM-500 Operations Manual

GEM-500

OPERATION MANUAL

For further information contact:

CES-LANDTEC
850 S. Via Lata, Suite 112
Colton, CA 92324
Telephone: (909) 783-3636 / (800) LANDTEC
Fax: (909) 825-0591
www.CES-LANDTEC.com

TABLE OF CONTENTS:

Chapter 1 - Getting Started

Unpacking the GEM-500™

The GEM-500™ unit is normally shipped in a special protective Styrofoam shipping unit. An optional protective hard case with a foam interior offers additional protection, transportation convenience and component hardware storage. When properly sealed, the hard case is watertight. The hard case is equipped with a pressure relief valve (located under the handle on the case) that is normally kept closed. If there is a change in elevation, the hard case may not open until internal pressure is equalized by turning the pressure relief valve. When shipping a GEM-500™ back to CES-LANDTEC for calibration or service, always ship it in the original packaging to protect unit from damage.

Carefully unpack the contents of the GEM-500™, inspect and inventory them. The following items should be contained in your package:

- The GEM-500™ unit
- GEM-500™ Operation Manual
- Registration/Warranty Card and other instructional information
- Soft carrying case with replaceable protective window and carrying strap
- External (clear vinyl) sampling hose assembly (5 ft.) with external water trap filter assembly
- Blue ¼" vinyl pressure tubing sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue vinyl tubing
- Spare external water trap filter element
- 110-volt Nickel-Cadmium battery charger
- GEM-500™ download software on DataField 3.0 C.S. CD
- RS-232 serial cable for computer/printer data downloading
- Temperature probe (optional)
- Hard carrying case (optional)

Immediately notify shipper if the GEM-500™ unit or accessories are damaged due to shipping. Contact CES-LANDTEC if any items are missing. If you have any questions, please contact CES/ LANDTEC technical support at (800) 526-3832 or (800) LANDTEC. Complete the Registration/Warranty Card and return it to CES-LANDTEC. The model and serial numbers are located on the back of the GEM-500™ unit.

Attaching the Hose Assembly

The GEM-500™ hose assembly comes fully assembled but it needs to be connected to the GEM-500™. Connect the clear tubing with the external filter/water trap assembly to the static pressure/ sampling port (top left corner) on the GEM-500™ (See Figure 1.1). The shorter piece of tubing (from the water trap filter hosing) should be connected to the GEM-500™. This allows you to see any liquid entering the hose and shut the unit off before the liquid reaches the GEM-500™. Always connect the hose in the same direction. Connect the blue tubing to the impact pressure port on the GEM-500™ (See Figure 1.1). This port is located on the bottom left corner of the GEM-500™. **DO NOT** block the exhaust port (See Figure 1.1).

Quick Connect Fittings

The quick connect fittings will simplify taking well field readings. They are easy to install on your landfill gas extraction system and on perimeter probes. Many different types are available. CES-LANDTEC maintains a stock of fittings used on its equipment for your convenience.

The GEM-500™ comes with quick connect fittings for the AccuFlo™ wellhead. Insert the hose barb end of the male connector into the end of the clear and blue tubing.

GEM-500™ Keyboard and Port Descriptions

1. **Red On/Off Key**—Turns unit on or off.
2. **Blue Number/Letter Toggle Key**—Enables well ID code to be entered by toggling between number and letter mode and toggles contrast on the gas read screens.
3. **Receptacle Port**—Used for battery recharging, RS232 serial communications, temperature probe or gas pod.
4. **Backspace/Exit Key**—Acts as backspace key when pressed and held for one second, to correct entry of wrong number/letter, returns to previous procedure or steps back one layer of menus (similar to pressing the ESCAPE key in many computer programs).

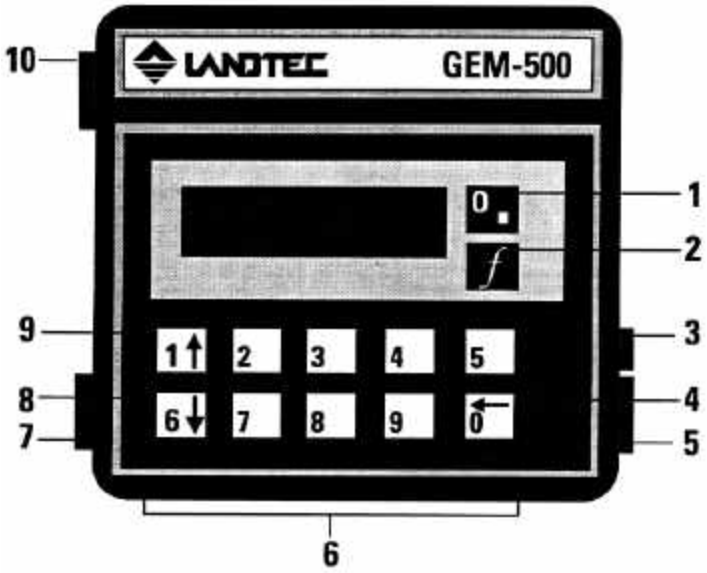


FIGURE 1.1

5. **Exhaust Port**—This port must be kept clear. If blocked while operating, over-pressurization may occur causing damage to internal components and case.
6. **Number Keys**—Enter numbers 0 through 9.
7. **Impact Pressure Port**—Measures impact pressure when connected to wellhead impact pressure port, pitot tube or orifice plate.
8. **Cursor-Down Key**—Enters number 6, scrolls down lines of information on display screens, and also scrolls down alphabetic character list.
9. **Cursor-Up Key**—Enters number 1, scrolls up lines of information on display screens, and also scrolls up alphabetic character list.
10. **Static Pressure/Sampling Port**—Measures static pressure and is inlet for gas sampling.

Must Do's Before Using the GEM-500™

Read Chapter 2 – *Using Menu Screens*.

Proper operation of the GEM-500™ requires the following functions to be completed before proceeding.

- Charge the unit with the battery charger
- Check the Time/Date
- Field Calibrate the unit

Calibration Gases

Calibration gases are required to field calibrate the GEM-500™. Portable Calibration Gas Kits and 4-unit or 12-unit cylinder cases are available from CES-LANDTEC. (See Chapter 2 -- *Field Calibration*)

Special Key Functions

Entering an ID code with Letters and Numbers
Use the blue toggle key (***f***) to shift back and forth between number mode and letter mode. When in number mode, use number keys to enter numbers. When switched to letter mode, use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll to desired letter, press **0** KEY to enter the letter on the display. Repeat this process for all letters. After entry, the first four characters will remain as a default for ease in entering the next ID. If different characters are desired, replace the defaults by using the backspace function described below.

Backspace Function
To change or correct an entry, use the **0** KEY (**BACK ARROW**) as a backspace key by holding it down for one second. In normal use, this key is quickly pressed and released.

Contrast Adjustment
Contrast can be adjusted when the unit is either first turned on or while taking a reading. While taking a reading, use the Blue f KEY to enter the contrast adjustment screen. To adjust, use 1 KEY (UP ARROW) to darken the screen and the 6 KEY (DOWN ARROW) to lighten screen.

Starting Up the GEM

This procedure is the same each time the GEM-500™ is turned on by pressing the RED On/Off KEY. The following steps will allow you to proceed to the Main Menu Screen of the GEM-500™ .

1. Turn unit on by pressing the RED **On/Off** KEY (see Figure 1.1)

   Note: If the GEM is turned on and no additional keys are pressed within 15 minutes, the unit will automatically shut off.

2. The Warning screen appears for five seconds. This is a reminder that the GEM-500™ is not to be used in areas such as vaults, excavations or other confined spaces. An explosion could result causing serious injury or death.

FIGURE 2.1

3. The Service Contract screen may appear for five seconds if activated by CES-LANDTEC. Otherwise, the Not Covered screen is displayed. The GEM-500™ is a portable, scientific, field instrument that does require factory maintenance and calibration at recommended six-month intervals under normal landfill usage.

FIGURE 2.2

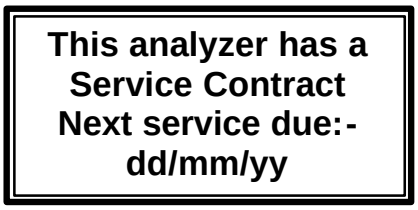


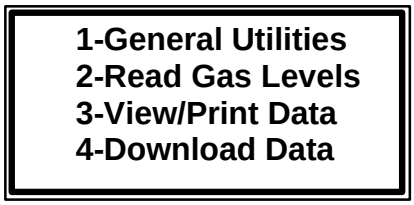
FIGURE 2.3

4. The CES-LANDTEC/Contrast screen allows the user to adjust the contrast of the characters on the liquid crystal display screen. Press and hold the **1** KEY (**UP ARROW**) to increase contrast. Press and hold the **6** KEY (**DOWN ARROW**) to decrease the contrast. Adjust the contrast as necessary (contrast levels are **NOT** saved when the unit is turned off). Press the **0** KEY to proceed to the Main Menu screen.

FIGURE 2.4

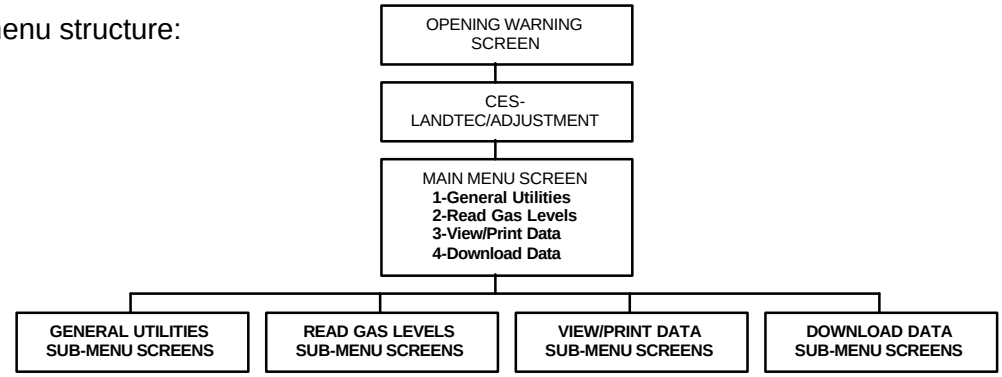
5. **The Main Menu Screen.** All the GEM-500™ functions are accessed from the Main Menu Screen. All subsequent instructions about the GEM-500™ functions will start from this screen.

FIGURE 2.5



GEM-500 Menu Tree

The overall menu structure:



Review of the Main Menu and Sub-Menu Screens

General Utilities
Refer to Chapter 4 for further information. The General Utilities function has sub-menu screens that allow housekeeping and other maintenance including:

1. CHECK TIME/DATE: Set or check time and date.
2. BATTERY STATUS: Graphic display of remaining power in batteries.
3. ZERO PRESSURES: Zero pressure transducers.
4. MEMORY: Check memory available or clear all data and ID information.
5. USA/METRIC UNITS: Select either USA standard or metric measurement units.
6. GAS CALIBRATION: Allow methane, Carbon Dioxide and oxygen to be field calibrated by the user with calibration gas mixtures for increased accuracy (see Chapter 3).
7. GAS ALARM: Set gas alarm levels.
8. ID MAINTENANCE: View, enter, edit or delete ID information.

Read Gas Levels
Refer to Chapter 5 for further information. Read Gas Levels function allows gas, pressure, flow and BTU readings to be viewed and recorded. Sub-menu screens include:

1. Read GAS with Existing ID code.
2. Read GAS without ID code.

View/Print Data
For further information, refer to Chapter 6. The View/Print Data function allows previously stored data to be scanned on the GEM-500™ display screen, individually displayed, or printed via the RS-232 cable to a serial printer.

Download Data
The Download Data function allows stored data to be downloaded via the RS-232 cable to a computer in a format that can be uploaded into DataField (CES-LANDTEC database management program) or onto spreadsheets. See Chapter 7 for further information.

Note: The 0 KEY (BACKSPACE) acts as an exit or ESCAPE key at the end of each sub-menu by returning to the Main Menu.

Chapter 3 - Field Calibration

Field Calibration is menu guided and can be completed in about ten minutes. To streamline the procedure, the pump remains running during field calibration. The GEM-500™ contains a calibration map accessed by its microprocessor for baseline reference data. This reference data was programmed into the GEM-500™ during factory calibration using various traceable gas mixtures in an environmental chamber. At any time, the GEM-500™ can be reset to factory settings which clears any user calibration settings and restores the GEM-500™ to its original factory calibration.

The factory calibration has been designed to give the best possible results over a wide range of conditions. However, the instrument's accuracy can be improved in specific operating ranges by performing a field calibration. Most field instruments are calibrated or adjusted prior to taking a series of gas or pressure readings. They may also be checked for calibration during and after readings in order to verify the accuracy of the data collected.

It is important to field calibrate the GEM-500™ on-site after the instrument has stabilized at working temperature. For this reason, a GEM-500™ that was calibrated in the cool of the morning may not read as accurately during the hottest part of the day.

Note: Field calibration of the GEM-500™ will improve the data collected in the range of the calibration gases used. Less accurate readings of concentrations outside the calibrated range may occur. For example, a GEM-500™ that was field calibrated using 50% CH_4 and 35% CO_2 will give improved readings for most gas extraction systems. Recommended gas mixtures for reading migration probes are 15% methane, 15% Carbon Dioxide with balance nitrogen. A 4.0% oxygen with balance nitrogen mixture may be used for both types of testing.

Calibration Gas/Span Gases

Field calibration requires two calibration gas mixtures. One gas mixture is used to span oxygen and zero methane. The other is used to span methane, Carbon Dioxide and zero oxygen. The oxygen has two curves: 0-5% and 0-25%. The zero point is the same for both curves; however, the span is different. The user need only span the instrument using calibration gas below 5% for the 0-5% range or calibration gas below 25% for the 0-25% range. Regardless of the ranges used, the instrument **must** be zeroed. Various calibration gas mixtures are available from CES-LANDTEC.

Zero Methane

Calibration of the GEM-500™ starts by establishing the bottom point of the methane gas curve. The methane (CH_4) is zeroed prior to taking readings at the start of each day. This function significantly improves the GEM-500™'s CH_4 accuracy over the entire range. **It is essential that the gas analyzer be clear of CH_4 when zeroed.** Care must be taken if the GEM-500™ is to be zeroed using air near a landfill site because there are situations where methane could be in the atmosphere.

Span Methane

A field calibration spans the methane range prior to taking readings at the start of each day. The best results are obtained after the instrument has stabilized at its working temperature. This procedure alters the methane calibration at all concentrations and stores the revised data in protected memory.

Note: Methane zero must be performed before setting the Methane Span.

Span Carbon Dioxide

Field calibration of CO_2 should be performed prior to taking readings at the start of each day after the instrument has stabilized at its working temperature. This procedure alters the calibration at all concentrations and stores the revised data in protected memory.

Zero Oxygen

This function is essential where low concentrations of oxygen are expected (below 5%). This establishes the zero point of an oxygen curve that is stored in the GEM-500™ protected memory.

Span Oxygen

The oxygen calibration map contains two span curves, one for oxygen below 5% and one for oxygen above 5%. The proper curve is automatically selected. If a calibration gas with less than 5% oxygen is used, the lower span curve is set. If the calibration gas has more than 5% oxygen, the higher calibration curve is set.

Note: The Oxygen zero must be set before setting the Oxygen Span.

Equipment

The following items are required to perform a field calibration:

1. Cylinder of methane and Carbon Dioxide span gas
2. Cylinder of 4/96 (4% O_2 and 96% N_2) calibration gas
3. Pressure regulators for the above cylinders capable of regulating in the range of 0 - 2 psig fitted with connectors suitable for ¼" tubing
4. CES-LANDTEC regulator and flow meter preset to deliver the required flow of 399-500 cc per minute at 2 psig. (See Figure 3.1a)
5. Interconnecting lengths of ¼" tubing

This equipment is available from CES-LANDTEC. The calibration equipment set up is shown in Figure 3.1.a and 3.1.b.

FIGURE 3.1.a Pressure/Flow Regulator

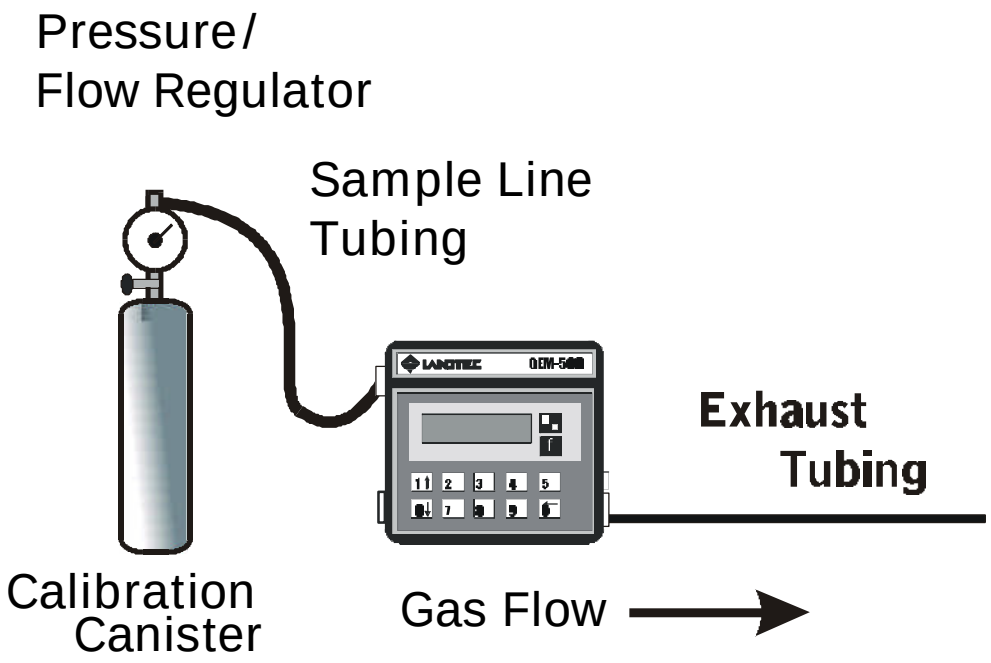
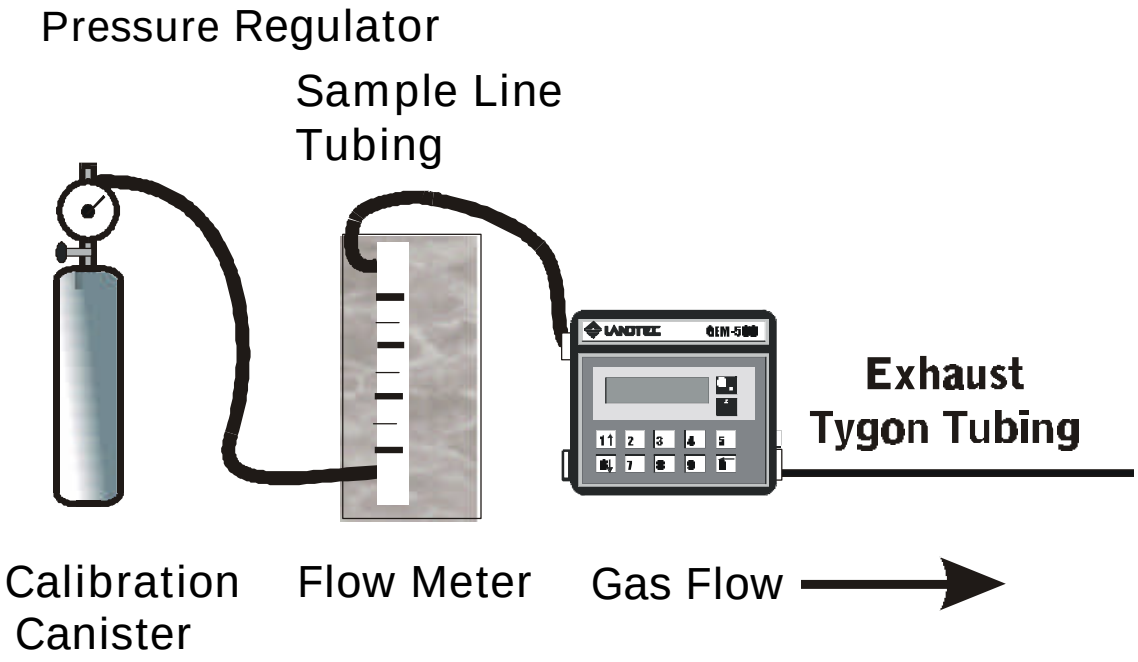


FIGURE 3.1.b Pressure Regulator with Flow Meter



Setting Up the Equipment

1. Connect the calibration gas cylinder to the pressure regulator.

2. Connect the sample input line to the regulator and to the GEM-500™.

3. Connect the second 24" section of ¼" tubing to the exhaust nozzle of the GEM-500™. Direct exhaust away from you and out of the immediate area.

4. If using a CES-LANDTEC regulator, no flow meter is required.

5. If **not** using the CES-LANDTEC regulator, adjust the regulator discharge pressure to 2 psig and the flow meter to 500 cc per minute. Pinch the gas supply hose that will attach to the GEM-500™ and verify the regulator discharge pressure does not exceed 5 psig. Turn off the cylinder valve.

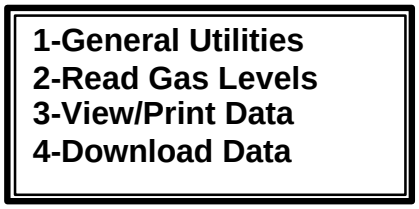
   Note: This procedure will be duplicated for the second span gas when oxygen is calibrated. The Oxygen/N_2 calibration gas cylinder will be substituted for the Methane/Carbon Dioxide calibration gas.

General Utilities KEY 5-Gas Calibration

The GEM-500™ is factory calibrated. To improve accuracy, all standard landfill gas instruments should be field calibrated, zeroed, or in other ways adjusted prior to every use. Field calibration is performed from the General Utilities Menu of the GEM-500™.

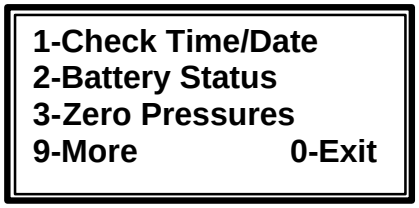
1. Press **1** KEY for **General Utilities** on the Main Menu Screen (See Figure 3.2.).

FIGURE 3.2



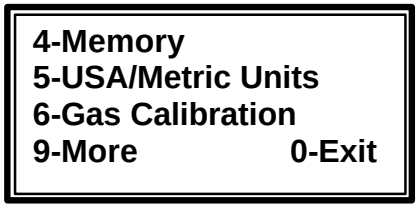
2. The General Utilities Screen appears as shown in Figure 3.3.

FIGURE 3.3



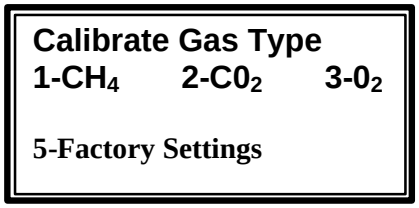
3. The gas calibration function is not on the first General Utilities screen. To reach this screen, press **9** KEY for **More** and **6** KEY for **Gas Calibration** (Figure 3.4). You may also press the **6** KEY while at the first General Utilities Screen to proceed directly to the Gas Calibration screen.

FIGURE 3.4



4. Pressing the **6** KEY for **Gas Calibration** on the General Utilities Sub-Menu screen, the first Gas Calibration screen is displayed as shown in Figure 3.5.

FIGURE 3.5



Methane (CH_4) Calibration - Zero CH_4

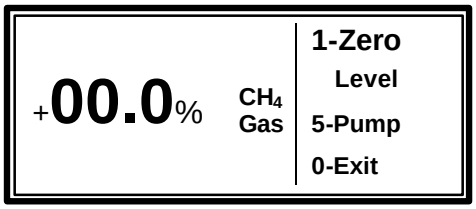
1. Press **1** KEY, **CH_4 Calibration**, to start the calibration procedure. Pressing the **0** KEY will exit the screen without changing the previous calibration.

FIGURE 3.6

2. Pressing **1** KEY, **Zero CH4**, initializes the Zero Methane procedure (Figure 3.7). A methane percentage will not display until the Infrared (IR) Bench warms up. A plus or minus sign may appear on the far left of the display. This symbol may be ignored.

DO NOT PERFORM THIS PROCEDURE IN THE PRESENCE OF METHANE.

FIGURE 3.7



3. If using air to zero methane, press the **5** KEY, **Pump**, to turn on the GEM-500™ sample pump. Calibration gas hoses should not be attached to the GEM-500™ during this procedure. Allow the pump to run for two minutes or until gas reading stabilizes. If using oxygen calibration gas to zero methane, see step 3-6 in the Span Methane section then return to step 2 of this section.

4. Press **1** KEY, **Zero level**. One of the following screens (Figure 3.8 or Figure 3.9) will be displayed for three seconds before returning to the Zero Methane Screen shown in Figure 3.7.

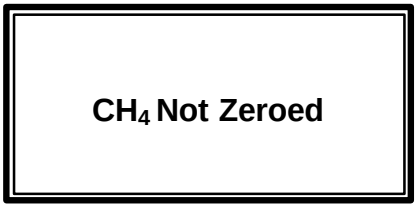


FIGURE 3.8

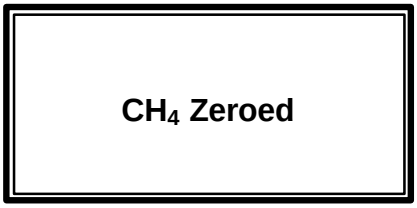
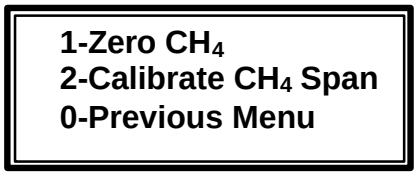


FIGURE 3.9

5. If the CH_4 Not Zeroed screen (Figure 3.8) is displayed, return to the Gas Calibration screen by pressing the **0** KEY, **Exit**. Verify methane is not present and re-zero the methane. If the problem continues, proceed to instructions contained in this section for Factory Settings.

6. If the CH_4 Zeroed OK screen (Figure 3.9) is displayed, press **0** KEY, **Exit,** to return to the Methane Calibration Screen (Figure 3.10). Press **2** KEY, **Calibrate CH_4 Span**, to proceed to the next section.

FIGURE 3.10



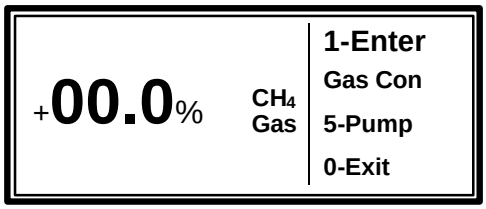
Methane (CH4) Calibration

1. Read the warning below before proceeding with the next steps.

WARNING! The GEM-500™ is not certified intrinsically safe. The following procedure MUST NOT be performed in a confined area (such as well vaults, underground or indoors) or where there is any possibility of sparking or ignition. Ensure that the exhaust port is not blocked and is properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.

2. After selecting the **2** KEY, **Calibrate CH_4 Span**, on the Methane Calibration screen, the following CH_4 Span screen appears (Figure 3.11).

FIGURE 3.11



3. Connect the ¼" tubing from the calibration gas regulator/flow meter to the GEM-500™ gas sample/impact port (Figure 1.1). It is **NOT** recommended to use the water trap sample tubing for calibration. Attach tubing to the exhaust port of the GEM-500™ and direct the exhaust flow away from you and out of the immediate area.

4. Press the **5** KEY, **Pump**, on the CH_4 Span screen to turn on the sample pump.

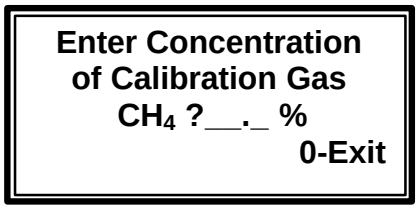
5. If not using CES-LANDTEC supplied regulator, make sure the calibration gas flow is 500 cc and pressure is no greater than 2 psig.

6. Allow the calibration gas to flow into the GEM-500™ for one minute or until instrument gas reading stabilizes.

7. After one minute, read the methane gas concentration on the screen. It should be stable and not changing more than a few tenths of one percent at the 15% gas level or 2% at the higher gas level.

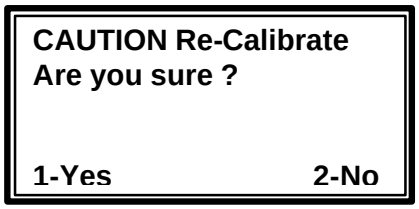
8. Press the **1** KEY, **Enter Gas Con**, and input the methane concentration of the calibration gas using the keyboard of the GEM-500™ (Figure 3.12). Enter the percentage as three digits XX.X%. (50% methane would be input as 500.) The GEM-500™ will automatically place a decimal point in the proper position. After the percentage is entered, press **0** KEY, **Exit**.

FIGURE 3.12



9. The next screen is the Caution Re-Calibrate Screen (Figure 3.13).

FIGURE 3.13



10. Press **1** KEY, **Yes**, and one of the two following messages will appear (Figure 3.14 or Figure 3.15). .

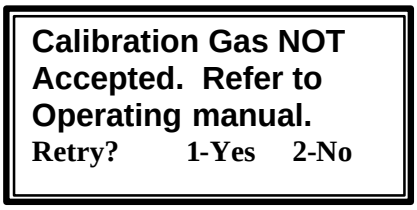


FIGURE 3.14

FIGURE 3.15

11. If the Calibration OK screen flashes (Figure 3.15), proceed to Step 13.

12. If the Calibration Gas Not Accepted screen appears (Figure 3.14), press the **1** KEY, **Yes**, and re-enter the methane percentage. If the Calibration Gas Not Accepted screen still appears, press **0** KEY, **No**, and start procedure again from zero methane. If problem persists, proceed to Factory Settings, discussed later in this chapter.

13. If required, proceed to $C0_2$ calibration Step 1.

14. Press the **0** KEY twice. Turn off the calibration gas cylinder. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM-500™. Leave the exhaust port hose connected and turn on the pump and allow it to purge the GEM-500™ with air for 60 seconds. Press the **5** KEY, **Pump**, again. The pump turns off and automatically returns to the Calibrate Methane screen.

15. If there is no further calibration, press the **0** KEY, **Exit**, to return to the Gas Calibration screen. Field calibration has successfully been completed.

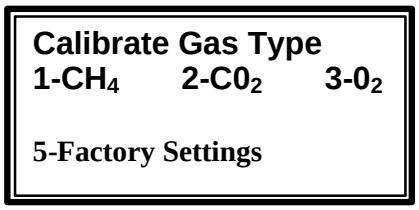
Carbon Dioxide (CO_2) Calibration

1. Because the cylinder used in this calibration contains methane, the following warning must be adhered to before proceeding with the steps below.

> **WARNING!** **The GEM-500™ is not certified intrinsically safe. The following procedure MUST NOT be done in a confined area (such as well vaults, underground or indoors) or where there is any chance of sparking or ignition. No smoking, exposed lighting, or other sources of ignition should be in the area. On the GEM-500™, ensure that exhaust port is not blocked and properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.**

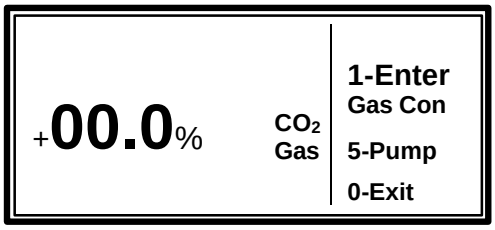
2. Press the **2** KEY, **CO_2 Calibration**, on the Gas Calibration screen (Figure 3.16).

FIGURE 3.16



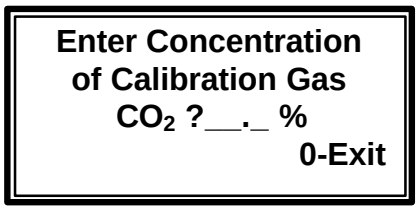
3. There is no Zero CO_2 function as there is in the methane or oxygen calibration procedures. The following CO_2 Span screen appears (Figure 3.17).

FIGURE 3.17



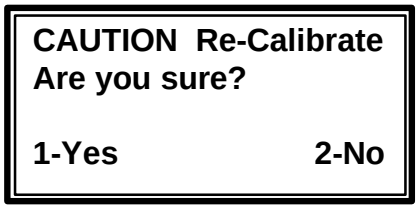
4. Press the **1** KEY, **Enter Gas Con**, to access the Enter Concentration screen (Figure 3.18). Input the percentage of Carbon Dioxide concentration of the calibration gas as three digits XX.X%. (40% Carbon Dioxide would be input as 400) The GEM-500™ will automatically place a decimal point in the proper position. After the percentage is entered, press the **0** KEY, **Exit**.

FIGURE 3.18



5. The next screen is the Caution Re-Calibrate screen (Figure 3.19).

FIGURE 3.19



6. Press the **1** KEY, **Yes**, and one of the two following messages will appear (Figure 3.20 or Figure 3.21). If the Calibration OK screen appears, go to step 9 below.

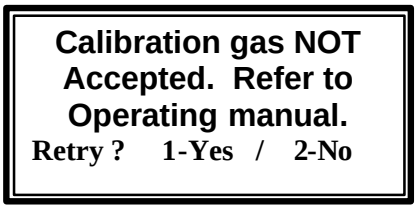


FIGURE 3.21

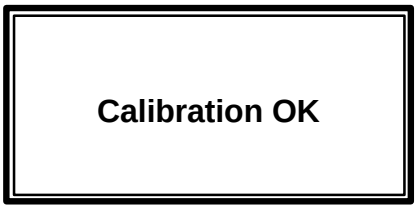


FIGURE 3.22

7. If the Calibration gas NOT Accepted screen appears, several things could have happened. Press the **1** KEY, **Yes,** and enter the percentage of Carbon Dioxide in the calibration gas. It is possible that the wrong percentage was input. If on a second attempt this does not work, press the **0** KEY, **No**, to return to the Gas Calibration screen and turn to the Factory Settings section for additional instructions.

8. If O_2 is to be zeroed, proceed to O_2 Calibration, step 1.

9. If no further calibration is needed, press the **0** KEY to **Exit** and return to the CO_2 Calibration screen shown on the prior page.

10. Turn off the calibration gas. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM-500™. Leave the exhaust port hose connected. Allow the GEM-500™ to purge with air for 60 seconds. Press the **5** KEY, **Pump**, to turn off the pump; then press the **0** KEY, **Exit**, to return to the Gas Calibration screen.

11. You have successfully completed a Carbon Dioxide Field Calibration. Immediately proceed to the next function, O_2 Calibration.

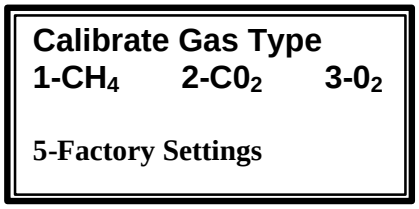
Oxygen (O_2) Calibration - Zero O_2

1. There are two calibration gas mixtures used for the calibration of oxygen. The methane/ Carbon Dioxide calibration gas previously used to calibrate the methane and Carbon Dioxide is used to Zero oxygen. A second calibration gas with a mixture of oxygen and nitrogen is used to set the oxygen level in the next section. Because the calibration gas used contains methane, the warning below must be followed before proceeding with the following steps.

> **WARNING! The GEM-500™ is not certified as intrinsically safe. The following procedure MUST NOT be done in a confined area (such as well vaults, underground and indoors) or where there is any chance of sparking or ignition. No smoking, exposed lighting, or other sources of ignition should be in the area . On the GEM-500™, ensure that exhaust gas port is not blocked and properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.**

2. Press Key 3-O_2 Calibration on the Gas Calibration Screen (Figure 3.22).

FIGURE 3.22

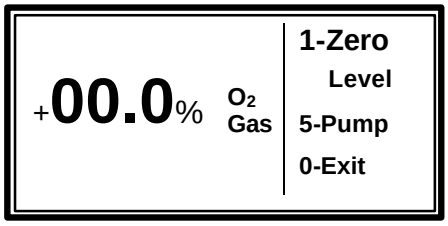


3. The Oxygen Calibration Screen will appear (Figure 2.23).

FIGURE 3.23

4. Pressing the **1** KEY, **Zero O_2**, will bring up the Zero Oxygen screen (Figure 3.24).

FIGURE 3.24



5. Read the oxygen Gas Concentration on the screen. It should be very near 00.0% and not changing more than a few tenths of one percent.

   Note: Even if the screen displays 00.0% oxygen, proceed with step 6 below, the Oxygen must be zeroed anyway.

6. Press the 1 KEY, Zero level, and one of the following screens (Figure 3.25 or Figure 3.26) is displayed for three seconds before returning to the Zero Oxygen screen shown above.

FIGURE 3.25

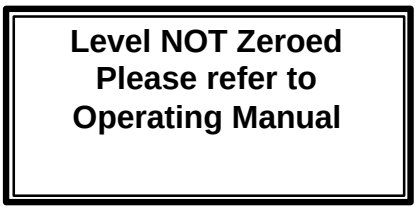


FIGURE 3.26

7. If the O_2 Zeroed screen displays, proceed to step 9 below.

8. If the Oxygen NOT Zeroed screen displays, return to the Oxygen Calibration screen. Check that the calibration gas contains no oxygen. Connect the correct gas and re-zero the oxygen. If the problem continues, proceed to instructions contained in this section for Factory Settings.

9. If the Oxygen Zeroed OK screen appears, turn off the calibration gas.

10. Remove the hose from the flow regulator to the GEM-500™. Let the pump run for at least 60 seconds to purge the instrument with air. Press the **5** KEY, **Pump**, to turn off the pump.

11. Press the **0** KEY, **Exit**, to return to the Oxygen Calibration screen and proceed to oxygen span.

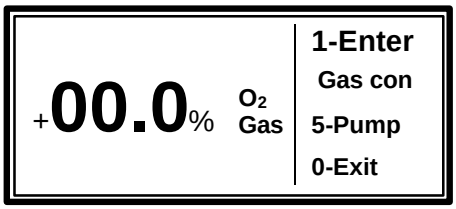
O_2 Calibration - O_2 Span

1. From the Gas Calibration screen, press the 3 KEY, zero O_2, and the Oxygen Calibration screen (Figure 3.27) will appear.

FIGURE 3.27

2. Press the **2** KEY, **Calibrate O_2 Span**, on the Oxygen Calibration screen will appear (Figure 3.28).

FIGURE 3.28



Note: The calibration gas used in this procedure is a mixture of oxygen and nitrogen. The oxygen concentration by volume can be 2-5% with the remainder N_2.

3. Change the calibration gas mixture to Oxygen/Nitrogen. Install the regulator/flow meter on the new calibration gas mixture as directed previously in *Setting Up the Equipment*, page 4. Check and adjust the gas flow to 500 cc and pressure to 2 psig. Turn off the gas.

4. Connect the ¼" tubing from the calibration gas regulator/flow meter to the GEM-500™ gas sample/static pressure port (Figure 1.1). Attach tubing to the exhaust port of the GEM-500™, if not already attached, and direct the exhaust away from you and out of the immediate area.

5. Press the **5** KEY, **Pump**, displayed on the O_2 Span screen shown above. (Figure 3.28)

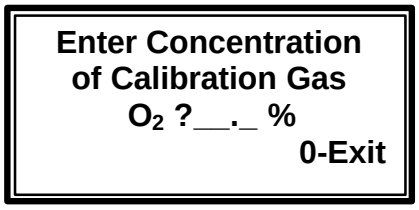
6. Turn on the calibration gas mixture of oxygen and nitrogen.

7. Allow the calibration gas to flow into the GEM-500™ for 60 seconds.

8. After 60 seconds, read the Oxygen Gas Concentration on the screen. It should be stable and not changing more than a few tenths of one percent.

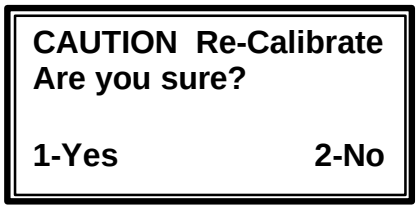
9. Press the **1** KEY, **Enter Gas Con**, and input the oxygen concentration of the calibration gas (typically 4%) using the keyboard of the GEM-500™ (Figure 3.29). Enter the percentage as three digits XX.X%. (4% O_2 would be input as 040) The GEM-500™ will automatically place a decimal point in the proper position. After the percentage is entered, press the **0** KEY to **Exit**.

FIGURE 3.29



10. The next screen to appear, Figure 3.30, is the Caution Re-Calibrate Screen.

FIGURE 3.30



11. Press the **1** KEY, **Yes**, and one of two screens will appear (Figure 3.31 or Figure 3.32).

12. If the Calibration OK Screen appears proceed to step 15.

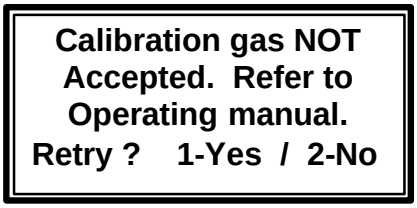


FIGURE 3.31

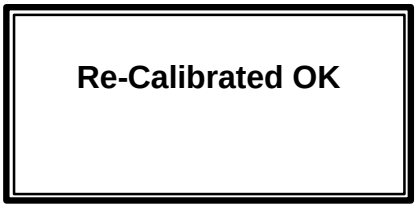


FIGURE 3.32

13. If the Calibration Gas NOT Accepted screen appears, press the **1** KEY, **Yes,** and re-enter the percentage of oxygen in the calibration gas. It is possible the wrong percentage was input. If, on a second attempt, this has not worked, press the **0** KEY, **No**, and return to the Oxygen Calibration Menu. Start the procedure over again. Zero and then calibrate the oxygen. If there are still problems, proceed to Factory Settings in this section.

14. Press the **0** KEY, **Exit**, to return to the Oxygen Calibration screen shown on the following page.

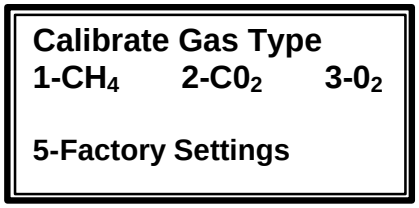
15. Turn off the calibration gas. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM-500™.

Factory Setting Calibrations

As previously mentioned, it is sometimes necessary to return the GEM-500™ to factory settings before trying to field calibrate the unit. If for some reason sampling conditions change radically, overall accuracy of the GEM-500™ can be improved by returning to factory settings and then re-calibrating. This procedure will overwrite previous field calibrations.

1. From the Gas Calibration screen, Figure 3.34, press the **5** KEY, **Factory Settings**.

FIGURE 3.34



2. The Caution screen, Figure 3.35, shown below will be displayed. If the **0** KEY, **No**, is pressed, the Not Set screen (Figure 3.36) appears for two seconds, then the Gas Calibration screen returns.

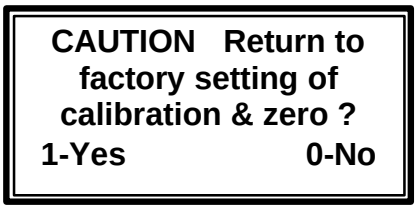


FIGURE 3.35

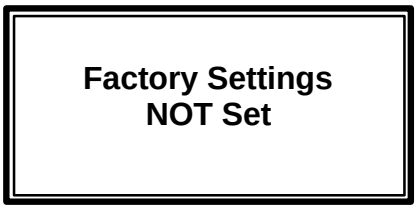


FIGURE 3.36

3. Press **1** KEY, **Yes**, and the Factory Setting Set OK screen (Figure 3.37) is displayed for three seconds before returning to the Gas Calibration screen shown in step 1.

FIGURE 3.37

4. After loading the factory settings, the methane and oxygen calibration **MUST BE RE-ZEROED PRIOR TO USE.** After completing the gas calibrations, the GEM -500™ is ready to read gas levels. Go to Chapter 5 of this manual, Read Gas Levels.

After Completing Gas Calibrations

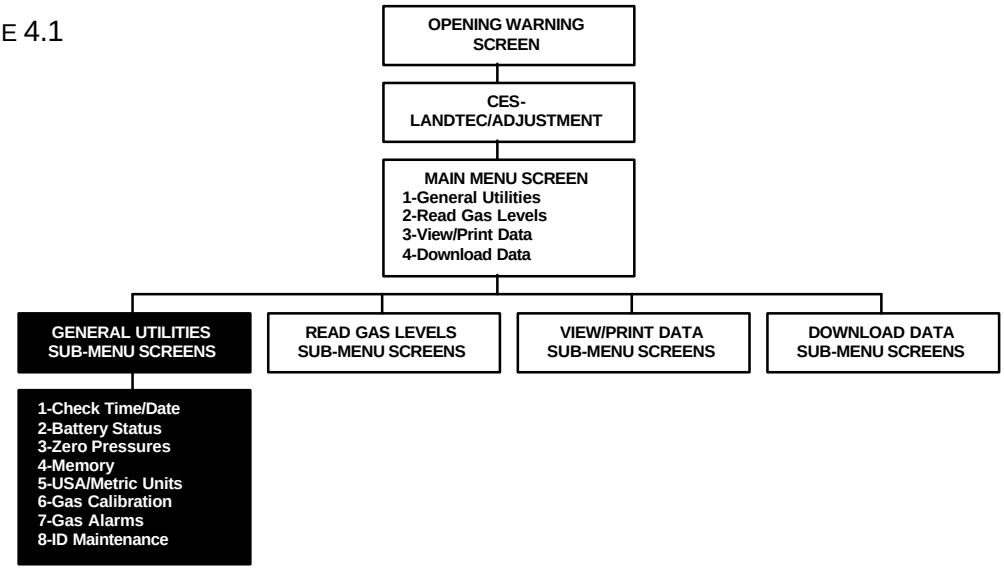
Additional general utilities functions should be addressed after the GEM-500™ is field calibrated. These functions are available on the General Utilities menu and include:

- **Check Time/Date** Assures that the data collected is properly time/date stamped.
- **Check Memory** Assures that there is enough memory space in the GEM-500™ to store the readings you plan to take. Otherwise the memory will need to be cleared. (See page 28, chapter 4)
- **Set Gas Alarms** Alerts the user to unusual gas conditions.

Chapter 4 - General Utilities Functions

General Utilities Screen Tree Diagram

FIGURE 4.1



General Utilities Menu

The General Utilities functions are displayed on three subsequent screens. (Figures 4.2, 4.3, & 4.4) Any of the functions may be selected while any of the three screens is displayed. Use the **9** KEY, **More**, to move from one screen forward to the next. Press the **0** KEY, **Exit**, to return to the main menu.

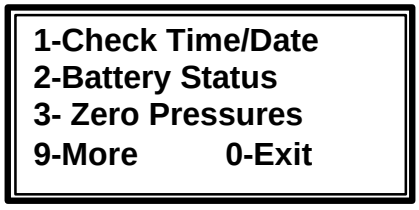


FIGURE 4.2

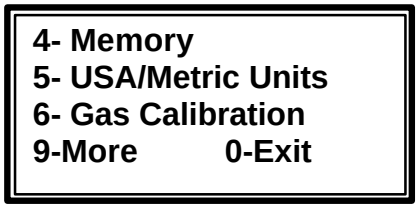


FIGURE 4.3

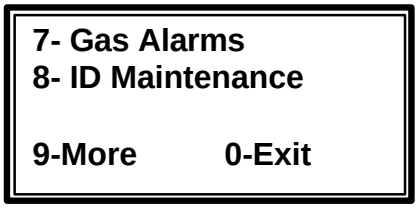


FIGURE 4.4

General Utilities Functions

1. **CHECK TIME/DATE:** Set or check time and date.

2. **BATTERY STATUS:** Graphic display of the percentage of power remaining in the batteries.

3. **ZERO PRESSURES:** Zero pressure transducers.

4. **MEMORY:** Check available memory and facilitate clearing of all data and ID information.

5. **USA/METRIC UNITS:** Select either USA standard (Imperial) or metric (SI) measurement units.

6. **GAS CALIBRATION:** Field calibrate methane, Carbon Dioxide and oxygen with special gas mixtures for increased accuracy.

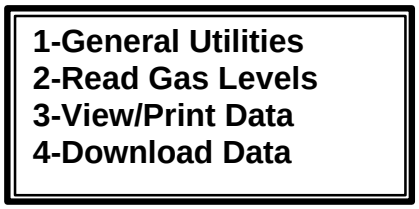
7. **GAS ALARMS:** Set gas alarm levels.

8. **ID MAINTENANCE:** View, enter, edit and delete well ID information.

Check Time/Date
There is an internal clock and calendar in the GEM-500™ powered by a secondary battery that maintains the clock function when the GEM-500™ is turned off. As each reading is stored in the GEM-500™, it is time and date stamped. Both the clock and calendar are set by CES-LANDTEC, however, they should be reset to the local time zone and checked weekly thereafter.

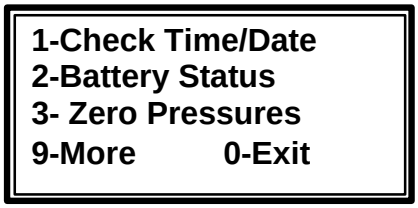
1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

FIGURE 4.5



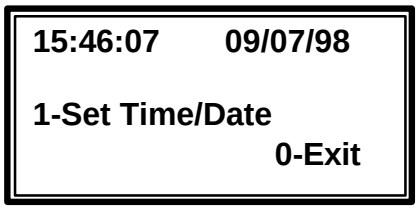
2. (Figure 4.6). Press the **1** KEY, **Check Time/Date**, on the General Utilities Sub-Menu screen to access the Check Time/Date function.

FIGURE 4.6



3. Press the **1** KEY, **Set Time/Date**, to proceed. (Figure 4.7)

FIGURE 4.7

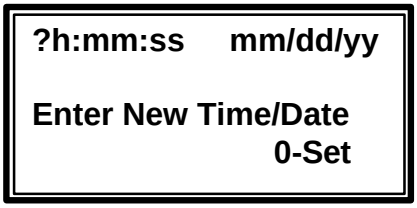


4. The time and date are displayed on the top line of the screen. A 24-hour clock or military time is used. If the time is after 12 noon, add 12 to the hour to convert it to the 24-hour format. Example: 3 p.m. is 12+3 = 15:00 hours. The time format is Hours: Minutes. Seconds. The date format used in the example is in U.S. calendar format with the month first and day second (mm/dd/yy).

5. If the time and date are accurate, end procedure by pressing the **0** KEY to **Exit** to the General Utilities Sub-Menu screen. If the time or date, or both, is wrong, press the **1** KEY, **Set Time/Date**.

6. Set the time and date by entering numbers from the GEM-500™ keyboard. For setting the time hh = hours, mm = minutes, and ss = seconds. The date is entered in the U.S. calendar format where mm = months, dd = days, and yy = years. When finished, press the **0** KEY to **Set**.

FIGURE 4.8



NOTE: If it is necessary to correct an entry error, use the 0 KEY as a Backspace Key by holding it down for 1 second. In normal use, the 0 KEY is quickly pressed and released.

7. After setting, one of two screens displays. If the date is valid, Figure 4.9 displays for three seconds. If the time or date is invalid, Figure 4.10 displays. The time or date is invalid when impossible numbers are entered into the field. For example, mm=15 is an invalid month. Return to step 5 above and reenter the correct time or date as instructed.

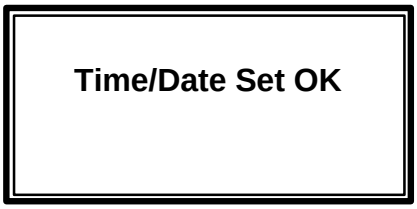


FIGURE 4.9

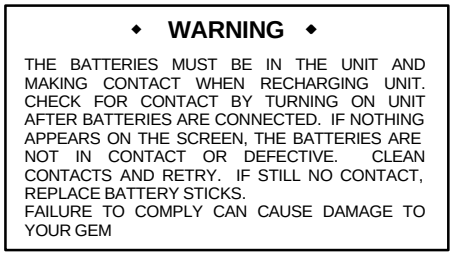
FIGURE 4.10

Battery Status

A Fast charger came with the GEM-500™. The Fast charger takes approximately 2.5 hours for a 90% charge, the charger will automatically switch to a slow charge after this time to prevent damage to the batteries. The fast charger may be left connected overnight without damage to the NiCad batteries. When the GEM-500™ is fully charged, it should be able to operate continuously for 6-8 hours depending upon the battery used and how it was charged. The GEM-500™ may be operated with Alkaline batteries, however, **ONLY** the NiCad batteries can be recharged. If the GEM-500™ is without batteries for more than 30-45 minutes, memory/data loss will occur and the internal back backup battery will run down. If this occurs, the unit will need to be returned to the lab for service.

WARNING! DO NOT TRY TO RECHARGE ALKALINE BATTERIES – DAMAGE TO THE UNIT WILL OCCUR. (Figure 4.11)

Figure 4.11



1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

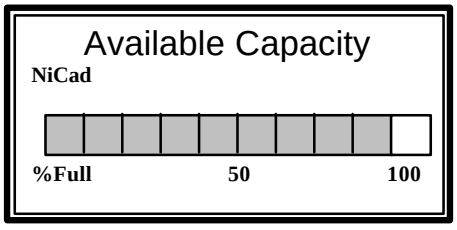
2. Press the **2** KEY, **Battery Status**, on the General Utilities Sub-Menu screen as shown in Figure 4.12.

FIGURE 4.12

.

3. The battery status graph displays the percentage of power remaining in the battery. When the graph reads 20-30%, a battery symbol indicator displays on the upper right of the screen, indicating approximately 1 hour of use remaining. When finished viewing the screen, press the **0** KEY to **Exit**.

FIGURE 4.13



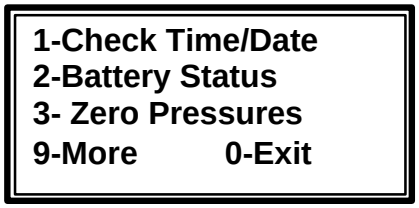
Zero Pressures
The GEM-500™ measures atmospheric pressure as part of the LFG flow calculation. To properly measure pressure and the vacuum used in landfill gas extraction systems, the pressure transducers must be reset to zero each time before taking a pressure or vacuum reading.

This procedure may also be done prior to doing any **Read Gas Levels** because the **Zero Pressures** function is also contained on the **Read Gas Levels** Sub-Menu screen as shown in Chapter 5.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

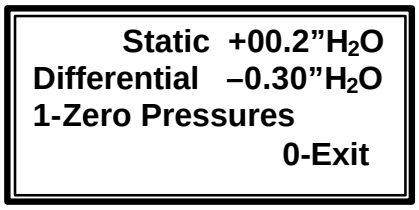
2. Press the **3** KEY, **Zero Pressures**, on the General Utilities Sub-Menu screen as shown in Figure 4.14.

FIGURE 4.14



3. Figure 4.15 displays the current readings of the static and differential pressure transducers. If both pressures do not read 00.0 **DISCONNECT ANY HOSES** ATTACHED TO THE GEM-500™ and press **1** KEY, **Zero Pressures**.

FIGURE 4.15



Note: Units displayed are inches of water column or (millibar) MB depending on measurement unit selected (USA or metric).

4. After the pressures have been zeroed, Figure 4.16 appears for three seconds. The Zero Pressures screen (Figure 4.15) then redisplays.

FIGURE 4.16

5. Press the **0** KEY, **Exit,** to return to the General Utilities Sub-Menu screen.

Memory

CAUTION: THIS FUNCTION CAN ERASE ALL STORED DATA. ONCE CLEARED, THE DATA CANNOT BE RECOVERED.

All well ID's and readings are stored in the GEM-500™'s memory. Eventually the memory becomes full. After each day's readings are completed, the remaining amount of memory should be checked. Normally, the readings for the day are downloaded to a computer. Downloading copies the information but does not clear it out of memory. That must be done manually, as described below. If the memory becomes full, a **MEMORY FULL** message displays. When this happens, the memory must also be manually cleared.

The GEM-500™ can store many well ID's. It is, therefore, possible to use it on several landfills.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

2. Since the **Memory** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **4** at this screen.

3. Press the **4** KEY**, Memory**, on the General Utilities Sub-Menu screen (Figure 4.17).

FIGURE 4.17

```
4- Memory
5- USA/Metric Units
6- Gas Calibration
9-More        0-Exit
```

4. The amount of available memory left in the GEM-500™ displays on The Number of Free Readings screen. (Figure 4.18) Three choices may be made on this screen. Press the **1** KEY, **Clear Readings**, to erase all gas/data readings but leave the ID's. Press the **2** KEY, **Clear ID Info**, to erase all ID numbers and the associated readings that have accumulated in the GEM-500™ from the ID MAINTENANCE and READ GAS functions. Press the **0** KEY, **EXIT**, to ESCAPE from the procedure and return to the General Utilities Sub-Menu screen.

FIGURE 4.18

```
  0479 Free Readings
1-Clear Readings
2-Clear ID Info
              0-Exit
```

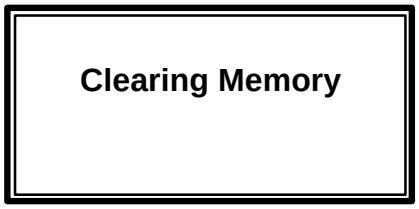
CAUTION: THIS STEP ERASES STORED DATA. YOU MAY WANT TO DOWNLOAD THE DATA FIRST SO IT IS NOT LOST.

5. After making your choice from the screen above, the Caution screen displays (Figure 4.19). As a final safety check, the code **0102** must be input from the GEM-500™ keyboard to clear the memory. **IF YOU DECIDE NOT TO CLEAR THE MEMORY AT THIS POINT, TURN THE GEM-500™ OFF BY PRESSING THE RED ON/OFF KEY** or enter an incorrect code then press the **0** KEY, **EXIT**, to return to the Memory screen. Do not input 0102 unless you want to clear the memory.

FIGURE 4.19

6. Enter 0102 from the keyboard and press the **0** KEY, Exit. The Clearing Memory screen displays for 3 seconds if the memory was erased.

FIGURE 4.20



After the Clearing Memory screen displays, the Number of Free Readings screen (Figure 4.18) redisplays. Press the **0** KEY to **Exit** to the General Utilities Menu screen.

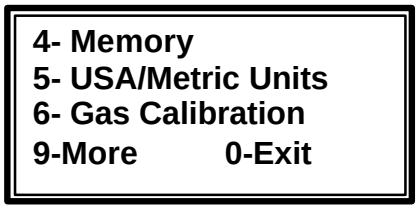
USA/Metric Units
The GEM-500™ can store and display data in 2 units of measure, Metric (SI) or Imperial (USA). This function allows setting the unit of measure.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

2. Since the **USA/Metric Units** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **5** at this screen.

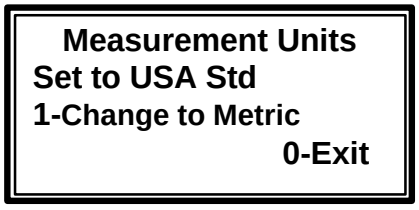
3. Press the **5** KEY, **USA/Metric Units**, on the General Utilities Sub-Menu screen (Figure 4.21).

FIGURE 4.21



4. The Measurement Units screen (Figure 4.22) displays how the GEM-500™ is currently set (Set to USA Std or Set to Metric). Press the **1** KEY to change from USA Std to Metric. (This setting acts as a toggle switching from one to the other.) If the GEM-500™ is currently displaying USA Std measurement units (Imperial — Btu's, Standard Cubic Feet, Fahrenheit temperatures, etc.) it switches to Metric and vice versa. When the GEM-500™ is set to the correct measurement unit, press the **0** KEY, **Exit,** to return to the General Utilities Sub-Menu screen.

FIGURE 4.22



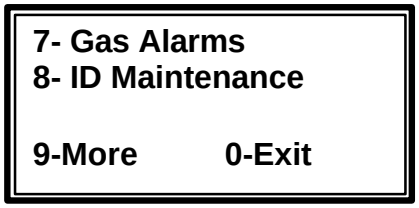
Gas Calibration
Please refer to Chapter 2 - Field Calibration for all information and instructions relating to the Gas Calibration function.

Gas Alarms
The GEM-500™ has two alarm options that can warn the operator if a gas sample contains concentrations of **Methane below** established levels or **Oxygen above** preset levels. If the alarms are activated, there is a beeping and the affected gas blinks when displayed on the Read Gas Levels screen.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

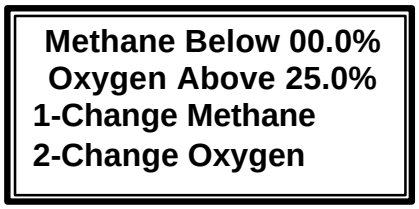
2. Since the **Gas Alarms** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **7** at this screen. (Figure 4.23)

FIGURE 4.23



3. The Gas Alarm Set screen displays the alarm set point of both methane and oxygen and presents the functions to change them. (Figure 4.24). Chose one to change the methane alarm set point or two to change the oxygen alarm set point. If no change in alarm set points is required, press the **0** KEY, **Exit**, to return to the General Utilities Sub-Menu screen.

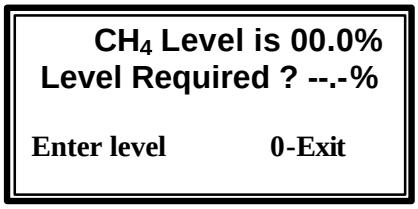
FIGURE 4.24



NOTE: To turn off alarms, set methane alarm to 00.0% and oxygen alarm to 25.0%.

4. If the **1** KEY, **Change Methane**, is pressed, the Methane Alarm Set Point screen displays. (Figure 4.25) Using the numbered keys on the GEM-500™ keyboard, input the new alarm level for methane (CH_4). All three digits must be entered (XX.X%). The decimal point is automatically inserted. Press the **0** KEY to save and **Exit**.

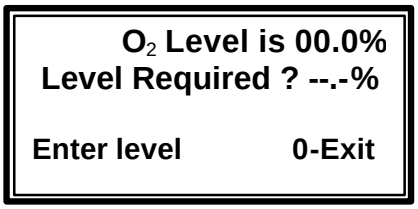
FIGURE 4.25



Note: If the GEM-500Ô receives CH_4 at or below this set point during the Read Gas Levels procedure, an audible alarm sounds to alert the operator.

5. If the **2** KEY, **Change Oxygen**, is pressed, the Oxygen Alarm Set Point screen displays. (Figure 4.26). Using the numbered keys on the GEM-500™ keyboard input the new alarm level for oxygen (O_2). All three digits must be entered (XX.X%). The decimal point is automatically inserted. Press the **0** KEY to save and **Exit.**

FIGURE 4.26



Note: If the GEM-500Ô receives O_2 at or above this set point during the Read Gas Levels procedure, an audible alarm sounds to alert the operator.

6. Press the **0** KEY**, Exit,** to return to the General Utilities Sub Menu screen.

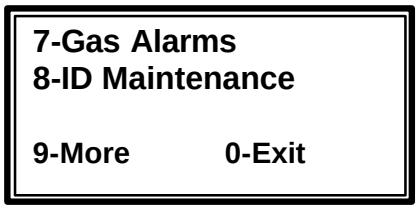
ID Maintenance

Each monitoring point on a site can be assigned a unique ID code using the ID Maintenance function. This code **must** be eight characters long. The characters can be any combination of letters and numbers. Typically, the landfill name or an abbreviation is used for the first four characters. After an ID code is entered (Step 4), the type of flow device (Accu-Flo, pitot tube, orifice plate or user defined) used at that ID location must also be entered (Step 5). Depending on the flow device selected, either no data, pipe ID (inner diameter), or both orifice and pipe ID size must also be entered.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

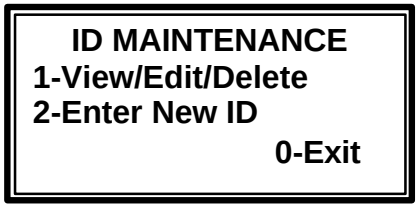
2. Since the **ID Maintenance** function is not on the first or second General Utilities screens, press the **9** KEY, **More**, twice or enter **8** at this screen. (Figure 4.27)

FIGURE 4.27



The ID Maintenance screen presents two options. If a well already has an ID number, option one, View/Edit/Delete should be accessed (Step *, Figure 4.*) If a well has no ID assigned in the GEM-500™, press the **2** KEY to **Enter New ID**.

FIGURE 4.28



Both numbers and letters can be input on the Enter ID screen. Use the **BLUE ¦** KEY to switch (toggle) between numbers and letters. See Keyboard Information in the Getting Started Section at the beginning of this Manual.

- For numbers, press the keypad **Number** KEYS (0-9). (Figure 4.29)
- For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to scroll through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 4.30)

After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

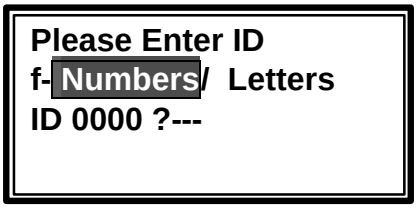


FIGURE 4.29

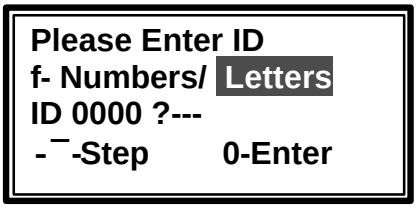
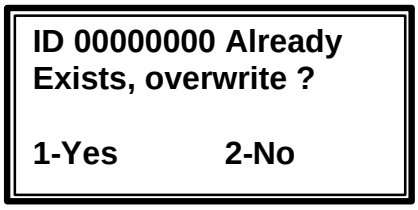


FIGURE 4.30

Note: When entering the very first well ID, four zeros will hold the first four places in the ID number. To replace these zeros with the well ID, use the 0 KEY to backspace over them by holding it down for more than a second. Then enter the first four characters of the well ID. These first four characters default to the second well ID entered, saving the user the time of reentering for each well.

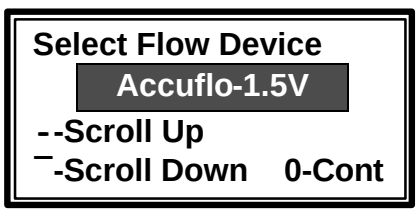
5. If an existing code is entered, the unit will ask if you want to overwrite. (Figure 4.31) If so, press the **1** KEY**, Yes**, to overwrite. If a mistake was made and an overwrite is not desired, press the **2** KEY, **No**, to return to the ID Maintenance screen. (Figure 4.28)

FIGURE 4.31



6. A well flow device is selected in the Flow Device screen. This selection is necessary for the GEM-500™ to be able to calculate flow when readings are taken. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 4.33. Once the desired flow device is located in the shaded selection window, press **0** to select and Continue. (Figure 4.32)

FIGURE 4.32



Note: Selection of User Input allows the entry of flow in SCFM, if known. Those without a flow device may wish to use this selection to record velocity or other relevant data. (For example, using a Kurz meter.)

FIGURE 4.33

Accuflo–1.5V (1½" Accu-Flo Model 150 Vertical Wellhead)
Accuflo–1.5H (1½" Accu-Flo Model 150 Horizontal Wellhead)
Accuflo–2V (2" Accu-Flo Model 200 Vertical Wellhead)
Accuflo–2H (2" Accu-Flo Model 200 Horizontal Wellhead)
Accuflo–3V (3" Accu-Flo Model 300 Vertical Wellhead)
Accuflo–3H (3" Accu-Flo Model 300 Horizontal Wellhead)
Orifice Plate (Orifice diameter and pipe inner diameter required)
Pitot Tube (Pipe ID required)
User Input (Pipe ID required)

7. If an Orifice Plate, Pitot Tube or User Input flow device is selected, additional information is required. If the pipe or orifice diameter screen appears, input the required size as necessary. Insert inches or centimeters (depending on whether US or Metric Units were selected on the USA/Metric Units screen). The unit uses XX.XX as the format and automatically enters the decimal point. Press the **0** KEY to enter and Continue.

FIGURE 4.34

Enter Pipe ID

?-.-- Inches

8. The ID Stored OK Screen displays for three seconds (Figure 4.35) then the ID Maintenance displays so the next ID can be entered (Figure 4.36).

FIGURE 4.35

ID Stored OK

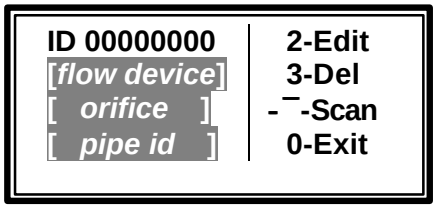
9. To View/Edit/Delete ID information, select the **1** KEY. (Figure 4.36)

FIGURE 4.36

ID MAINTENANCE
1-View/Edit/Delete
2-Enter New ID
0-Exit

10. The Well ID screen displays the Well ID and the associated flow device. The orifice and pipe data is also displayed if associated with a flow device. To scroll through the ID's stored in memory, use the **1** KEY, (**UP ARROW**) or the **6** KEY (**DOWN ARROW**). Press the **0** KEY to **Exit**.

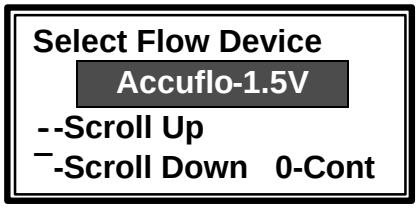
FIGURE 4.37



11. To edit the chosen Well ID information, press the **2** KEY, **Edit**. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 4.33. Once the desired flow device is located in the shaded selection window, press **0** to select and **Continue**. Press the **0** KEY, **Exit**, to return to the ID Maintenance screen. (Figure 4,38)

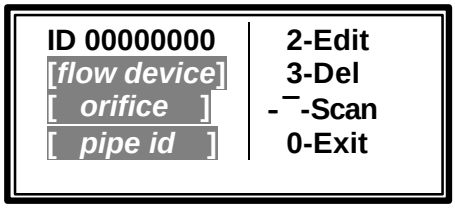
NOTE: Once the 2 KEY is pressed, the original flow device is erased and new data must be entered.

FIGURE 4.38



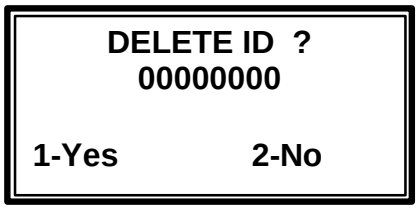
12. To delete a Well ID and the associated flow device, press the **3** KEY, **Del**ete.

FIGURE 4.39



13. The Delete ID screen displays the Well ID chosen and asks for confirmation of the delete. If this Well ID ***should not*** be deleted, press the **2** KEY, **No**, (Figure 4.40). The unit cancels the delete command and returns to the Well ID screen (Figure 4.39). If this Well ID ***should*** be deleted, press the **1** KEY, **Yes**. The ID is deleted and the unit returns to the Well ID screen (Figure 4.39). Press the **0** KEY to **Exit** to the ID Maintenance screen.

FIGURE 4.40



14. Before leaving this section, store at least three ID's. These will be necessary for use in the following chapters.

Chapter 5 - Read Gas Levels

This section instructs the operator in how to use the GEM-500™ to collect data from LFG extraction system wells and other monitoring points. Several things should be done prior to beginning to collect data readings with the GEM-500™.

The operator should have performed the following:

- Check the TIME/DATE. (See Chapter 4 - General Utilities)
- Charge the unit's factory provided nickel cadmium batteries. (See Chapter 8 - Maintenance)
- Perform a Field Calibration on the unit. (See Section 3 - Field Calibration)

The GEM-500™ is a sensitive measuring instrument. Vibration, shock, and great temperature changes can alter the field calibration. It is suggested that a field calibration be performed just prior to using the instrument at the site. Additional calibration is sometimes necessary in the field during the day.

WARNING! Review the warnings given in the beginning of this manual. The GEM-500™ is NOT to be used in dangerous, explosive or confined atmospheres. Do not use the GEM-500™ inside vaults, manholes, trenches or indoors. Do NOT block the exhaust port. If the exhaust port is blocked while the pump is operating, the pressure could force the unit to over-pressurize and damage the internal components and the case.

GEM-500™ Hose and Wellhead

The proper hoses must be connected from the GEM-500™ to the wellhead in order to collect data. As mentioned in the Getting Started Chapter, the clear tubing with the external filter/water trap assembly is attached to the static pressure port on the GEM-500™ (Figure 5.1). The almond colored male quick connect goes on the end of this tubing to read the static pressure on the Accu-Flo Wellhead and the blue hose is connected to the impact port of the GEM-500™.

On the following pages are examples of the Accu-Flo Wellhead, both vertical and horizontal models. Note the locations of the Static Pressure Port, Impact Pressure Port, Temperature Gauge, and Gas Sample Port.

Note: Five O-rings for quick disconnect fittings are supplied with Unit. Replace O-Rings when necessary because oxygen will be drawn into sample if O-rings are damaged. The GEM-500™ pump will pull up to 80" of vacuum.

FIGURE 5.1

1. Static Pressure/Sampling Port—Measures static pressure when connected to wellhead static pressure port by tubing. Always use water trap assembly.

2. Impact Pressure Port—Measures impact pressure when connected to wellhead impact pressure port by tubing.

3. Exhaust Port—This port must be kept clear. If blocked while operating, over-pressurization and damage to internal components and case could occur.

4. Data Port - Used for Temperature Probe, POD, downloading data, and battery recharging.

CES-LANDTEC Horizontal Accu-Flo Wellhead

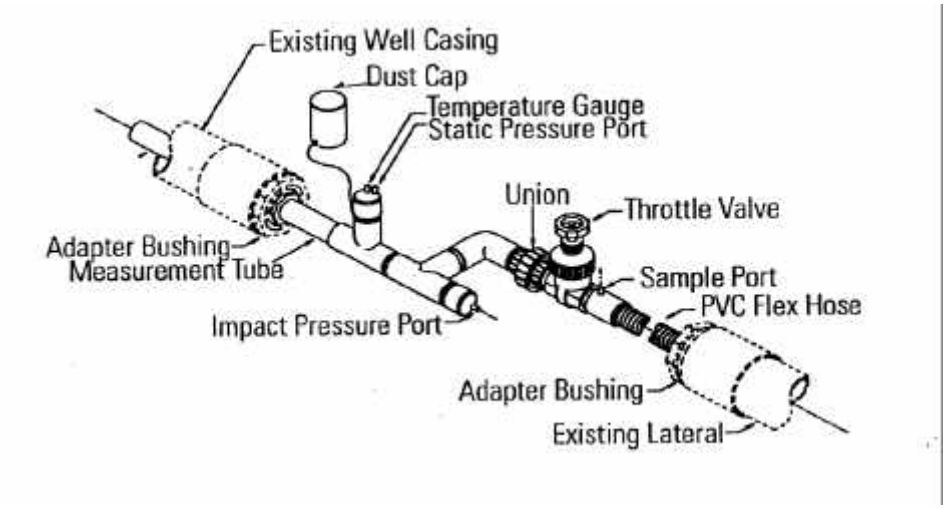


FIGURE 5.2

CES-LANDTEC Vertical Accu-Flo Wellhead

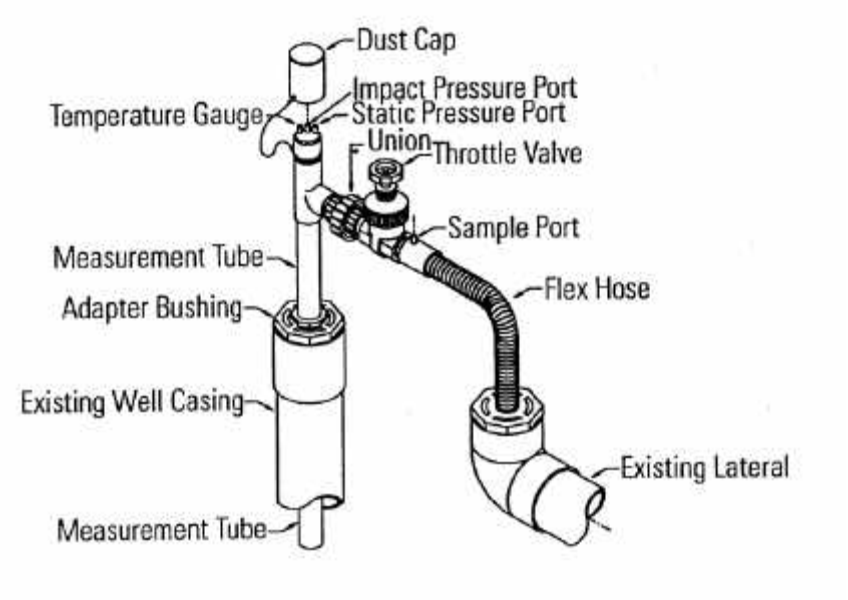
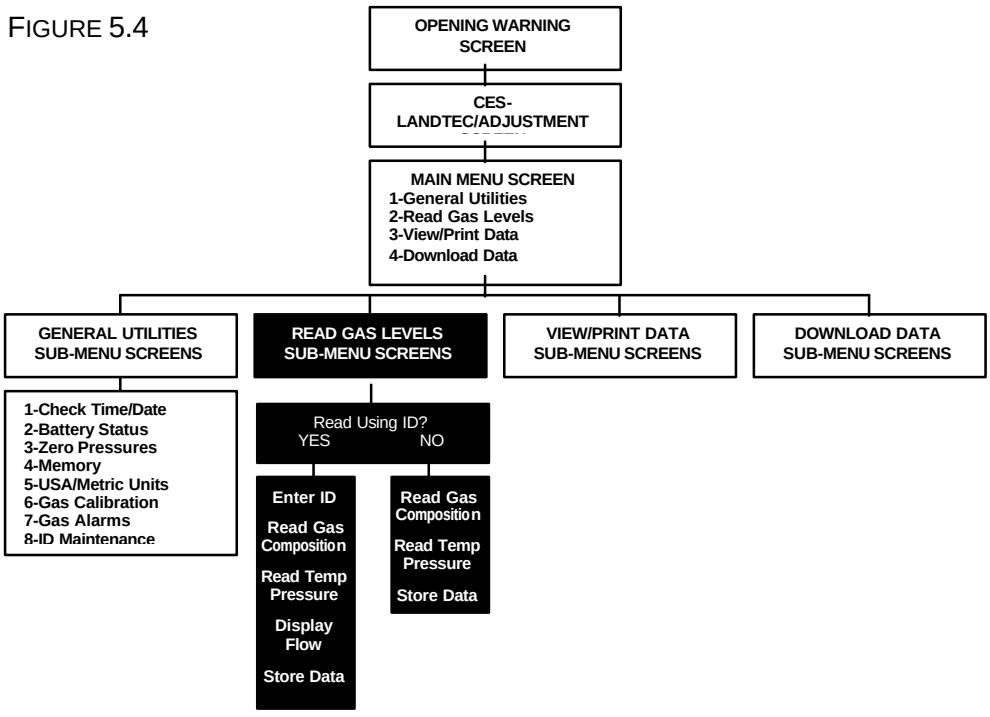


FIGURE 5.3

Read Gas Levels Screen Tree Diagram

FIGURE 5.4

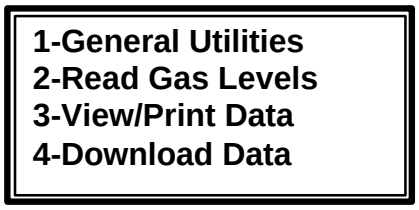


As shown in the screen tree diagram above (Figure 5.4), there are two menu paths that can be followed through the Read Gas Levels function. The path taken depends upon whether or not a well ID has been defined and stored in the GEM-500™. Well IDs can be added at several points during this procedure.

Read Gas Levels Menu – Read Using ID? No

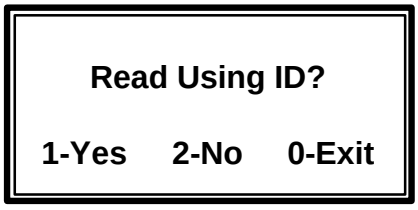
1. On the Main Menu screen press the **2** KEY (Figure 5.5) to initialize the Read Using ID screen.

FIGURE 5.5



2. The Read Using ID screen is displayed as shown in Figure 5.6. A choice needs to be made whether or not to read the well using an ID. If yes is chosen, a well ID is selected by scrolling through a list, or by entering the well ID manually. Typically, **NO** is chosen when a well only needs to be monitored or a well ID is not stored in memory in the unit.

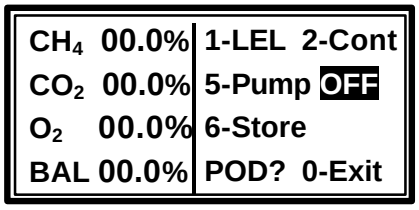
FIGURE 5.6



3. Select the **2** KEY, **No**.

4. Connect the GEM-500™ to the wellhead with supplied tubing—Static Pressure/Sampling Port to the Static Pressure Port and Impact Pressure Port to Impact Pressure Port. The Gas Levels screen is divided into two parts. The left side of the screen displays current percentages of CH_4, CO_2, O_2, and BAL, which is the balance of all other gases excluding the CH_4, CO_2, and O_2. The right side of the screen displays functional choices for this reading (Lower Explosive Limit, Continue to temperature and pressure data, Pump On/Off, Last Data, Exit) and POD reminder.

FIGURE 5.7



POD refers to interchangeable electrochemical gas pods that are used to extend the measurement capabilities of the GEM-500™ (Figure 5.8). These pods are available in seven different gases with nine different ranges and easily plug into the data port. The reminder lets the user know that if a pod were attached at this time, additional gas readings could be taken.

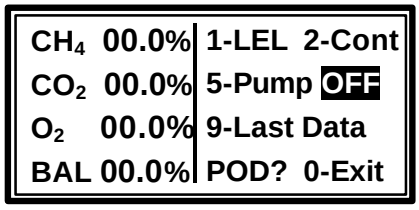
FIGURE 5.8

Interchangeable Electrochemical Gas Pods

Gas	Range (ppm)	Resolution (ppm)
H_2S	0 – 50	0.1
	0 – 200	1.0
CO	0 – 1000	1.0
SO_2	0 – 20	0.1
	0 – 100	1.0
NO_2	0 – 20	0.1
Cl_2	0 – 20	0.1
H_2	0 – 1000	1.0
HCN	0 – 100	1.0

5. Press the **5** KEY, **Pump**, to start the pump and draw a gas sample into the GEM-500™. The **5** KEY, **Pump**, works as a toggle switch to turn the pump on and off. Once the pump is turned on, the readings are not considered to be accurate until the percentages on the left side of the display stabilize, typically within 30-45 seconds. A timer displays on the screen to monitor the pump running time.

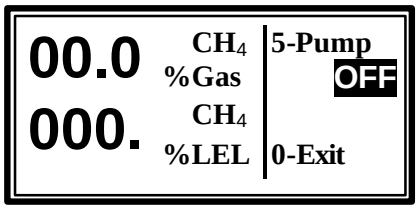
FIGURE 5.9



Note: The GEM-500™ may sound an alarm (beeping) while taking gas readings. The alarm means that gas levels set in General Utilities Gas Alarms (page 31) have been reached or exceeded. In addition to the alarm, the screen display of the gas that set off the alarm will also blink.

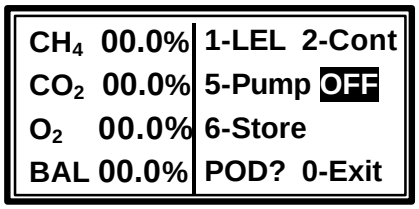
6. To monitor the LEL (Lower Explosive Limit), press the 1 KEY (Figure 5.9), to enter the LEL screen. If the LEL needs to be continuously monitored, just leave the pump running. When the LEL no longer needs to be monitored, press the 5 KEY again to toggle off the pump. Press the 0 KEY to Exit back to the Gas Levels screen.

FIGURE 5.10



7. To store the current readings press the **6** KEY, **Store**.

FIGURE 5.11



Since a well ID was not entered to begin with, one must now be entered. Use the **BLUE ¦** KEY to switch (toggle) between numbers and letters. See Keyboard Information in the Getting Started Section at the beginning of this Manual.

- For numbers, press the keypad **Number** KEYS (1-0). (Figure 5.12)
- For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to step through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 5.13)

After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

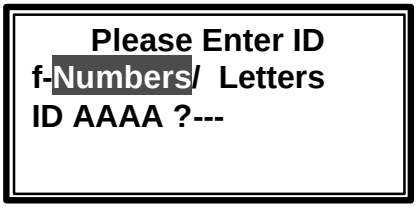


FIGURE 5.12

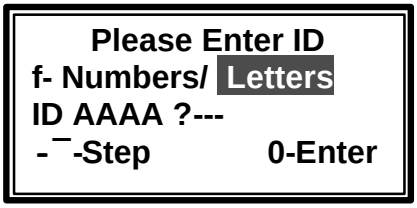


FIGURE 5.13

Note: Four letters from the previously entered ID default into the first four places of the ID number. To replace these letters, if needed, use the 0 KEY to backspace over them by holding it down for more than a second. Change the characters as needed.

9. On the Select Comments screen, use the **1** KEY to **Scroll Up** or the **6** KEY to **Scroll Down** through the comment list (Figure 5.15). When the correct comment appears in the comment display area, press the **2** KEY, to **Select**, then the **0** KEY to Store the readings.

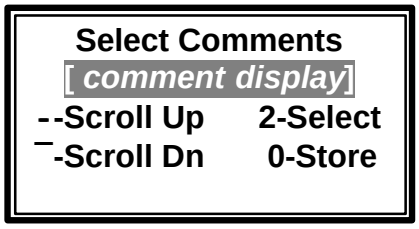


FIGURE 5.14

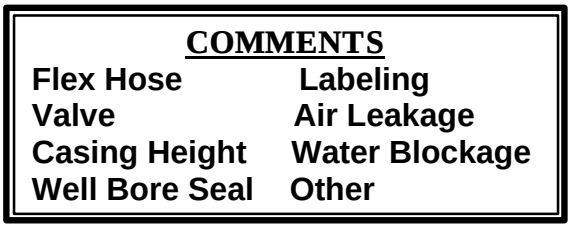


FIGURE 5.15

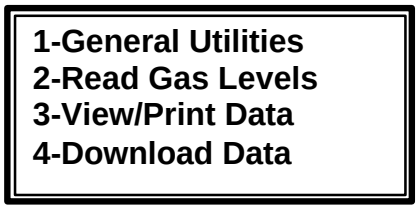
10. If the readings are successfully stored, the Readings Stored screen displays for three seconds (Figure 5.16). The Gas Levels screen (Figure 5.11) redisplays. The unit is now ready to accept another reading.

FIGURE 5.16

Read Gas Levels Menu – Read Using ID? Yes

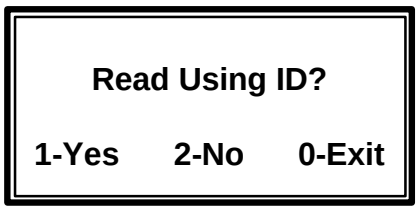
1. On the Main Menu screen, press the **2** KEY (Figure 5.17) to initialize the Read Using ID screen.

FIGURE 5.17



2. A choice needs to be made at the Read Using ID screen (Figure 5.18) whether or not to read the well using an ID. If **YES** is chosen, the well ID is selected by scrolling through a list or by entering the well ID manually. Typically, **NO** is chosen when a well only needs to be monitored or a well ID is not yet in memory.

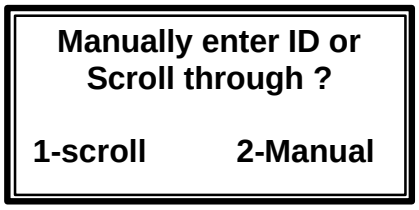
FIGURE 5.18



3. Select the **2** KEY **Yes**.

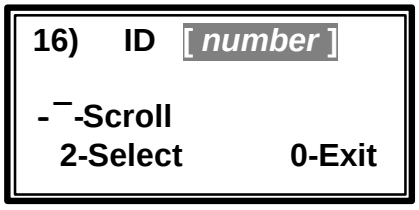
4. The Manually Enter ID screen allows the user to either scroll through a list of ID's that are already in memory or enter an ID manually. (Figure 5.19) If there are few ID's stored, it might be faster to use the scroll option; whereas the manual entry option might be faster to use if there are many ID's stored.

FIGURE 5.19



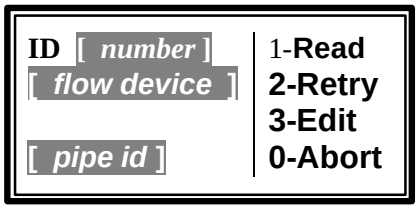
5. To scroll through the existing list of well ID's, press the **1** KEY, **scroll**. The Select ID screen displays a single ID at a time. (Figure 5.20) Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list. When the ID of choice is displayed, press the **2** KEY, **Select.**

FIGURE 5.20



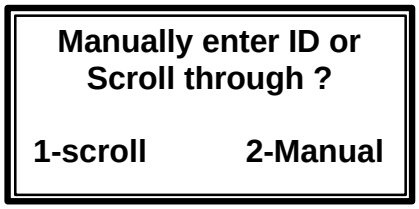
6. The chosen well ID and the type of flow device (Accu-Flo, Orifice Plate, Pitot Tube, or User Input) display on the left side of the screen and the Read, Retry, Edit, and Abort options display on the right. (Figure 5.21) Press the **1** KEY, **Read**, to continue to the Read Gas screen. (Skip to Step 14.)

FIGURE 5.21



7. To select manual entry press the 2 KEY, **Manual.**

FIGURE 5.22



8. Enter the well ID of choice. Use the **BLUE ¦** KEY to switch (toggle) between numbers and letters.

   - For numbers, press the keypad **Number** KEYS (0-9). (Figure 5.23)
   - For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to step through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 5.24)

   After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

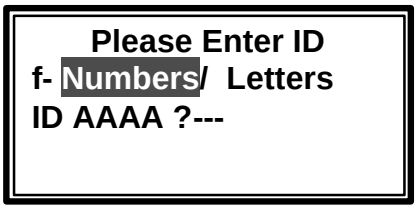


FIGURE 5.23

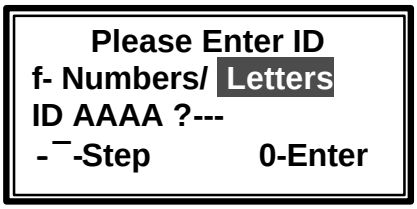
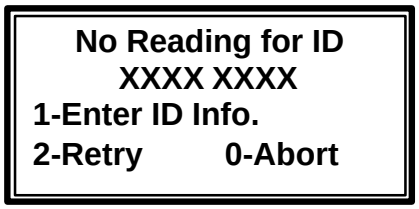


FIGURE 5.24

Note: Four letters from the previously entered ID default into the first four places of the ID number. To replace these letters, if needed, use the 0 KEY to backspace over them by holding it down for more than a second. Change the characters as needed.

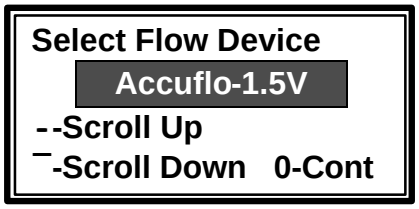
9. If the well ID is not yet entered into the unit, a No Reading screen appears. This screen provides three options. If the number is correct but has never been previously added, Enter ID Info. allows entry and flow device definition. If the well ID entered was in error, Retry takes the user back to the Manually Enter ID screen (Figure 5.22). The Abort command takes the user completely back out to the Main Menu (Figure 5.17). Press the **1** KEY, **Enter ID Info**.

FIGURE 5.25



10. A well flow device is selected in the Flow Device screen. This selection is necessary for the GEM-500™ to be able to calculate flow when readings are taken. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 5.27. Once the desired flow device is located in the shaded selection window, press **0** to select and continue.

FIGURE 5.26



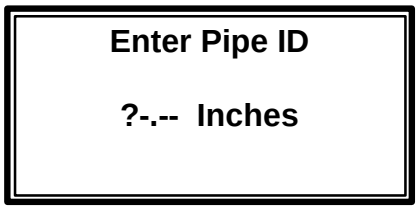
Note: Selection of User Input allows the eventual entry of flow in SCFM, if known (see Step 11). Those without flow devices may wish to use this selection to record velocity or other relevant data. (For example, when using a Kurz meter.)

FIGURE 5.27

Accuflo–1.5V (1½" Accu-Flo Model 150 Vertical Wellhead)
Accuflo–1.5H (1½" Accu-Flo Model 150 Horizontal Wellhead)
Accuflo–2V (2" Accu-Flo Model 200 Vertical Wellhead)
Accuflo–2H (2" Accu-Flo Model 200 Horizontal Wellhead)
Accuflo–3V (3" Accu-Flo Model 300 Vertical Wellhead)
Accuflo–3H (3" Accu-Flo Model 300 Horizontal Wellhead)
Orifice Plate (Orifice diameter and pipe inner diameter required)
Pitot Tube (Pipe ID required)
User Input (Pipe ID required)

11. If an Orifice Plate, Pitot Tube or User Input flow device is selected, additional information is required. If the pipe or orifice diameter screen appears, input the required size as necessary. Insert inches or centimeters (depending on whether USA or Metric Units were selected on the General Utilities USA/Metric units screen). The unit uses XX.XX as the format and automatically enters the decimal point. Press the **0** KEY to enter and continue.

FIGURE 5.28

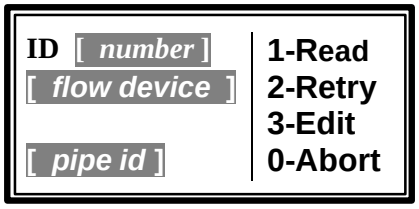


12. The ID Stored OK Screen displays for three seconds (Figure 5.29)

FIGURE 5.29

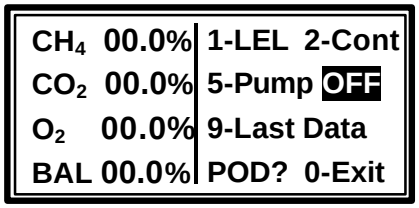
13. The chosen well ID and the type of flow device (Accu-Flo, Orifice Plate, Pitot Tube, or User Input) display on the left side of the screen and the Read, Retry, Edit, and Abort options display on the right. (Figure 5.30) Press the **1** KEY, **Read**, to continue to the Read Gas screen.

Figure 5.30



14. Connect the GEM-500™ to the wellhead with the supplied tubing—Static Pressure/Sampling Port to the Static Pressure Port and Impact Pressure Port to Impact Pressure Port. The Gas Levels screen is divided into two parts. The left side of the screen displays current percentages of CH_4, CO_2, O_2, and BAL, which is the balance of all other gases excluding the CH_4, CO_2, and O_2. The right side of the screen displays functional choices for this reading (Lower Explosive Limit, Continue to temperature and pressure data, Pump On/Off, Last Data, Exit) and a POD reminder.

FIGURE 5.31



POD refers to interchangeable electrochemical gas pods that are used to extend the measurement capabilities of the GEM-500™ (Figure 5.32). These pods are available in seven different gases with nine different ranges and easily plug into the data port. The reminder lets the user know that if a pod were attached at this time, additional gas readings could be taken.

FIGURE 5.32

Interchangeable Electrochemical Gas Pods

Gas	Range (ppm)	Resolution (ppm)
H_2S	0 – 50	0.1
	0 – 200	1.0
CO	0 – 1000	1.0
SO_2	0 – 20	0.1
	0 – 100	1.0
NO_2	0 – 20	0.1
Cl_2	0 – 20	0.1
H_2	0 – 1000	1.0
HCN	0 – 100	1.0

15. Press the **5** KEY, **Pump**, to start the pump and draw a gas sample into the GEM-500™. The **5** KEY, **Pump**, works as a toggle switch to turn the pump on and off. Once the pump is turned on, the readings are not considered to be accurate until the percentages on the left side of the display stabilize, typically within 30-45 seconds. A timer displays on the screen to monitor the pump running time.

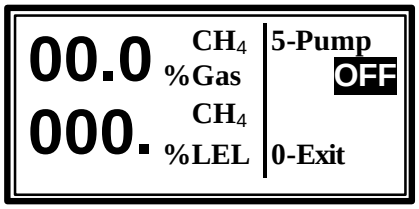
FIGURE 5.33

CH_4 00.0%	**1-LEL 2-Cont**
CO_2 00.0%	**5-Pump OFF**
O_2 00.0%	**9-Last Data**
BAL 00.0%	**POD? 0-Exit**

Note: The GEM-500™ may sound an alarm (beeping) while taking gas readings. The alarm means that gas levels set in General Utilities Gas Alarms (page 31) have been reached or exceeded. In addition to the alarm, the screen display of the gas that set off the alarm also blinks.

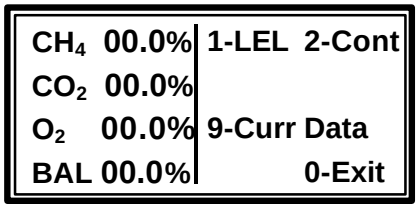
16. To monitor the LEL (Lower Explosive Limit), press the 1 KEY (Figure 5.33) to enter the LEL screen. If the LEL needs to be continuously monitored, just leave the pump running. When the LEL no longer needs to be monitored, press the 5 KEY again to toggle off the pump. Press the 0 KEY to Exit back to the Gas Levels screen (Figure 5.33).

FIGURE 5.34



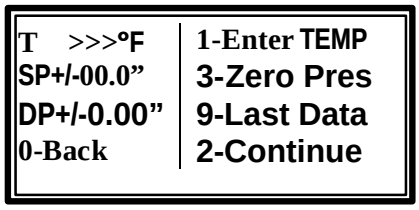
17. If at any time, while working on this screen, reference needs to be made to the prior reading on this wellhead, press the **9** KEY, **Last Data**. The unit displays the very last stored reading. The **9** KEY works as a toggle switch between the current reading and the last reading. From the Last Data (Figures 5.33 & 5.35) screen, the user can go directly into monitoring current LEL or continue directly to the current Temperature/Pressure screen.

FIGURE 5.35



18. From the Read Gas Levels screen (Figure 5.33), press the **2** KEY, Continue, for the Temperature and Pressure screen (Figure 5.36). This screen shows temperature, static pressure, differential pressure, and a number of functional options. If a temperature probe is used, it should be connected from the data port on the right side of the GEM-500™ (Figure 5.1) to the temperature gauge port on the wellhead. When the temperature probe is connected to the GEM-500™, the functional option Enter TEMP disappears as it displays only for manual entry. The temperature probe needs to remain in the wellhead until the entire reading is completed and stored. If a temperature probe is not used, the temperature can be read on a thermometer placed in the temperature gauge port on the wellhead and entered manually into the GEM-500™. To enter the temperature manually, press the **1** KEY, **Enter TEMP**.

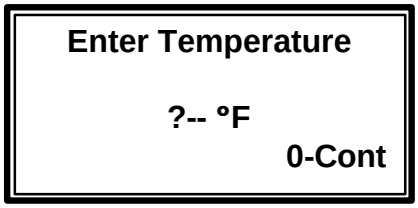
FIGURE 5.36



Note: If flow measurement is required, temperature must be entered either manually or with the optional temperature probe.

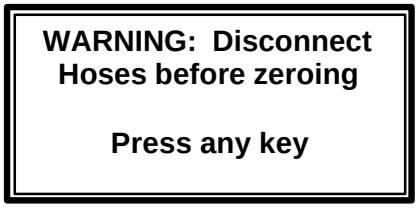
19. Temperature is entered in either Fahrenheit (F) or Celsius (C) depending on whether USA or Metric was chosen in the General Utilities USA/Metric Units screen (page 30). Number keys and leading zero(s) are used to enter a three digit temperature value, i.e., 78° is 078 and 5° is 005. Press the **0** KEY to Continue back to the Read Gas Levels screen (Figure 5.36).

FIGURE 5.37



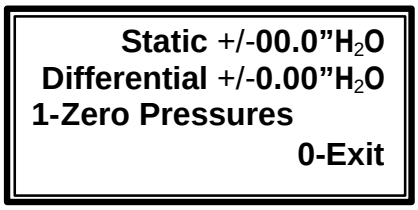
20. From the Read Gas Levels screen (Figure 5.36), press the **3** KEY, **Zero Pres**sures, before proceeding. This is necessary because by taking a LFG sample, the impact port pressure transducers have been pressurized. The **Warning Disconnect hoses** screen displays before the Zero Pressure screen. (Figure 5.38). Disconnect all the hoses from the GEM-500™ to the wellhead and press any key to continue.

FIGURE 5.38



21. The pressures displayed on the Static/Differential screen are displayed with either a positive or negative and need to stabilize (quit changing) before being zeroed. When stabilized, press the **1** KEY to **Zero Pressures**. (Figure 5.39)

FIGURE 5.39



Note: The units displayed are in inches of water column or MB depending on whether USA or Metric was chosen in the General Utilities USA/Metric Units screen (page 30).

22. The Zeroed OK screen (Figure 5.40) displays for 3 seconds, then the Static/Differential screen (Figure 5.41) redisplays. Occasionally the pressures will not zero completely. If this happens, press the **1** KEY, **Zero Pressures**, again until the pressures are completely zeroed. Once the static and differential pressures are zeroed, press the **0** KEY to **Exit.** The Temperature/Pressure screen then redisplays (Figure 5.42).

FIGURE 5.40

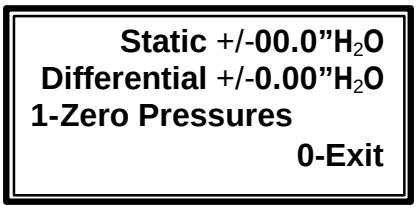


FIGURE 5.41

23. At the Temperature/Pressure screen, reconnect the tubing (Figure 5.43). Allow the instrument to read, then press the **2** KEY to Continue to the Flow/Btu screen.

FIGURE 5.42

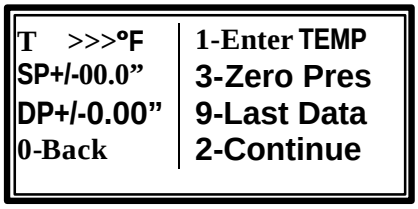


FIGURE 5.43

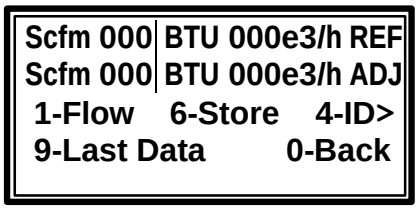
CONNECTIONS

1. **On an Accu-Flo wellhead, connect the Static Pressure/Sampling port (top left) on the GEM-500Ô to the Static Pressure Port on the wellhead, and the Impact Pressure Port on the wellhead. (Figures 5.1, 5.2, 5.3)**
2. **On a pitot tube, connect the hoses from the GEM-500Ô to the Impact and static Pressure ports.**
3. **On an orifice plate, connect the hoses on the GEM-500Ô to either side of the orifice plate.**

Note: To get a flow reading, the differential pressure (DP) must be positive with respect to the static pressure. If it is not, reverse the hoses.

The Flow screen displays the reference flow (REF) and adjusted flow (ADJ). The reference flow is static and will not change unless the Temperature/Pressure screen is re-accessed. Whereas the adjusted flow is active and is typically used to display changes in flow while adjustments are made. If an Accu-Flo, pitot tube, or orifice plate wellhead is in place, the GEM-500™ automatically calculates the reference and adjusted flow. Other functions available here are the ability to store the data, go to the next wellhead ID, view the last data on this wellhead, or go back to the Temperature/Pressure screen. The units displayed on this screen, Scfm (Standard cubic feet per minute) and BTU (British Thermal Units, in thousands) are the USA units that are selected in the General Utilities USA/Metric Units screen (page 30).

FIGURE 5.44



If the flow needs to be changed, adjust the control valve on the wellhead. Within a few seconds the new flow is displayed on the GEM-500™ as the adjusted value. When satisfied with the flow adjustment, press the **6** KEY to **Store** the information and continue to the Select Comments screen.

24. On the Select Comments screen, use the **1** KEY to **Scroll Up** or the **6** KEY to **Scroll Down** through a comment list (Figure 5.45). When the correct comment appears in the comment display area, press the **2** KEY, to **Select**, then the **0** KEY to store the readings.

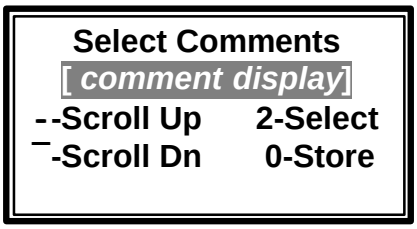


FIGURE 5.45

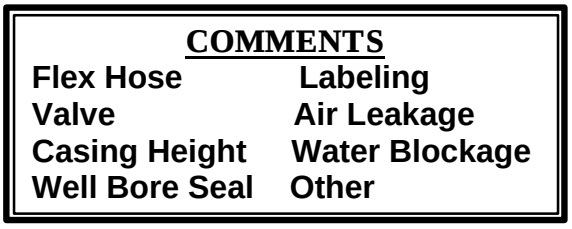


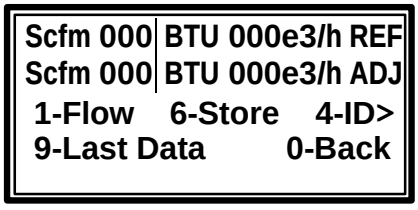
FIGURE 5.46

25. If the readings are successfully stored, the Readings Stored screen displays for three seconds (Figure 5.47). The Flow screen (Figure 5.44) redisplays.

FIGURE 5.47

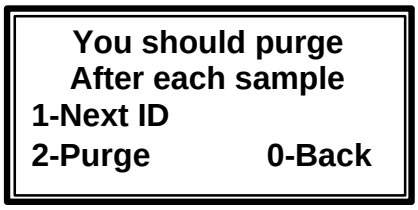
26. Press the **4** KEY, **ID** to advance to the next wellhead ID in memory. If the wellhead ID's were loaded into the GEM-500™ in order, the unit will purge and the next ID will display after purge is completed.

FIGURE 5.48



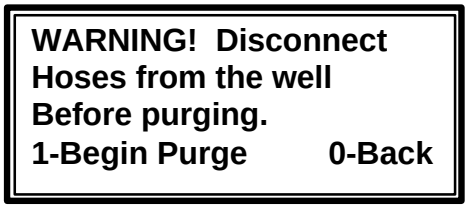
27. The Purge Prompt Screen (Figure 5.20) reminds the user that the GEM-500™ needs to have any residual gases purged from its system to guarantee the accuracy of the next reading. Press the **5** KEY, **Purge,** to initialize the purge process.

FIGURE 5.49



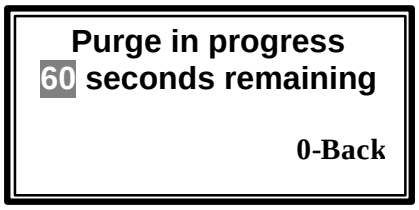
28. The Warning screen displays to remind the user to disconnect the hoses from the wellhead before starting the purge process. Once the hoses are removed, press the 1 KEY to begin the purge (Figure 5.50).

FIGURE 5.50



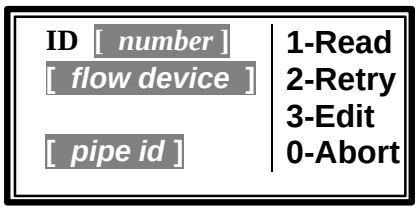
29. The pump starts and the Purge in Progress screen displays the number of seconds remaining in the purge (Figure 5.51). This purge process can be taking place while walking to the next wellhead.

FIGURE 5.51



30. The pump will run for 60 seconds and then shut off allowing the next well ID to be displayed. (Figure 5.52)

FIGURE 5.52

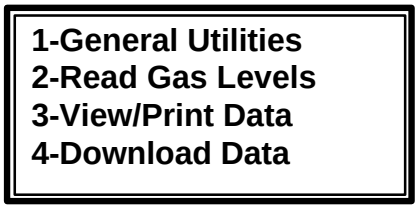


Chapter 6 - View Data

View Data

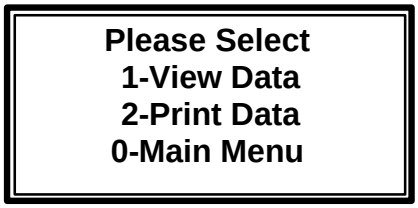
1. From the Main Menu, select the **3** KEY, **View Data** (Figure 6.1)

FIGURE 6.1



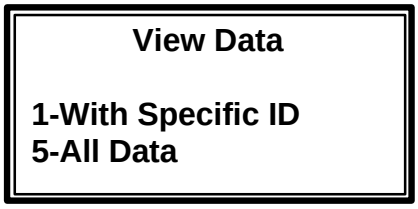
From the View/Print Select screen, the user can choose to view data, print data or return to the main menu. Press the **1** KEY, **View Data** to view data in memory in the GEM-500™.

FIGURE 6.2



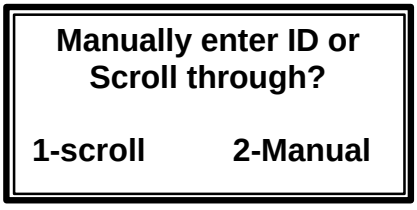
To view data from just one wellhead, press the **1** KEY, **With Specific ID**. This option allows manual entry of a single wellhead ID. If data from all wellheads needs to be viewed, press the **5** KEY, **All Data** and proceed to step 4.

FIGURE 6.3



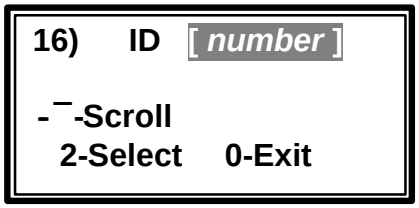
The Manually Enter ID screen allows the user to either scroll through a list of ID's that are already in memory or enter an ID manually. If there are few ID's stored, it might be faster to use the scroll option; whereas the manual entry option might be faster to use if there are many ID's stored (Refer to page 44 number 7). (Figure 6.4)

FIGURE 6.4



2. To scroll through the existing list of well ID's, press the **1** KEY, **Scroll**. The Select ID screen displays a single ID at a time. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list. When the ID of choice is displayed, press the **2** KEY, **Select.** (Figure 6.5)

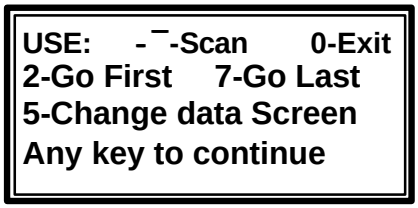
FIGURE 6.5



3. The following options are used to move around within the Data screens: (Figure 6.6)

- ↑↓-Scan – Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list.
- 2-Go First – Use the 2 KEY to go to the first well ID in the list.
- 5-Change Data Screen – Use the 5 KEY to toggle between the Gas Concentrations screen (Figure 6.7) and the Flow screen (Figure 6.8).
- 7-Go Last – Use the 7 KEY to go to the last well ID in the list.
- 0-Exit – Use the 0 KEY to exit at any time.

FIGURE 6.6



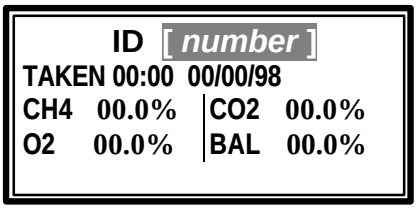


FIGURE 6.7

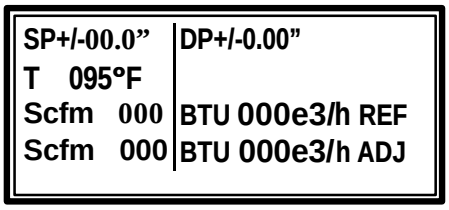


FIGURE 6.8

Chapter 7 – Communications

DataField 3.0CS Software

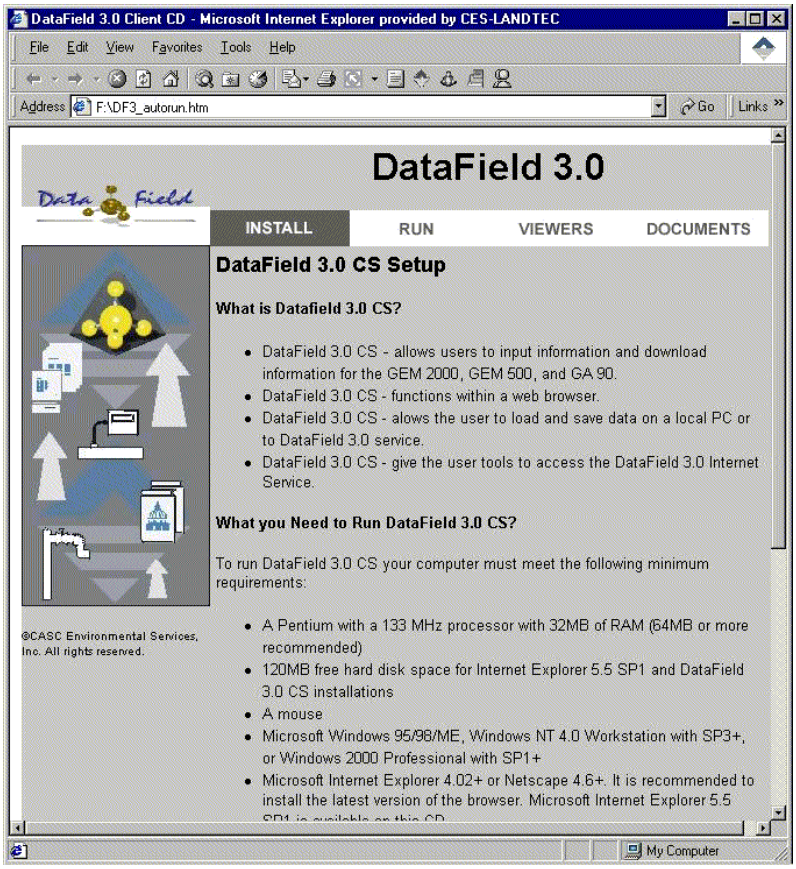
DataField 3.0CS is an integrated software program designed to communicate with the GEM™2000, 500 and GA90 instruments. The software will create files used for storing gas read data, ID data, comments and instrument configuration data. The files created are significantly different from the files created with GEM_COMM or GA_COMM software and are not compatible with these versions of software.

DataField 3.0CS is browser based (Java enabled) and will operate on Windows95b and higher Windows operating systems. Minimum hardware requirements are:

- Pentium 133 level microprocessor or equal.
- 32MB RAM.
- 120MB hard disk space.
- CDROM drive.
- Mouse or pointer system.
- Standard keyboard.
- Installed printer.

Installing DataField 3.0CS

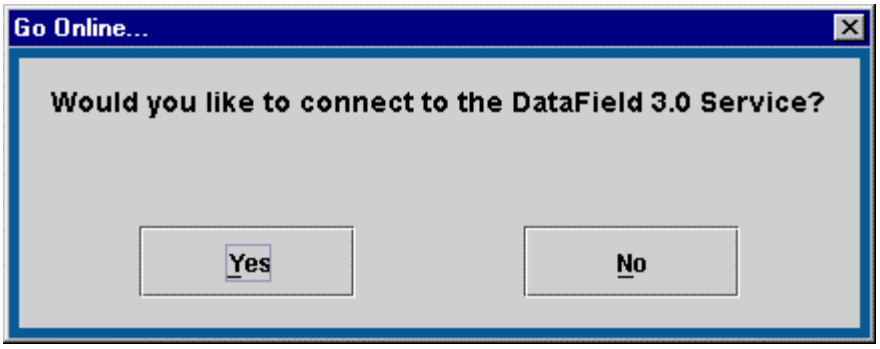
Be sure your computer is turned on and all software programs have been properly closed. Place the program disk in the CD ROM drive and close the tray. DataField 3.0CS will self start and display the DataField C.S. setup screen.



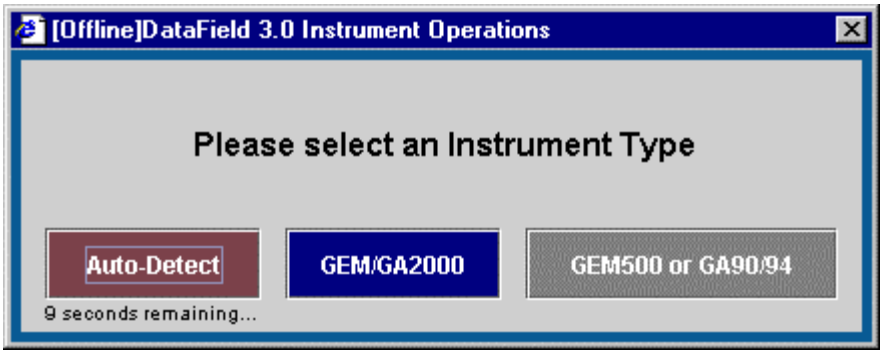
Install – Scroll to the bottom of the setup screen and follow steps 1 thru 3.
Note: Make sure to remove CD and reboot the computer after step 1, after reboot install CD and proceed to step 2.
Run – Allows the user to run the application from the CD Rom Drive.
Note: This option could make the application run slower due to the speed of the CD Rom.
Viewers – Allows the viewing of electronic information as supplied by CES-LANDTEC (after installing the
appropriate viewer.)
Documents – Electronic Manuals and Data sheets.

Establishing Communications

Click on the Start menu then Programs menu. Scroll to DataField and then DataField 3.0CS to start the software. The following screen will appear on the computer.

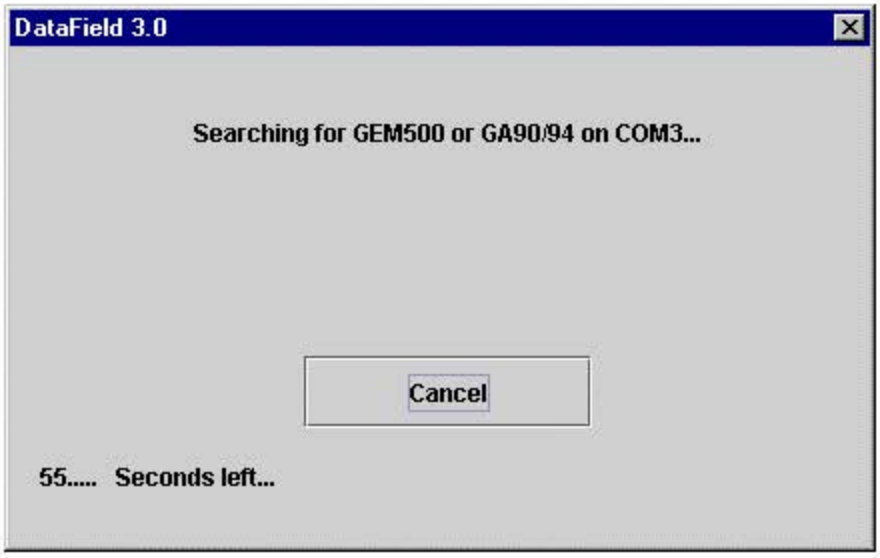


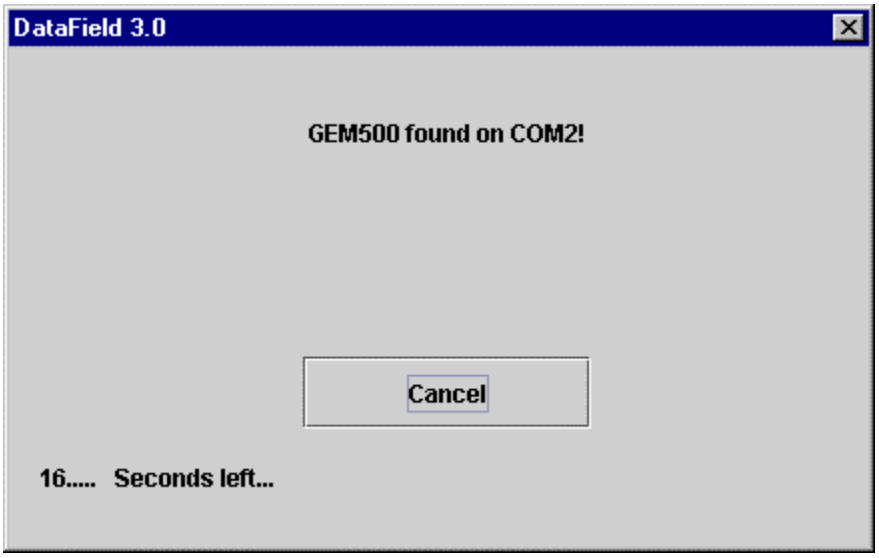
Click “NO” to connecting to the DataField 3.0 service.



Now select “GEM500 or GA90/94”

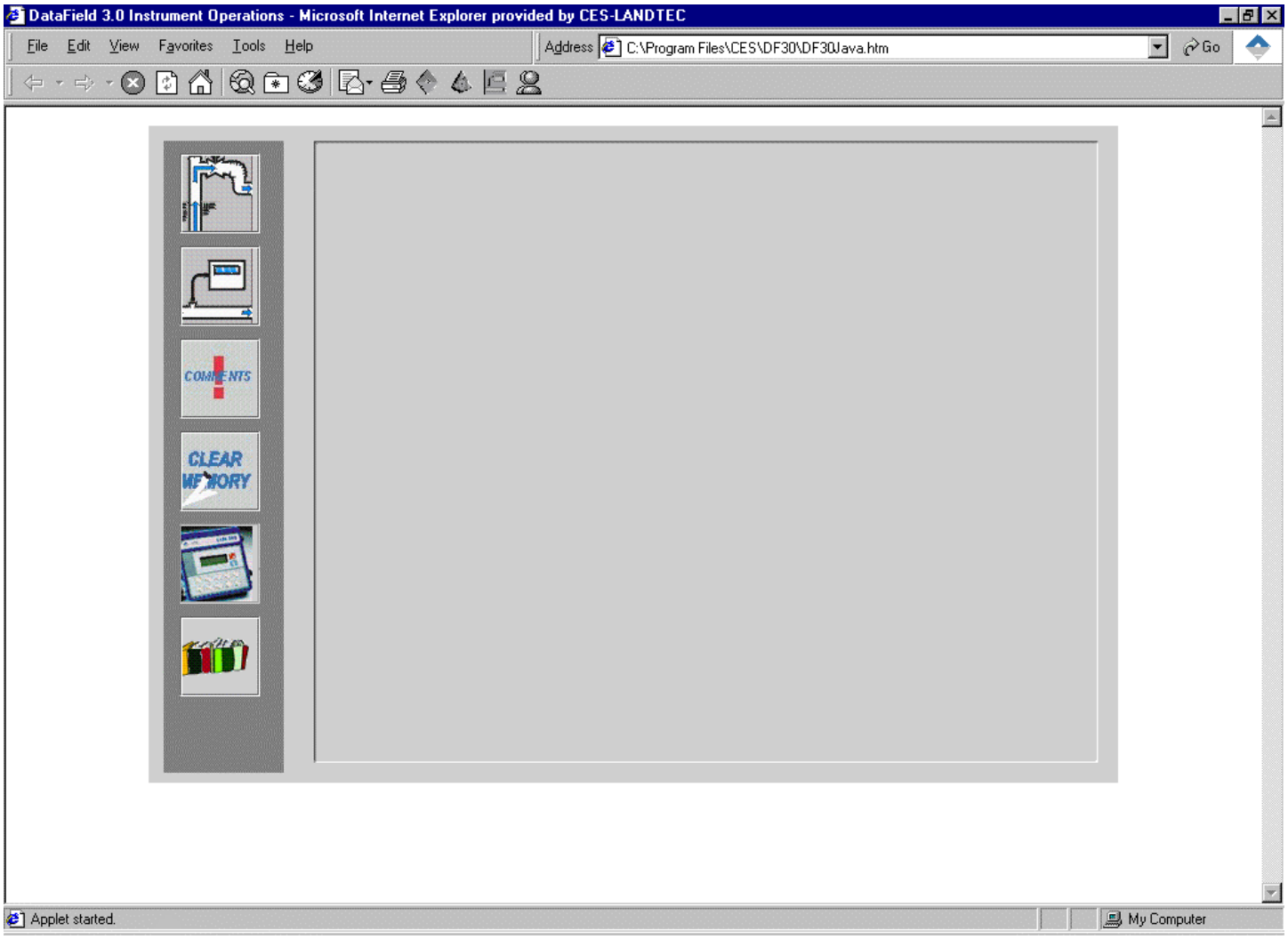
Before clicking OK connect cable to computer, plug cable into instrument, and turn on GEM500/GA90. Wait for self test. Then press “0” followed by “4” to go into download mode. Now the instrument is ready to establish communications, Press “OK”.





Main Screen

Once DataField 3.0CS establishes communications with the instrument, the main software screen will appear.



Six main categories (buttons) are listed down the left side of the screen: ID Functions, Download Comments, Clear Memory, Instrument Settings and Resource Links. Clicking on any one of the buttons will take the user to that functionality of the application.

File

Clicking on the **File** heading will allow you to select **Exit** from program. This will close all files and exit the program.

Communications

It is not possible to change instruments and establish communications without re-starting the software.

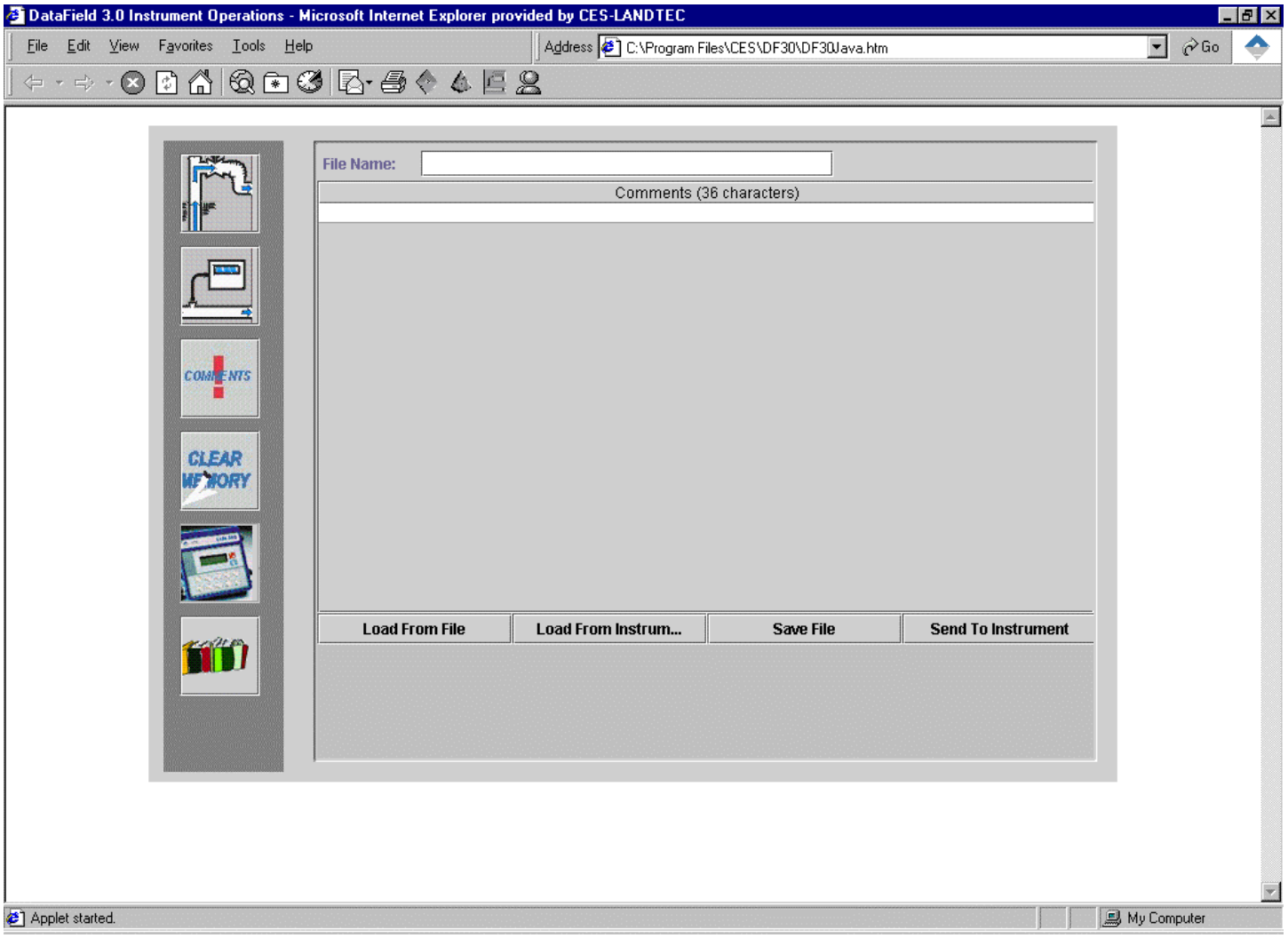
Functions

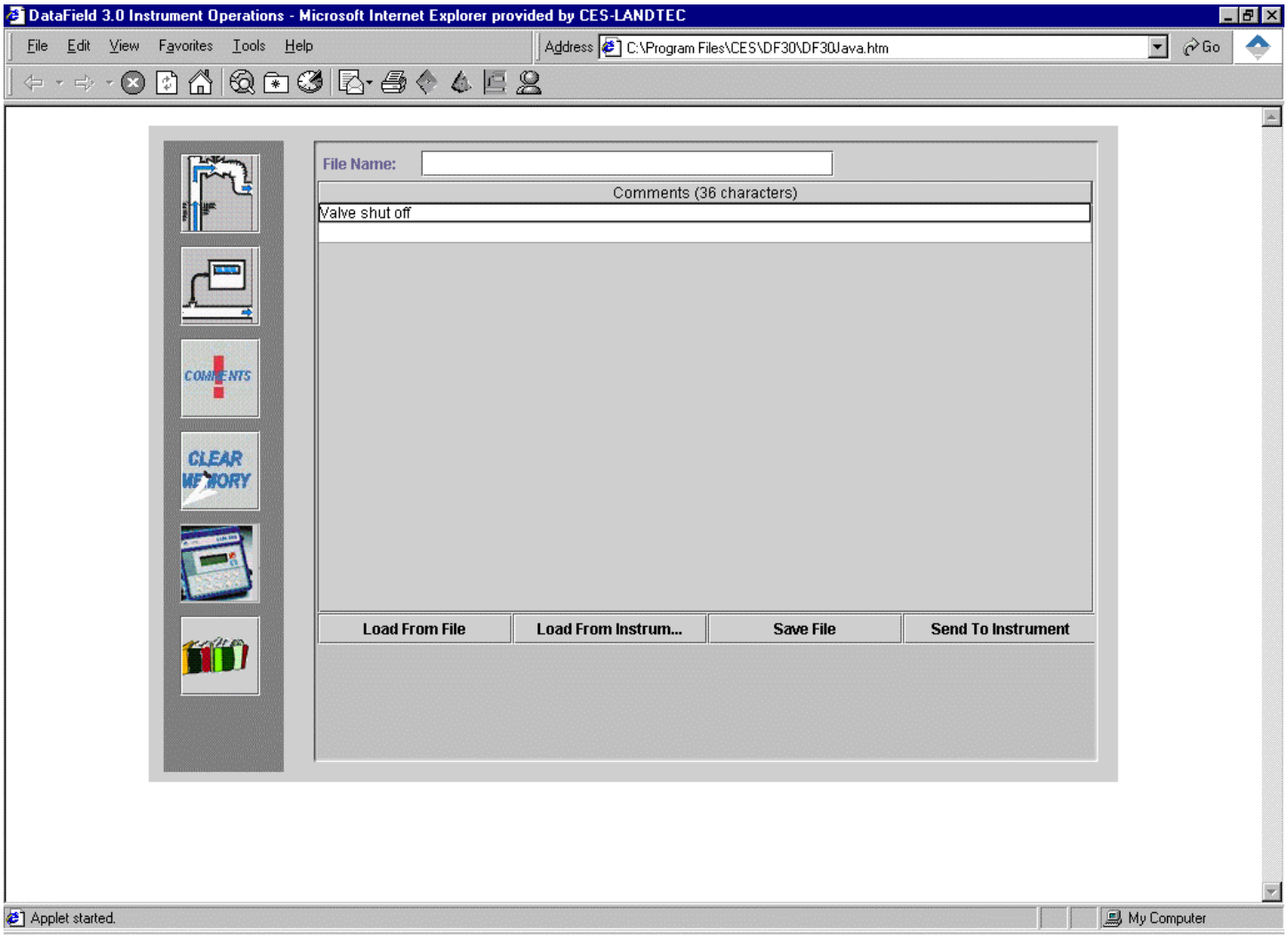
Each button has a specific function as listed below:

1. **Comments** – Allows entry of comments that may be selected for the ID's. A total of seven comments and one exclusive comment may be selected for each ID.
2. **ID's** – Used for adding new ID's, editing ID's or deleting ID's and entry of ID parameters such as pump run time, flow device, comments and questions for the ID.
3. **Readings** – Allows downloading and viewing data from instrument and uploading of previous data to the instrument.
4. **Clear Memory** – Allows the deletion if selective ID's, readings, comments, site questions or all memory loaded in instrument memory.
5. **Resource Links** – Allows the user to directly access information via the www.

Comments

DataField 3.0CS allows up to 64 comments to be created for upload to the GEM™500. Each comment may be 36 characters in length and may be alphanumeric or any character on the computer keyboard. From the opening screen, click on the **Comments** button to open the following screen.

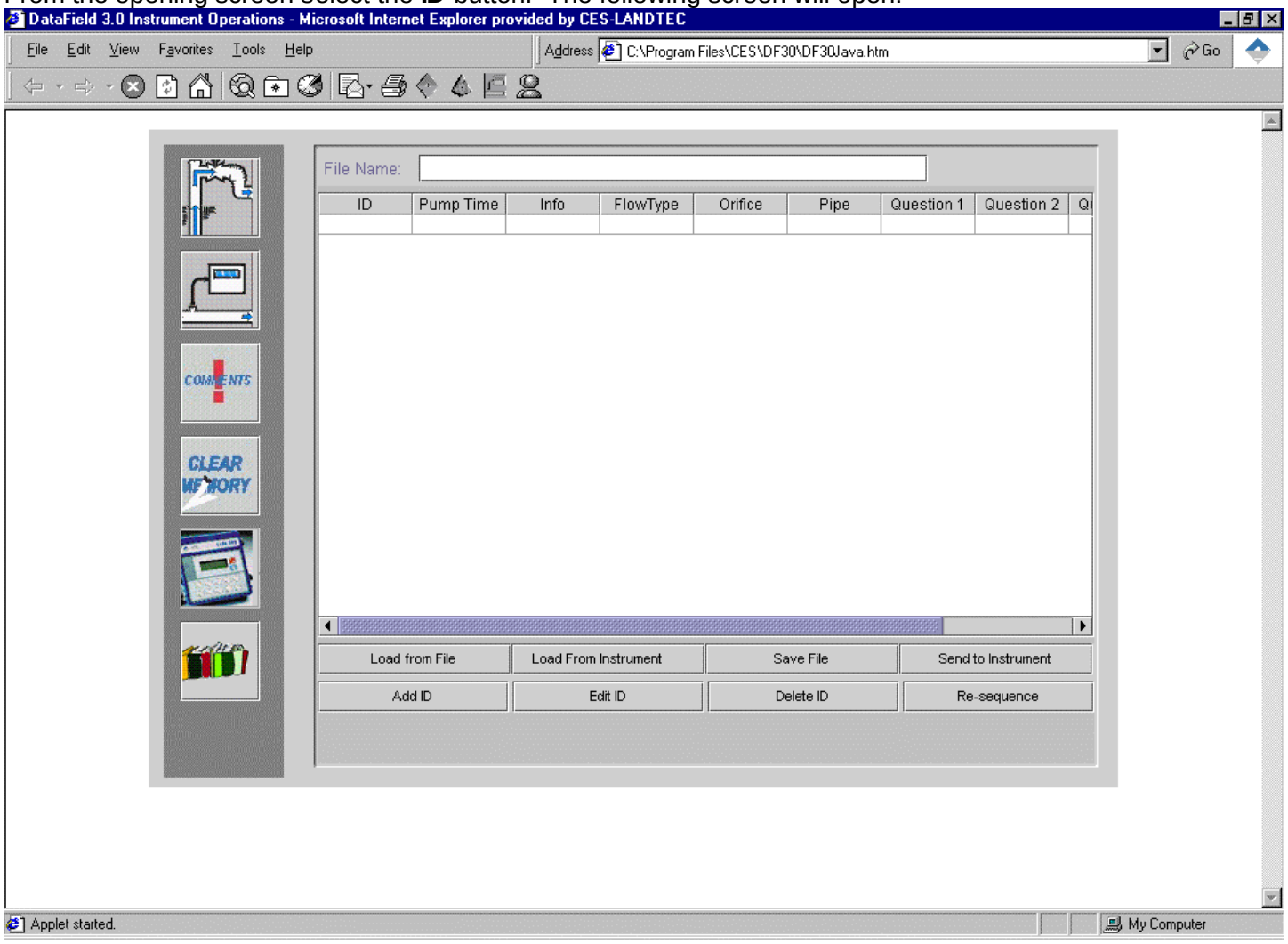




Enter the comment on the comment line and press **Enter** to continue entering comments until all the desired comments have been entered. Click on **Save File** to save the data to disk and then click on **Send to Instrument** to save the comments in the instrument. To delete a comment, click on the comment to highlight the comment and press the **Delete** key on the computer keyboard to remove the highlighted comment. It is always suggested to save the comment file because of the potential size and time required to recreate the comments. Once created, the comment file may be modified and saved under a different file name at any time.

Entering ID's

From the opening screen select the **ID** button. The following screen will open:



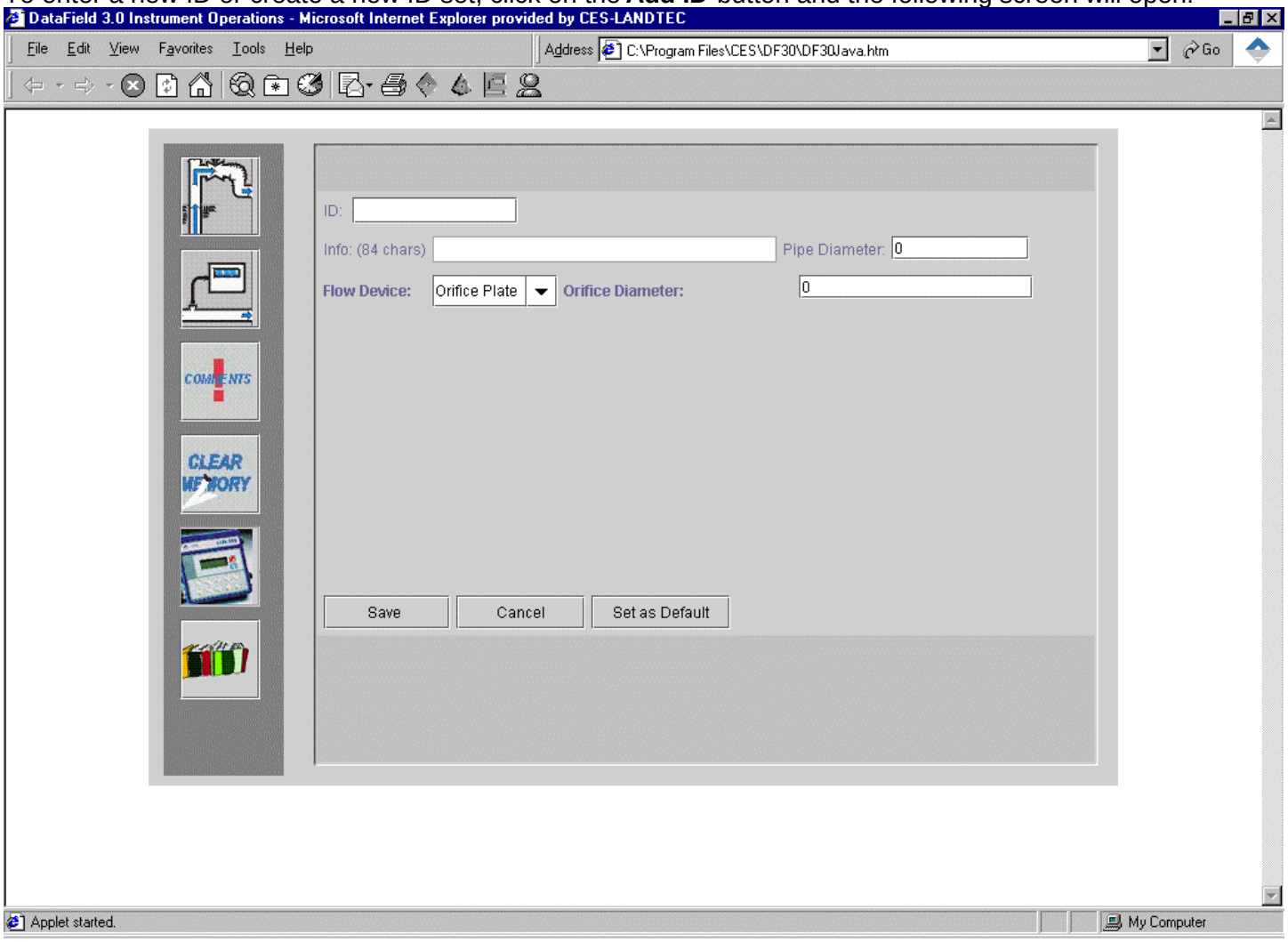
Selecting the **Save File** button will allow you to enter the name for the file you wish to save.

Selecting the **Load from File** button will allow a previously created file to be loaded from the computer disk drive.

Selecting the **Load from Instrument** button will allow previously loaded ID's in the instrument to be downloaded for modification such as increasing the pump run time or adding additional comments to a specific ID.

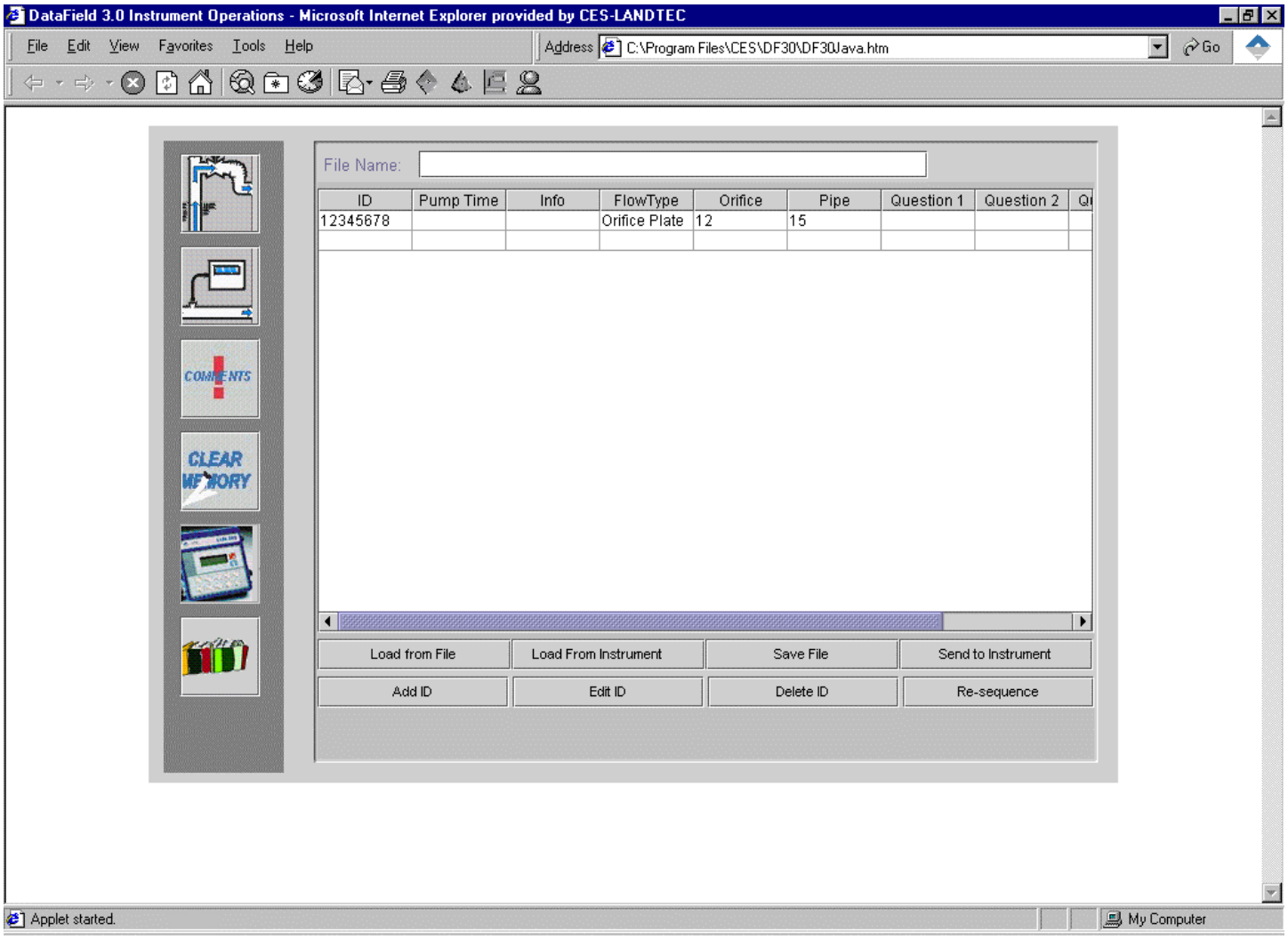
Add ID button is used for the creation of a new ID or multiple ID's that may be sent to the instrument or saved to a new file for later use.

To enter a new ID or create a new ID set, click on the **Add ID** button and the following screen will open:



Enter the Well ID in any combination of alpha or numeric characters for a maximum of eight characters. **All eight characters must be used**. Enter the type of flow device used with the well (Accu-Flo wellhead, Pitot tube, or orifice plate); user input may also be selected (GEM500 only). If Pitot tube or orifice plate is selected, the **inside** pipe diameter and **orifice diameter** must be entered. If the flow device is going to be the same for multiple wells, click on **Set as Default** to lock the values.

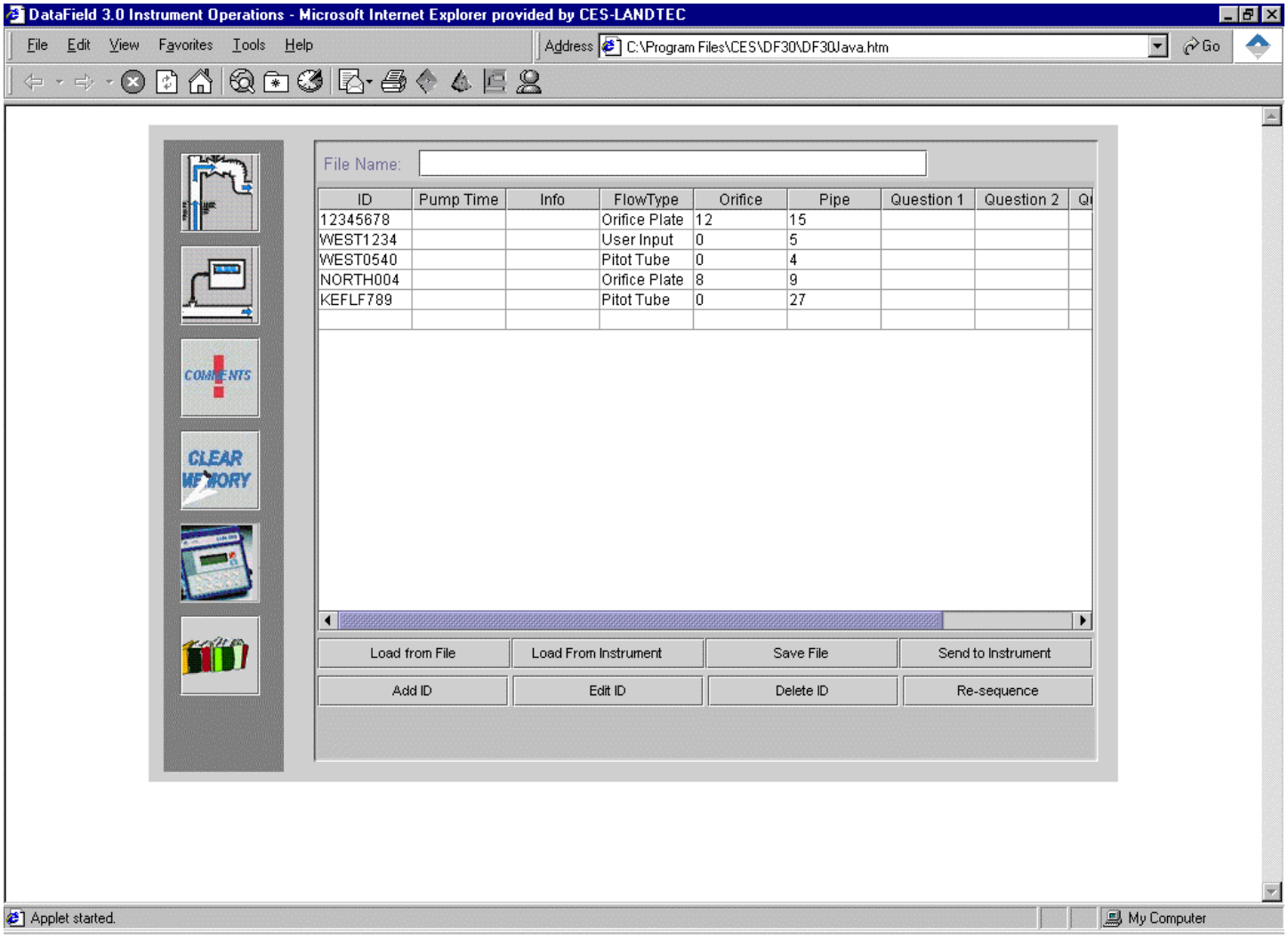
Click on **Add** to add this to the editor screen seen below. If additional ID's need to be entered, simply click on **Add ID** and enter the data as before.



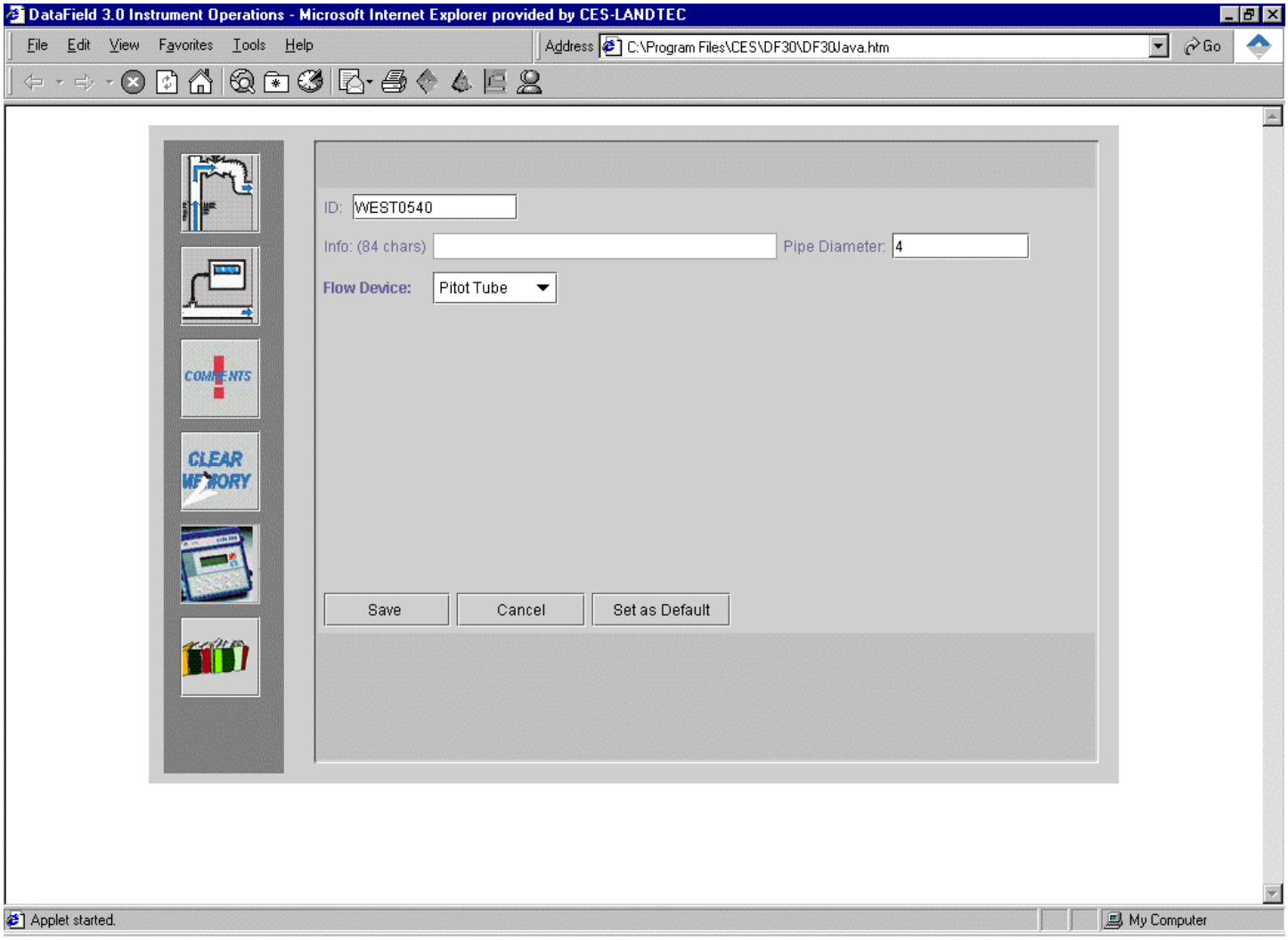
Once all the ID's have been entered, click **Save to File** button to save the ID data to a file or **Send to Instrument** button if data is to be uploaded to an instrument for field sampling.

Editing ID's

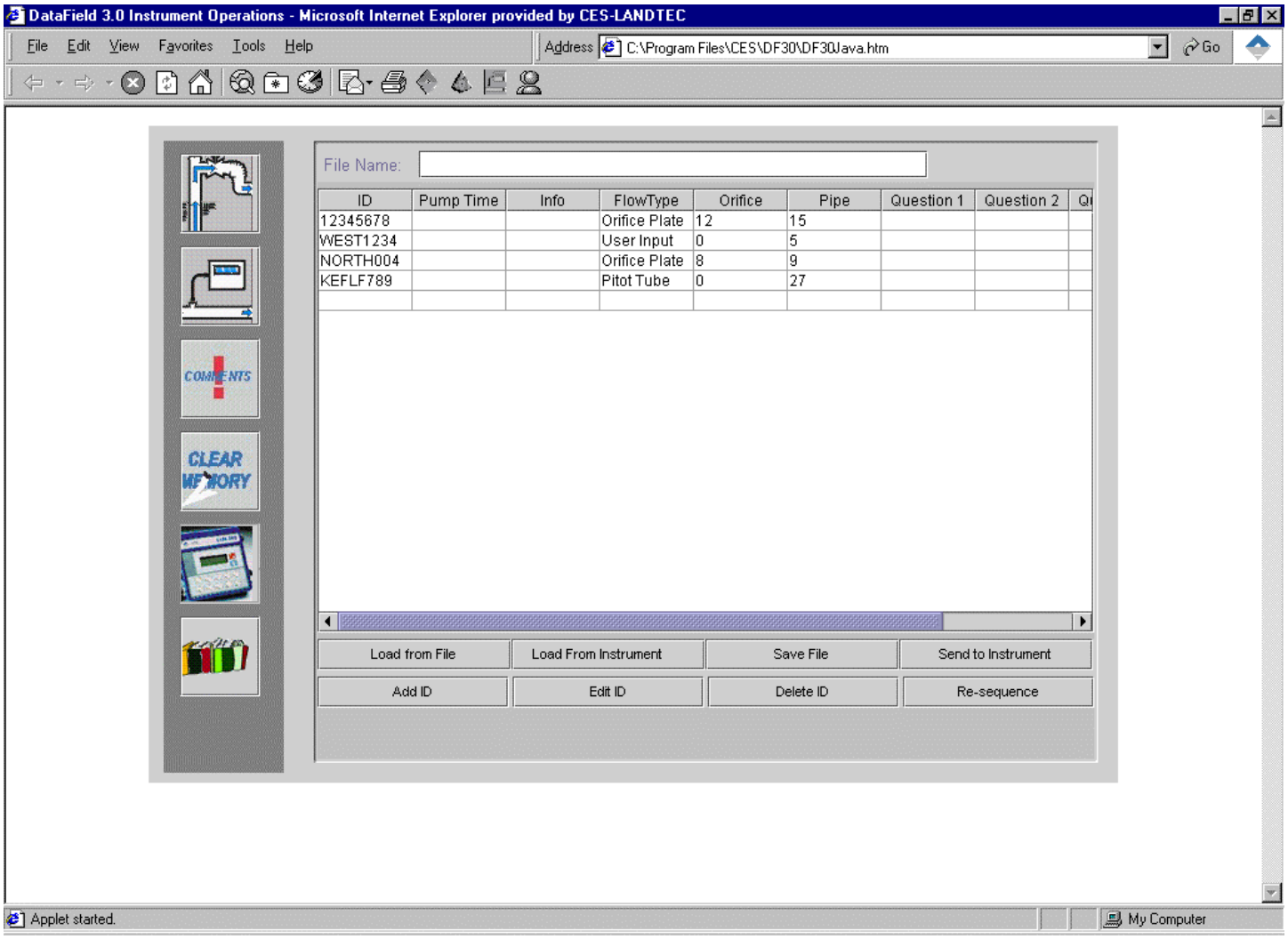
ID's may be edited in a similar manner to entering a new ID. Click on the **ID** button. Click on **Load from File** button if the ID's to be edited are in a saved file on disk or click on **Load from Instrument** if the ID's to be edited reside in the instrument. Once the ID's have been opened, the **ID Editor** screen will appear as below.



To select an ID for editing, click on the ID to highlight the ID, and then click on **Edit ID** at the bottom of the screen. The Edit ID screen will open and allow information for the selected ID to be changed. When finished with the changes, click on **Save** to save the edited ID to the ID list.



When editing is completed, click on **Save File** to save the edited data to disk or **Send to Instrument** to update data in the instrument.

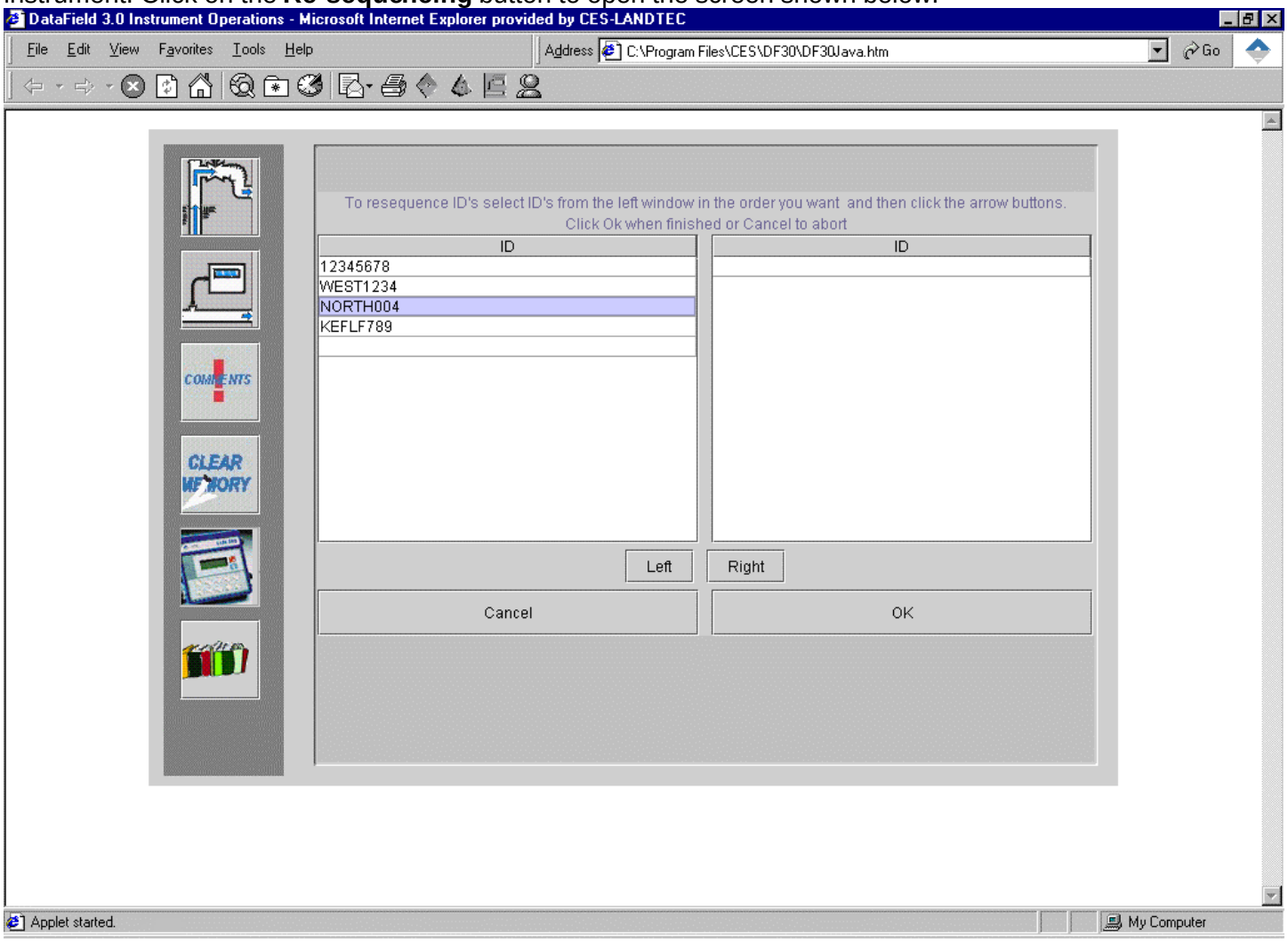


Delete ID's

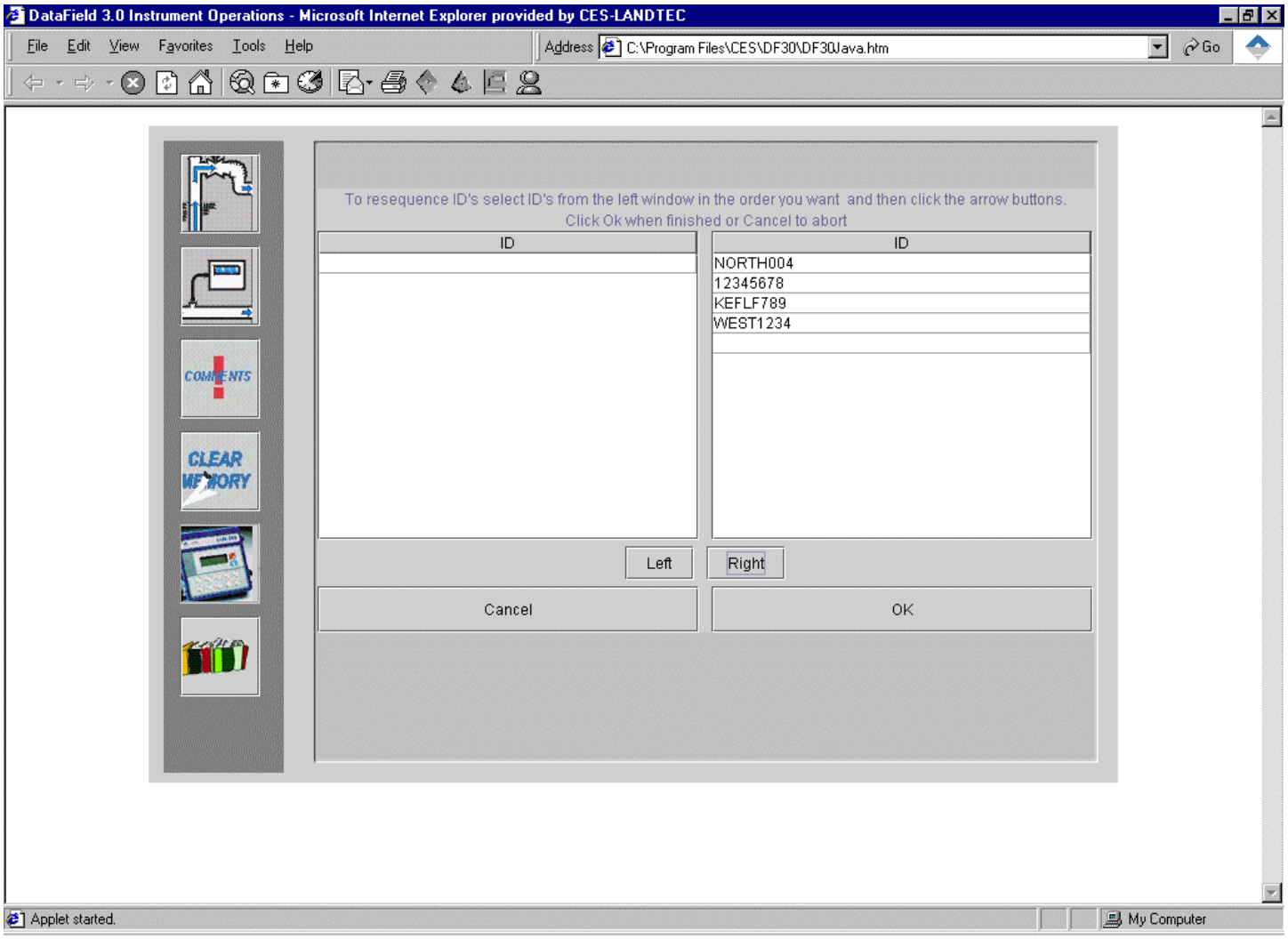
To delete an ID select either **Load from File** (if the ID to be deleted is in a file saved on disk) or **Load from Instrument** (if the ID to be deleted is in the instrument). The **ID Editor** screen will open with the ID information listed. Select the ID to delete and click on the ID to highlight the ID. Click on **Delete ID** at the bottom of the screen. A prompt will appear to verify the action. Clicking **Yes** will delete the ID. Click on **Save File** to save the updated file to disk or click on **Send to Instrument** to update the instrument for field sampling.

Re-sequencing

With DataField 3.0CS it is possible to change the order of the ID's in a file to be in the same order as they are sampled in the field, this is called **Re-sequencing**. To re-sequence an ID data set, click on the **ID** button to open the ID editor. Load the ID data set from a file or download the data set from the instrument. Click on the **Re-sequencing** button to open the screen shown below.



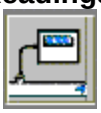
Select the ID from the left side window and click on the **Right** button to move ID to the right window to create the new sequence order. Repeat this process moving all ID's to the right side of the desired order.

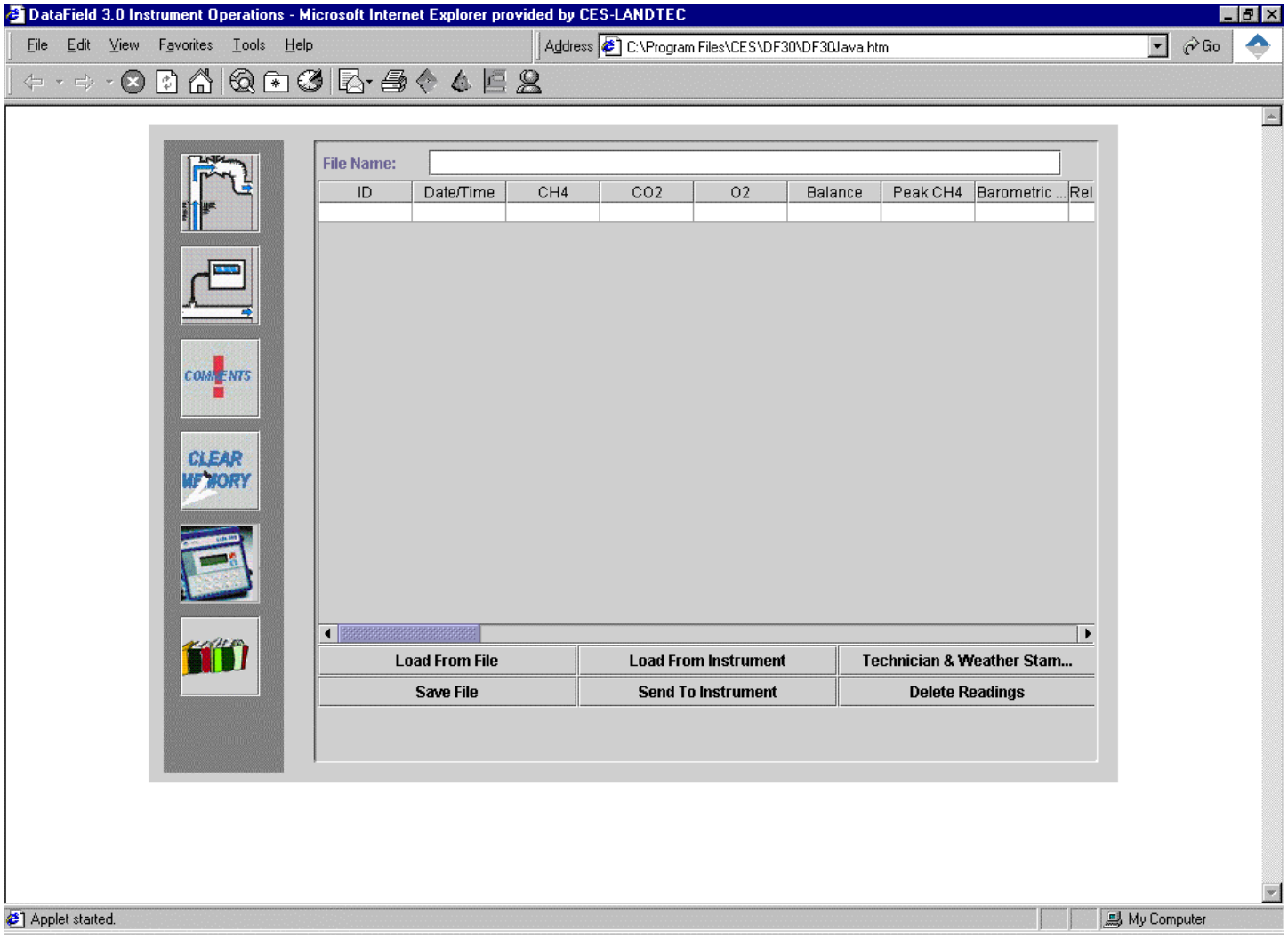


Click OK when the desired new sequence is obtained. Click on the **Save File** button to save the new data set to a file on disk or click on **Send to Instrument** to upload the new data to the instrument. Either action will overwrite the previous data.

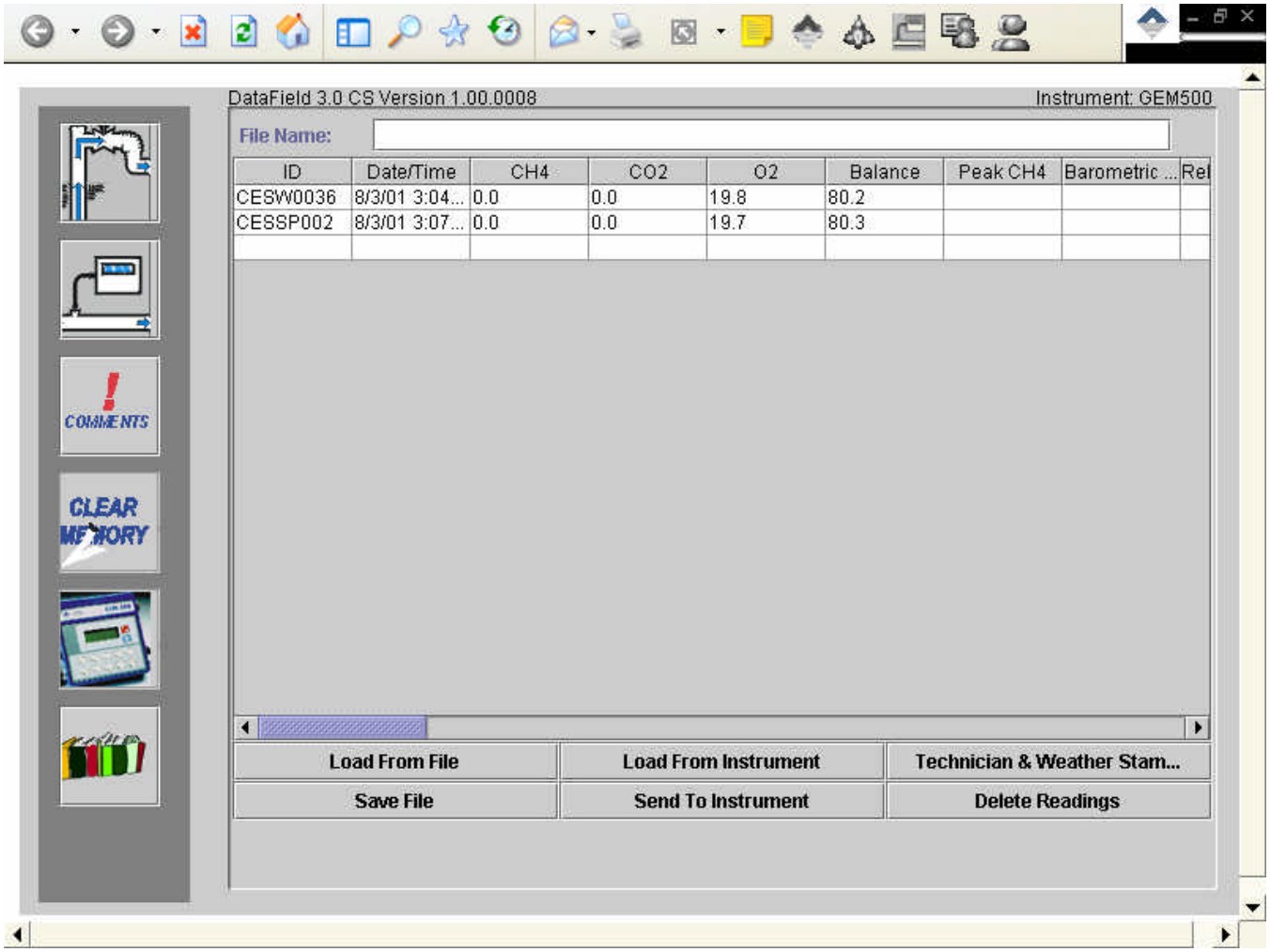
Readings

The Readings screen provides the capability to download, upload, view, save data to a file and delete individual or multiple readings from a data set. Click on **Readings** to open the screen shown below.





Click on **Load from File** to open a file folder of saved data on the disk drive or click on **Load from Instrument** to download data from the instrument. Either action will open the following screen.



Once the file has been opened or data downloaded from the instrument, either **Save File** or **Send to Instrument** may be selected. If an attempt is made to save the data to an existing file, a warning message will display indicating the file will be overwritten and data lost. Data sent to the instrument will be displayed as the previous sampled readings for the selected ID.

To delete data from the data set, click on the button to the left of the desired ID to highlight that ID and click on **Delete Readings**. If multiple consecutive readings need to be deleted, click and highlight the first reading, hold down the **Shift** key on the computer keyboard and click on the last reading to highlight all consecutive readings. (See figure 7.6A) Click on **Delete Readings** to delete the selected readings. If multiple separated readings need to be deleted, highlight the first reading; hold down the **Ctrl** key on the computer keyboard and click on subsequent readings to be deleted. (See figure 7.6B) When all the readings have been selected, click on **Delete Readings**.

Fig. 7-6A

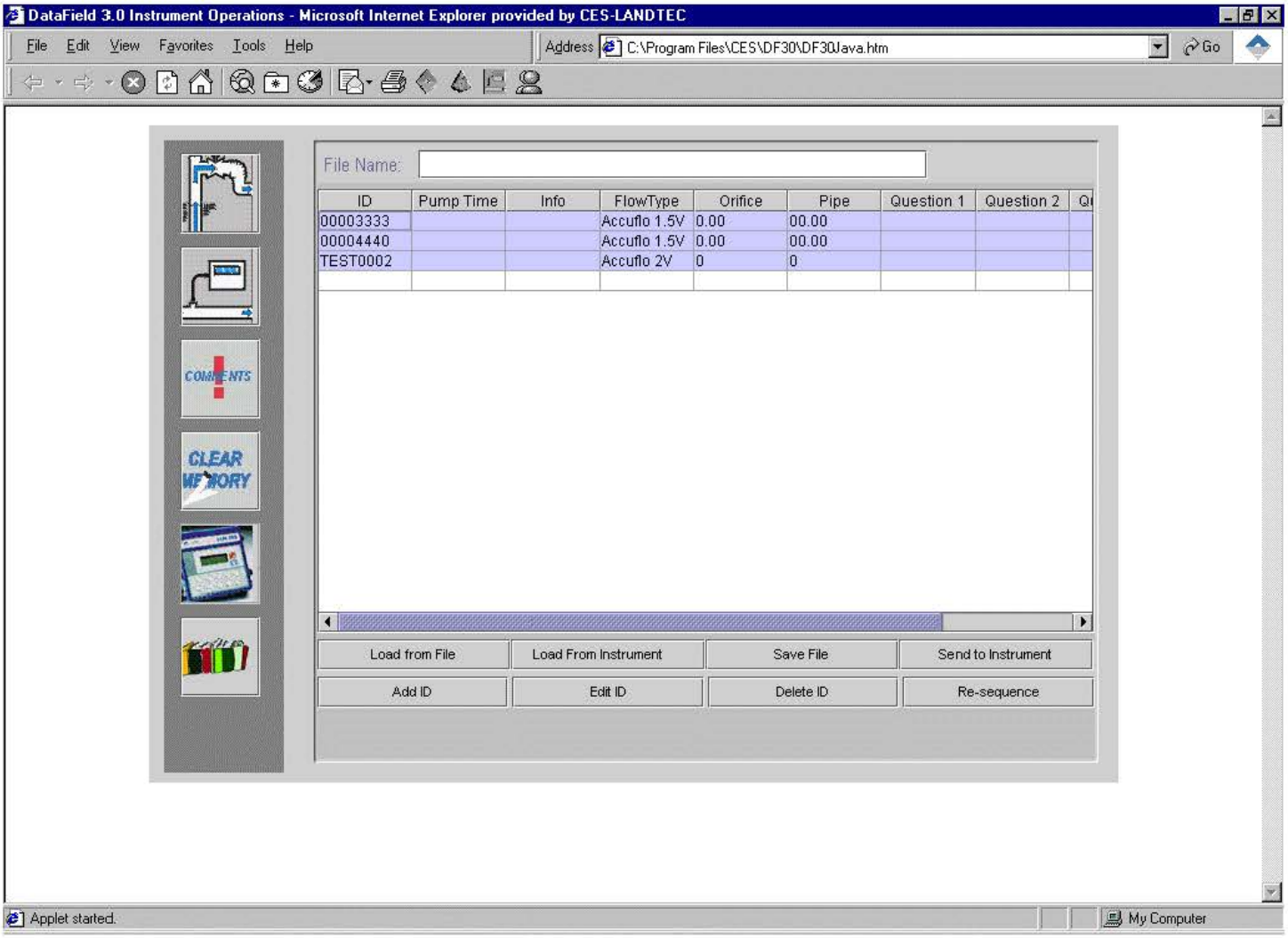
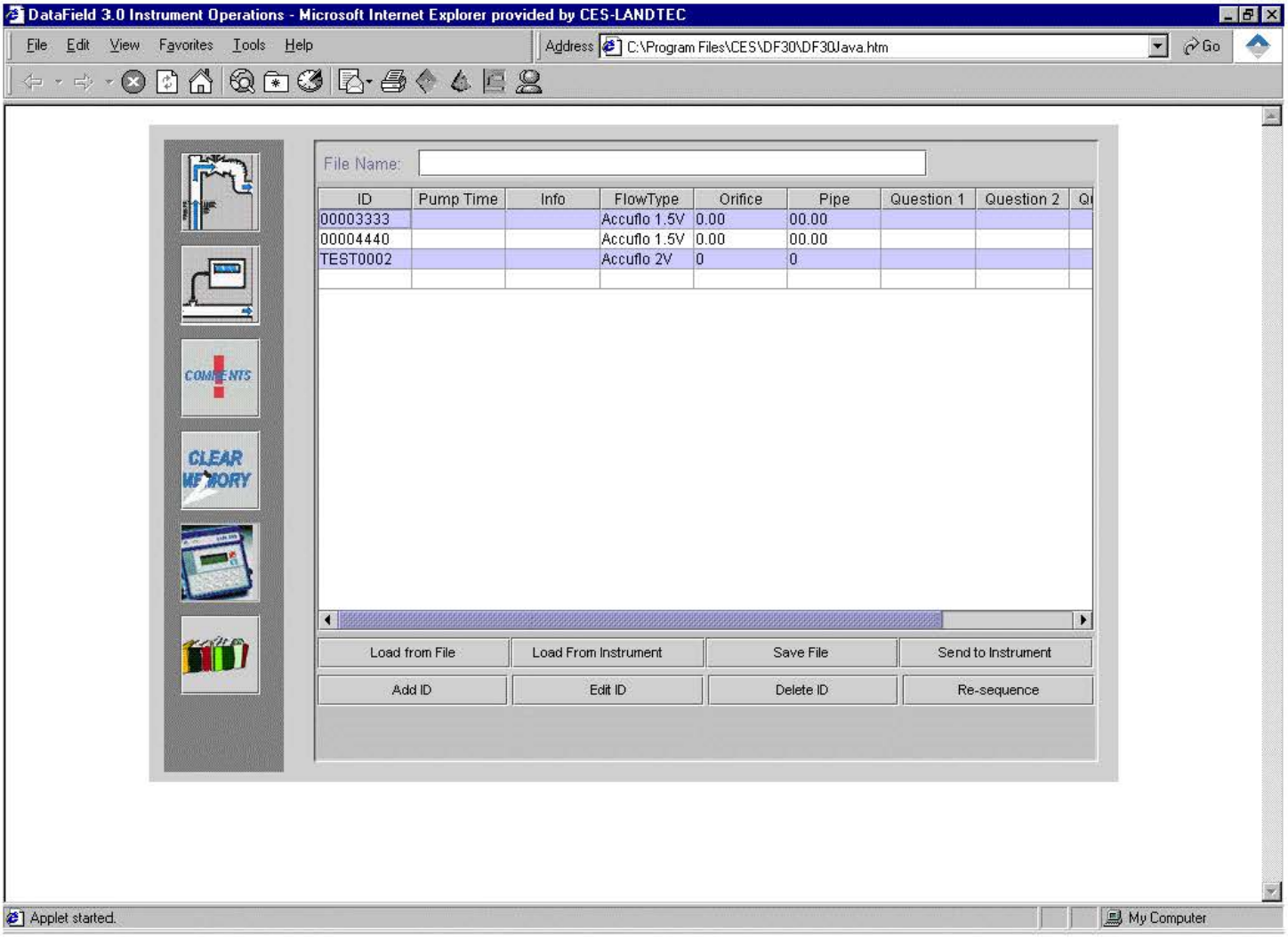
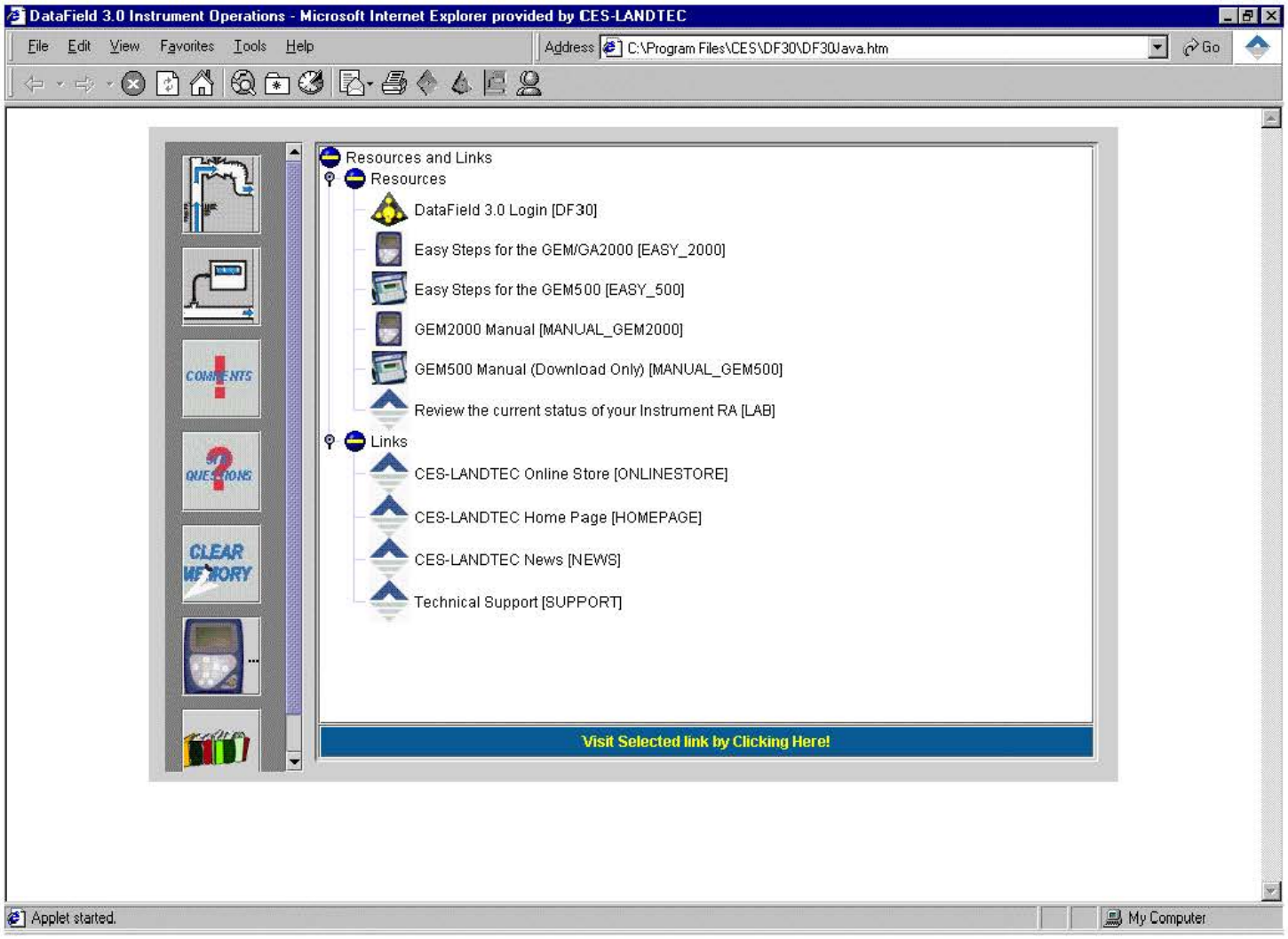


Fig. 7-6B



Resource Links

By clicking on the supplied link the user is taken directly to the www and the information listed.



Chapter 8 - Maintenance

Servicing

The GEM-500™ has been electronically and functionally tested before leaving the factory. It is recommended that with normal usage, the unit should be serviced every **six months** for routine factory service and maintenance which includes:

- Replace all Filters and O-rings.
- Perform Bench Test with 10 Test Gases.
- Minor Adjustments.
- Check Overall Performance.
- If needed, run through Environmental Chamber.
- Check Charging Circuit and Battery Pack.
- Check Inlet Port Fittings.
- Calibrate Transducers.
- Check the Pump.
- Check the Flow Fail.
- Perform Leak Test.

Cleaning

Protect the GEM-500™ by keeping it in its protective soft case. The keypad (polycarbonate membrane) should be wiped clean with soapy water and a damp cloth. Other cleaning agents may damage the membrane.

Sunlight and Heat

The GEM-500™ should not be left out in direct sunlight for long periods of time as this raises the temperature inside the case and may cause damage to the components. The unit may not operate or may operate erratically if it gets too hot or cold. The operating temperature range may be extended by use of heat packs in extremely cold conditions or cold packs in extreme heat conditions, these packs may be placed in the rear pouch of the soft case.

Dust Cap

Always keep the protective dust cap in place when the data port is not in use.

Filters

The GEM-500™ is equipped with two filters:

Water Trap Filter — This filter is external to the GEM-500™ and is located in-line in the sample hose. Unscrewing the two halves of the filter holder gives easy access to the filter. This filter should be routinely changed every one hundred hours of use or when water is sucked through the filter. The filter should also be replaced when the sample pump has difficulty drawing a sample of gas through it and into the unit. When this happens, the GEM-500™ sounds a continuous audible warning and a **Flow Fail** message appears on the screen.

Particulate Filter — This filter is inside the GEM-500™ and is located just inside the Static Pressure/Sampling port. (Figure 1.1, Figure 5.1) This filter is accessed by unscrewing the port (counter-clockwise) using the wrench provided.

Both filter holders are sealed with o-rings. Periodically inspect the o-rings to check their condition. Replace the o-rings if they become nicked, cut, swollen, or otherwise damaged. The GEM-500™ unit is shipped with a spare filter of each type. Only genuine CES-LANDTEC filters should be used and can be purchased through the CES-LANDTEC Sales Department by dialing 1-800-LANDTEC or on our web page at CES-LANDTEC.COM.

Travel and Storage

Travel – The GEM-500™ is a delicate scientific instrument and should be stored in its optional protective hard case when carrying it from site to site. This case affords maximum protection for the unit and offers enough storage space to take along all of the required accessories for the GEM-500™.

Storage – If the unit is to be stored for a long period, the internal batteries should be charged prior to storage. Recharge the unit every two weeks during storage.

When loading the GEM-500™ into its protective hard case, place the unit with the keyboard facing out and the CES-LANDTEC logo (upside down) closest to the handle on the front of the case. This will assure that the unit is stored right-side up when the case is closed and standing with its handle up in the carry position.

Battery Charging

The internal battery pack of the GEM-500™ is designed to be recharged many times, but as with all nickel-cadmium cells, certain rules should be observed or the batteries might not provide their full power or operating time. Please follow these instructions carefully.

WARNING! ONLY CHARGE A GEM-500™ WITH A LANDTEC BATTERY CHARGER (PROVIDED WITH THE UNIT).

1. Let the batteries almost fully discharge before recharging.

2. Do not top off an almost full battery charge because memory patterns can be established and the battery may not provide its full capacity.

   Note: If the GEM-500™ is repeatedly given small "top-off" charges, the battery capacity can be reduced. To restore the battery to full capacity, totally discharge the unit and then charge it for a full 14 hour period.

   When charging the batteries, let them charge at least 12 to14 hours. If using the optional CES-LANDTEC Smart Charger, batteries can be completely recharged in approximately 3 hours.

3. Never let the batteries charge for more than three or four days.

4. Disconnect the charger from the GEM-500™ after the batteries have charged.

Note: Heat from the battery compartment makes the front of the GEM-500™ (under the GEM-500™ label) warm to the touch while the batteries are charging.

Battery Shut-Off

A circuit within the GEM-500™ continuously monitors the battery voltage. If the battery voltage falls below a predetermined level, the unit automatically shuts itself off in order to prevent memory loss. If the unit shuts itself off, it requires a full charge of 14 hours (approximately 3 hours with the CES-LANDTEC Smart Charger) to restore the battery to its maximum level.

Battery Low Symbol

This Battery Symbol displays in the top right corner of the display screen. It displays as the battery capacity reaches about 10% of full charge. There are only about 30-45 minutes of full pump power left in the GEM-500™ when the symbol is displayed.

Automatic Power-Off

The GEM-500™ has an automatic power-off timer to conserve battery power. If no key is pressed for 15 minutes, the unit automatically switches itself off (no stored readings are lost).

Emergency Battery Power

In emergencies, the GEM-500™ may be operated with 6 “C” sized alkaline batteries. To use alkaline cells, remove the nickel-cadmium battery pack by using a Phillips screwdriver on the back battery compartment of the GEM-500™. Insert the alkaline battery “C” cells in the correct direction.

WARNING! DO NOT USE THE BATTERY CHARGER FOR STANDARD ALKALINE BATTERIES AS THEY MAY EXPLODE.

WARNING! BE SURE TO REPLACE BATTERIES IN CORRECT DIRECTION OR UNIT WILL BE DAMAGED.

Chapter 9 - Troubleshooting

Problem	Corrective Action/Reason
Unit does not turn on or operation is erratic	Battery charge is too low-recharge batteries. Unit is too hot - cool down unit and try again. Contact the factory.
"Flow Fail" is displayed and an audible alarm is heard	The inlet is blocked - remove blockage and retry. The particulate filter or water trap filter needs replacing – see chapter 8 Maintenance.
Readings taken are not what was expected	Unit may be cut out of calibration – calibrate unit with known gas concentration. Water trap filter or particulate filter are clogged – replace filter.
Unit displays***** or >>>>>	These symbols are substituted when the measured reading is out of range of the instruments capabilities in some fields or when a value needs to be entered manually such as temperature.
Oxygen reading is high on all wells	Check that the water trap housing is screwed on tight. Check or replace o-rings on the water trap and instrument inlet. Check the wellhead inset for cracks, replace o-ring on insert. Field calibrate oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software (see chapter 7). Contact the factory.
Methane and Carbon Dioxide readings drift	Perform a field calibration and check well again. Verify cal gas is flowing when regulator is turned on. Verify all connections are tight and filters are not clogged. Contact the factory.
Oxygen readings drift	Perform a field calibration – zero and span (see chapter 3) Contact the factory
Black screen displayed when unit turned on	Charge unit over night and try again. Unit too hot – cool down and try again. Try adjusting contrast level (see chapter 2) Contact factory
Nothing happens when the Gas Pod is installed	Remove and re-seat the Gas Pod. Contact the factory.
Temperature does not update when temperature probe is installed	Check the probe fitting is fully seated. Check the probe plug is screwed together tightly. Contact the factory.

Chapter 10 - Measurement Units & Specifications

Measurement Units

Screen 1

Type	Displayed As	USA (Imperial)	Metric (SI)
Methane	CH_4%	% by volume	% by volume
Carbon Dioxide	CO_2%	% by volume	% by volume
Oxygen	O_2%	% by volume	% by volume
Balance	BAL	% by volume	% by volume

Screen 2

Type	Displayed As	USA (Imperial)	Metric (SI)
Methane	CH_4%	% by volume	% by volume
Lower Explosive Limit	CH_4% LEL	% of 5% CH_4	% of 5%CH_4

Screen 3

Type	Displayed As	USA (Imperial)	Metric (SI)
Static Pressure	SP"	"w.c. (H_2O)	mb (millibar)
Differential Pressure	DP"	"w.c. (H_2O)	mb (millibar)
Temperature	T °F/°C	°F (degrees Fahrenheit)	°C (degrees Celsius)

Screen 4

Type	Displayed As	USA (Imperial)	Metric (SI)
Ref (past) BTU	BTU Ref	per cubic foot	
Ref (past) BTU	KJ Ref		per cubic meter
Ref (past) Gas Flow	scfm Ref	std. cubic feet per min.	
Ref (past) Gas Flow	scfm Ref		std. cubic meters per min.
Adj. (present) BTU	BTU ADJ		per hr.
Adj. (present) BTU	KJ ADJ		per hr.
Adj. (present) Gas Flow	scfm ADJ		std. cubic feet per min.
Adj. (present) Gas Flow	scfm ADJ		std. cubic meters per min.

Operating Temperature

10 to 104° F/-10 to 40° C

Range and Resolution

	Sensor Range Imperial	Resolution Imperial
Methane	0-100%	0.1
Carbon Dioxide	0-50%	0.1
Oxygen	0-25%	0.1
Pressure-Differential	0-10 “w.c.	0.01
Pressure-Static	0-100 “w.c.	0.1

Typical Accuracy

Gas	0 - 5% Volume	5% - 15% Volume	15% - Full Scale
Methane	0.3%	1.0%	3.0%
Carbon Dioxide	0.3%	1.0%	3.0%
Oxygen	0.5%	1.0%	1.0%

Chapter 11 - Field Operations

Landfill Gas Generation

A brief overview of the theory of landfill gas generation and methane recovery follows. Initially, when decomposable refuse is placed into a solid waste landfill, the refuse is entrained with air from the surrounding atmosphere. Through a natural process of bacterial decomposition, the oxygen from the air is consumed and an anaerobic (oxygen free) environment is created within the landfill. This anaerobic environment is one of several conditions necessary for the formation of methane-CH_4.

If oxygen is reintroduced into the landfill, those areas are returned to an aerobic (oxygen present) state and the methane producing bacteria population are destroyed. A period of time must pass before the productive capacity is returned to normal. Since there is some methane of a given quality within the landfill void space, a decline in methane quality is only gradually apparent depending upon the size of the landfill.

Carbon Dioxide is also produced under either an aerobic or anaerobic condition. Under static conditions, the landfill gas will be composed of roughly half methane and half Carbon Dioxide with a little nitrogen.

As air is introduced into the landfill, the oxygen is initially converted to Carbon Dioxide and residual nitrogen remains. Measurement of residual nitrogen is usually a good indicator of the anaerobic state of the landfill; however, it cannot be directly measured. It can, however, be assumed and estimated using a subtraction basis as the balance gas. Hence, the measurement of Carbon Dioxide is an intermediary step. Because Carbon Dioxide levels may fluctuate depending on the changing concentrations of the other constituent gases, Carbon Dioxide levels are not evaluated directly but are considered in light of other data.

In evaluation of residual nitrogen, allowances must be made if there has been any air leakage into the gas collection system or if there has been serious over pull. If enough air is drawn into the landfill, not all oxygen is converted into Carbon Dioxide and the oxygen is apparent in the sample. It is ideal to perform routine analysis of individual wells, as well as an overall well field composite sample, by a gas chromatography. This is not always practical at every landfill.

Under some conditions there may be a small amount of hydrogen in the LFG, (about 1 percent, usually much less). This may affect field monitoring response factors, but otherwise it can be ignored.

Subsurface Fires

If very large quantities of air are introduced into the landfill, either through natural occurrence or overly aggressive operation of the LFG system, a partly unsupported subsurface combustion of the buried refuse may be initiated. Subsurface fire situations are difficult to control or extinguish once started, present health and safety hazards, and can be quite costly. Therefore, prevention by good operation of the collection system and maintenance of the landfill cover, is the best course of action. The presence of Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide are indicators of poorly supported combustion within the landfill.

Techniques for Controlling Landfill Gas

There are many techniques for controlling landfill gas extraction. These techniques represent tools which are used together to control landfill gas. The Accu-Flo™ wellhead is designed to work with all of these techniques. Below is a discussion of the individual techniques, how to use them, and their limitations. Reliance on only a few of the techniques discussed can lead to misinterpretation of field data and improper operation of the well field. Later the best use of these techniques to optimize landfill gas control will be discussed.

Controlling by Wellhead Valve Position

Unless the valve handle is calibrated for a given flow rate, this method is unreliable. The position of the valve handle alone does not provide sufficient information about the well to control it. It is useful to note the relative position of the valve, and essential to know which valves are fully open or fully closed.

Controlling by Wellhead Vacuum

This technique relies on the relationship of well pressure/vacuum to flow for a given well. Reliance upon this method, however, can be misleading. This is because the square root relationship between flow and pressure is difficult to affect while performing day-to-day well field adjustments. As decomposition, moisture, and other conditions change, this method shows itself to be inadequate and imprecise.

Controlling by Gas Composition

This method determines methane, nitrogen (balance gas) and other gas composition parameters at wellheads and at recovery facilities using portable field instruments and, sometimes, analytical laboratory equipment. Complete knowledge of gas composition (i.e., major fixed gases: Methane, Carbon Dioxide, Oxygen and Nitrogen) is desirable. It is also necessary to check other gas parameters, such as Carbon Monoxide, to fully evaluate the condition of the well field. Reliance on this information can lead to improper operation of the well field. Indications of excessive extraction often do not show up right away. This method often leads to a cycle of damage to the methane producing bacteria population and then to over-correction. This cycling of the well and producing area of the landfill is not a good practice. It leads to further misinterpretation of the condition of the well field and has a disruptive effect on the operation of the well field. The use of analytical laboratory instrumentation such as a gas chromatograph is a valuable supplementary tool to verify gas composition. This normally requires collection of samples at the wellhead and analysis at some fixed location where the equipment is located. The drawbacks of this method as a primary means of obtaining information for well field adjustment are the time expended, cost, and probably most important, responsiveness to the needs of the well field for timely adjustment. The laboratory equipment required is also very costly. Some analysis is recommended for verification of field readings from time to time. It is recommended a monthly sample of the composite gas be taken at the inlet to the flare or gas recovery facility.

Controlling by Flow Rate

This is a more exacting technique for determining and adjusting gas flow at individual wells. It requires using a fixed or portable flow measurement device at each wellhead to obtain the data needed to calculate volumetric (or mass) flow rates. It is normally convenient to use cubic feet per minute or per day, as a standard unit of measure for volumetric flow. It is important to distinguish between the volumetric quantity of landfill gas and the volumetric quantity of methane extracted from each well and the landfill in total. The two variables are somewhat independent of each other and it is the total quantity of methane extracted we are interested in. It is possible for the total quantity of landfill gas extracted to increase while the total quantity of methane extracted decreases. To monitor this, the quantity of methane extracted (LFG flow x percent methane) or the quantity of BTUs recovered per hour (LFG flow x percent methane x BTUs per cubic foot of methane x 60 minutes per hour) can be calculated. It is conventional to measure BTUs per hour as a unit of time. There are approximately 1012 BTUs of heat per cubic foot of pure methane (like natural gas), although this figure varies a little among reference texts.

Measuring flow is an essential part of monitoring and adjusting a well field. The well should be adjusted until the amount of methane recovered is maximized for the long term. A greater amount of methane or energy can usually be recovered over the short term; however, this ultimately leads to diminishing returns. This is seen in stages as increased CO_2 and gas temperature and later as increased oxygen from well over-pull. In time, the methane will also decline. This is the result of a portion of the landfill, usually at the surface, being driven aerobic. In this portion of the landfill, the methane producing bacteria will have been destroyed (due to the presence of oxygen). With the methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this area, and may lead to the operator opening the well or increasing flow.

Well field Monitoring

The frequency of LFG well field monitoring varies depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring session with full field readings (suggested normal and abbreviated field readings list follows) will vary from typically once a month to once a week. Well field monitoring should not normally be extended beyond one month. The importance of regular, timely monitoring can not be overemphasized.

Typical Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM-500™ or magnehelic) or other device (anemometer/velometer)
- Velocity head (P or PT) (from GEM-500™ or pitot tube and magnehelic)

- Wellhead gas flow (from GEM-500™, or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well's LFG and methane flow and sum total
- Observations/comments

Additionally, Carbon Monoxide (CO) or Hydrogen Sulfide (H_2S) readings may be taken if problems are suspected. Supplementary monitoring once to several times a week may be performed using an abbreviated form of field readings.

Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM-500™, GA-90 or magnehelic)
- Velocity head (P or Pt) (from GEM-500™ or pitot tube and magnehelic)
- Wellhead gas flow (from GEM-500™, or pitot tube and magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Observations/comments

Line vacuums and gas quality may be taken at key points along the main gas collection header and at subordinate branches. This helps to identify locations of poor performance, excessive pressure drop, or leakage. Perform systematic monitoring of the well field, taking and logging measurements at each wellhead and major branch junction in the collection system.

During monitoring, examine landfill and gas collection system for maintenance issues. Record needed maintenance or unusual conditions. Examples of unusual occurrences or conditions are unusual settlement, signs of subsurface fires, cracks and fissures, liquid ponding, condensate/leachate weeping from side slopes, surface emissions and hot spots, and liquid surging and blockage in the gas collection system. Field readings should be kept in a chronological log and submitted to management on a timely basis.

Well field Adjustment Criteria

There are several criteria used in well field adjustment. The primary criterion is methane quality. Methane quality is an indicator of the healthy anaerobic state of the landfill and thus proper operation of the LFG collection system. However, a decline in the healthy productive state of the landfill is usually not immediately apparent from methane quality. Due to this several criteria must be considered at once.

Following are well field adjustment criteria for consideration.

- Methane quality (ranging from 26 percent upwards)
- The degree to which conditions within the landfill favor methane production. Typical conditions include:
  - pH
  - temperature
  - general overall quality
  - moisture conditions
  - waste stream characteristics
  - placement chronology
  - Insulation characteristics
- Oxygen quality (ranging below 1 percent, preferably less then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
  - type of fill
  - size and shape of refuse mass
  - depth of fill
  - compaction
  - leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

Establishing Target Flows

For a given individual well, a target flow is established which will likely support maintenance of methane and oxygen quality objectives while maximizing the recovery of landfill gas. Typically, small adjustments are made in flow to achieve and maintain quality objectives. The well must not be allowed to over pull. High well temperatures, (130° to 140° F and greater), are an indication of aerobic activity and, thus, well over-pull. These effects may not be immediately apparent.

Well adjustment should be made in as small an increment as possible, preferably an increment of ten percent of the existing flow or less. There may be obvious conditions when this is not appropriate, such as when first opening up a well or when serious over-pull is recognized. Every effort should be made to make adjustments and operations as smooth as possible. Dramatic adjustments, or operating while switching between a high flow mode and a well shutoff mode, should be avoided.

Well field Optimization

Every effort should be made to continuously locate and correct or eliminate conditions (e.g., gas condensate, surging and blockage, settlement, etc.) which inhibit efficient operation of the gas collection system. This allows well monitoring and adjustment to be significantly more effective.

Migration Control—Dealing with Poor Methane Quality

If methane and oxygen quality objectives cannot be maintained at a given well, such as a perimeter migration control well, then an attempt should be made to stabilize the well as closely as is practical, avoiding significant or rapid down-trending of methane or up-trending of oxygen.

It is not uncommon for perimeter migration control wells to be operated at less than 40 percent methane or greater than one-percent oxygen. It should be recognized that these wells are likely in a zone where some aerobic action is being induced, and that there is some risk of introducing or enhancing the spread of a subsurface fire. Sometimes a judicious compromise is necessary to achieve critical migration control objectives or because existing conditions do not allow otherwise. Such situations should be monitored closely.

Well field Adjustment—Purpose and Objectives

The objective of well field adjustment is to achieve a steady state of operation of the gas collection system by stabilizing the rate and quality of extracted LFG in order to achieve one or several goals. Typical reasons for recovery of LFG and close control of the well field are:

- Achieve and maintain effective subsurface gas migration control.
- Achieve and maintain effective surface gas emissions control.
- Assist with proper operation of control and recovery equipment.
- Avoidance of well over pull and maintenance of a healthy anaerobic state within the landfill.
- Optimize LFG recovery for energy recovery purposes.
- Control nuisance landfill gases odors.
- Prevent or control subsurface LFG fires.
- Protect structures on and near the landfill.
- Meet environmental and regulatory compliance requirements.

Well field adjustment is partly subjective and can be confusing because it involves judgment calls based on simultaneous evaluation of several variables, as well a general knowledge of site specific field conditions and historical trends. Well field evaluation and adjustment consist of a collection of techniques, which may be used, in combination, to achieve a steady state of well field operation.

CES-LANDTEC Technical Tips

Landfill Control Technologies regularly produces technical landfill related information and educational material. Please call CES-LANDTEC at (800) LANDTEC, to receive the current series of these Technical Tips.