



**GEM™2000**

**GEM™2000 Plus**

GAS ANALYZER & EXTRACTION MONITOR

**OPERATION MANUAL**

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## 1 Introduction

LANDTEC is the premier manufacturer of products, instruments and software for landfill gas extraction and for regulatory monitoring compliance. LANDTEC has provided the landfill industry with a technologically innovative family of products for more than a decade. These products are the result of field-proven experience in design, operation and maintenance of landfills for environmental compliance.

The GEM™2000 and GEM™2000 Plus, designed by LANDTEC, are specifically for use on landfills to monitor landfill gas (LFG) extraction systems, flares and migration control systems. Both instruments sample and analyze the Methane, Carbon Dioxide and Oxygen content of LFG. The GEM™2000 Plus also samples and analyzes Carbon Monoxide and Hydrogen Sulfide. The readings are displayed and can be stored in the instrument or downloaded to a personal computer for reporting, analyzing and archiving.

The GEM™2000 / GEM™2000 Plus instrument is frequently shipped in an optional protective hard case with a foam interior that 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 turning the pressure relief valve equalizes internal pressure. When shipping a GEM™2000 / GEM™2000 Plus back to LANDTEC for calibration or service, always ship it in the original packaging to protect unit from damage.

Carefully unpack the contents of the GEM™2000 / GEM™2000 Plus, inspect and inventory them. The following items should be contained in your package:

- The GEM™2000 / GEM™2000 Plus instrument
- GEM™2000 / GEM™2000 Plus Operation Manual
- Registration/Warranty Card
- Soft carrying case with replaceable protective window and carrying strap
- Clear ¼" vinyl sampling hose assembly (5 ft.) with external water trap filter assembly
- Blue ¼" vinyl pressure sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue vinyl hose
- Spare external water trap filter element
- 100-240 volt battery charger
- DataField CS software on CD-ROM
- RS-232 serial cable for computer/printer data downloading
- Temperature probe (optional)
- Hard carrying case (optional)

Complete the Registration/Warranty Card and return it to LANDTEC. The model and serial numbers are located on the back of the GEM™2000 / GEM™2000 Plus instrument.

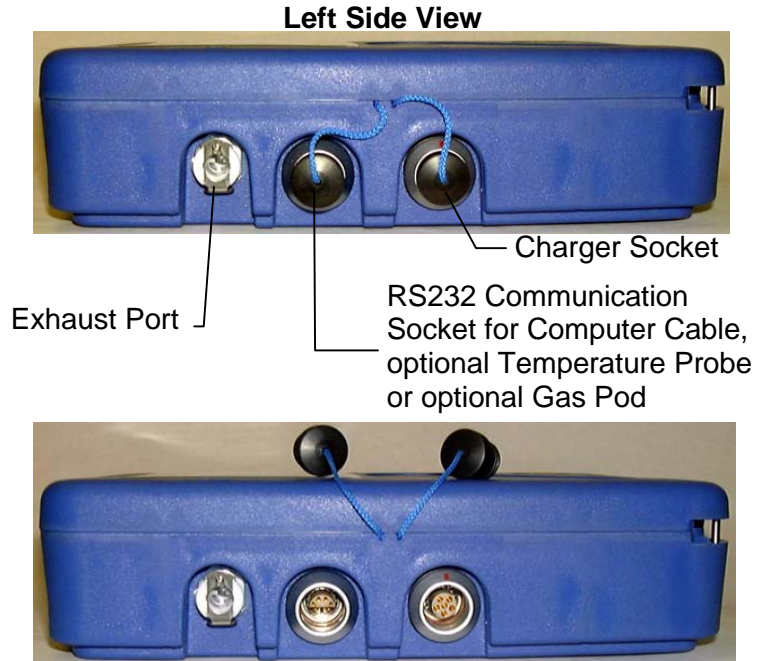
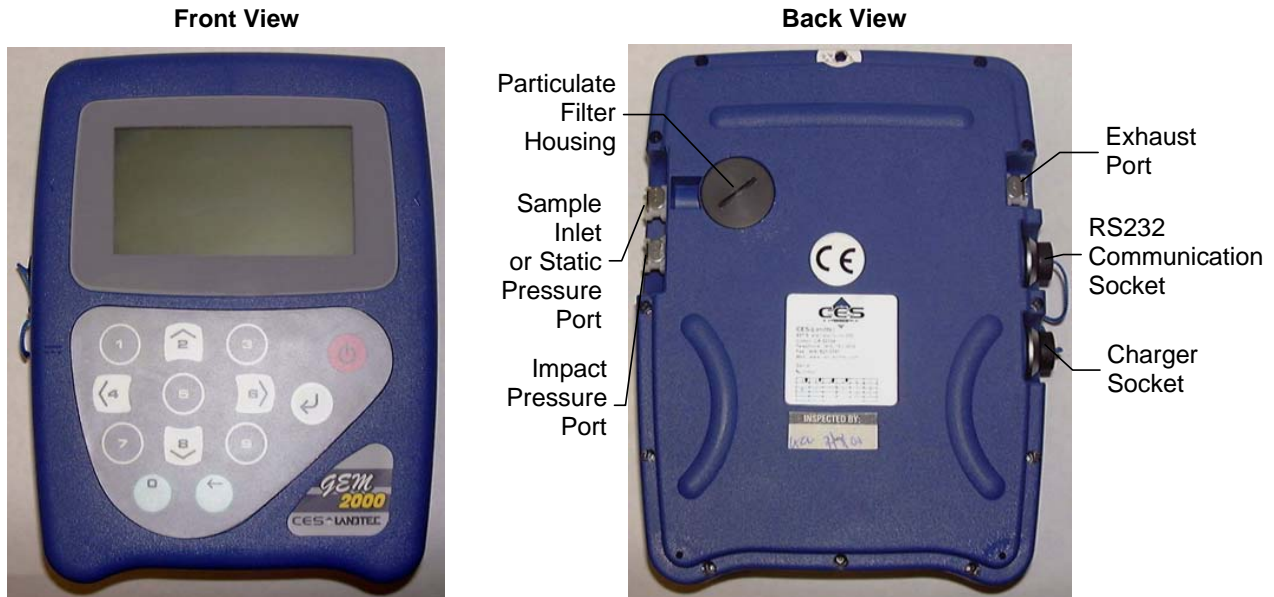
**Immediately notify shipping company if the GEM™2000 / GEM™2000 Plus unit or accessories are damaged due to shipping.** Contact LANDTEC immediately if any items are missing.

For questions regarding instrument operation and procedures, please contact LANDTEC at:

Customer Service or Technical Support  
Factory Service  
Spare Parts and Calibration Gas (800) 821-0496  
DataField Software Support

## 2 General Operational Features

### 2.1 Physical Characteristics of the GEM™2000 / GEM™2000 Plus



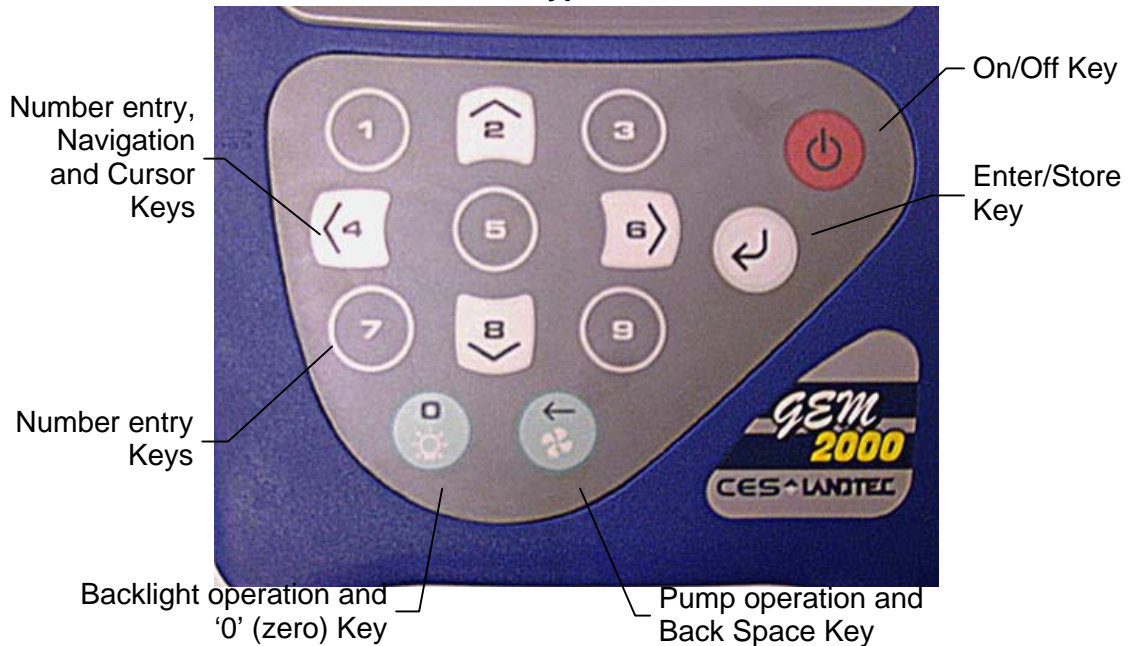
**Right Side View**



Impact Pressure Port

Sample Inlet or  
Static Pressure Port

**Keypad**



Number entry,  
Navigation  
and Cursor  
Keys

Number entry  
Keys

Backlight operation and  
'0' (zero) Key

Pump operation and  
Back Space Key

On/Off Key

Enter/Store  
Key

Whenever a key is pressed the unit will emit a short 'beep' as an acknowledgement. This function cannot be turned off.

**2.2 Turning the Instrument On/Off**

When switching the instrument on, a long beep will sound, followed by the LANDTEC logo being displayed and the self-test will commence.

When switching the instrument off, the On/Off button must be held down for approximately 15 seconds, at which point a clean air purge will be carried out. If for any reason the instrument 'locks-up' and will not switch off, press and hold the On/Off button for 15 seconds. This will force the instrument to switch off.

**2.3 Warm-up Self Test**

When switched on, the instrument will perform a predetermined self-test sequence taking approximately 20 seconds, during this time many of the instrument's functions are tested, including:

- General operation
- Pump function
- Gas flow measurement
- Calibration
- Backlight function
- Solenoid function

During the self-test, the following information is also displayed:

- Calibration due date.
- Software version.
- Lifetime guarantee covered (or not).
- Date format.
- Serial Number.
- Operating language.

Upon self-test completion, the GEM™2000 / GEM™2000 Plus should automatically enter the read gas levels screen.

### 2.4 Warning and Error Display

During the self-test, if any operational parameters are out of specification or the pre-programmed recommended calibration/service date has passed errors or warnings may be displayed. Only three errors/warnings can be displayed at any time. To ascertain if more errors occurred, use the '∧' and '∨' key to scroll up/down the list.

#### 2.4.1 WARNING Displayed

All warnings displayed will be prefixed by the word '**WARNING**' followed by a relevant description. Two types of warnings may be displayed.

1. General warnings that may not have an effect on the instrument's function and those where the self-test has detected a function that is outside the usual programmed operating criteria (e.g. Battery charge low, memory nearly full, etc.).
2. Specific warnings of operational parameters that can affect the performance of the instrument (e.g. O<sub>2</sub> Cell out of calibration, CH<sub>4</sub> out of calibration, CO<sub>2</sub> out of calibration, etc.).

The most likely reason for the errors is either an incorrect user calibration, or sensor failure. If an incorrect user calibration has caused the warning, it should be correctable by way of returning the instrument to factory settings, zeroing or carrying out a user calibration as necessary for the relevant function.

#### 2.4.2 ERROR Displayed

All errors displayed will be prefixed by the word '**ERROR**' followed by a number and description. The errors detected by the self-test are usually caused by a user calibration being out of specification or possibly memory corruption. This will have an effect on the functionality of the instrument and should be corrected before use (e.g. 01 - User cal data, CH<sub>4</sub> reading or channel out of specification, 02 - User cal data, CO<sub>2</sub> reading out of specification).

*If any other Warnings or Errors are displayed, contact LANDTEC for further information.*

**LANDTEC is the ONLY authorized service center for the GEM™2000 / GEM™2000 Plus instruments in the Americas.**

### 2.5 Storage

Do not keep the instrument in the trunk of a car or shed because it may be exposed to temperature extremes.

When not in use, instruments should be kept in a clean, dry and warm environment such as an office.

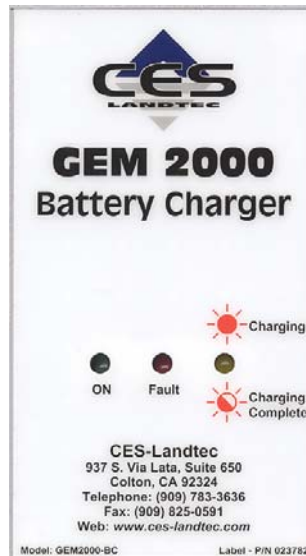


The instrument batteries should be discharged and fully charged at least once every four weeks regardless of indicated charge state. The discharge function may be carried out with the use of the Data Logging Function in GA mode of operation.

### 2.6 Battery/Charging

**The Battery Charger IS NOT covered by the unit UL certification. Therefore, when connected to the Battery Charger, the instrument IS NOT intrinsically safe and should not be used in confined spaces.**

The battery used in the GEM™2000 / GEM™2000 Plus is a Nickel Metal Hydride manufactured as an encapsulated pack from six individual cells. This type of battery is not so susceptible to “memory effects” as Nickel Cadmium batteries, although it is not recommended that the unit be given short-term charges. When the flashing LED indicates “Charging Complete”, disconnect the charger.



The battery charger indicates when the unit is charging, charged or if there is a fault. A full charge should take approximately 2 hours. Charge the batteries until the ‘Charging Complete’ indicator is flashing.

**2.7 Read Gas Levels Screen (GA mode of operation)**

The read gas levels screen is also considered the normal operation screen and all operations are carried out from this starting point. The following information is displayed in various boxed sections at this time:

- Current programmed time and date.
- Current selected ID code.
- Pump status.
- Pump run time.
- Three main constituent gases – CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub> (in %).
- Two minor gases – CO & H<sub>2</sub>S (GEM™2000 Plus only)
- Balance gas.
- Last read time/date (if previous data is in memory), the benefits of this are, 1 – it is easily noted if a reading has been taken/stored, 2 – the current and previous readings can be easily compared.
- External Gas Pod “Not Fitted” (displays pod type when attached).
- Peak CH<sub>4</sub> reading (in %) (GA mode only).
- LEL CH<sub>4</sub> (GA mode only).
- Current barometric pressure reading.
- Current relative pressure reading (GA mode only).
- Gas Pod or Temperature Probe reading (if connected).
- Battery Charge graph (5 segment, flashes at 20% remaining).
- Memory Usage graph (5 segment, flashes at 5% remaining).

Other options:

- ① Menu                      Allows access to all instrument user functions.
- ③ Next ID                    Allows the next ID to be selected (if data available).
- ⌚ Previous Reading        Allows the previous reading of the selected ID to be viewed (if data available).
- ↵ Store Reading            Stores the current displayed reading. (GA mode only)

**2.8 Optional Gas Pods**

Optional gas pods are available for use with the GEM™2000 / GEM™2000 Plus. These pods are available in seven different gases with nine different PPM ranges. Connection to the instrument is made via the data port and exhaust port. The detected PPM level is displayed in the upper right area of the gas read screen and is saved in the same manner as the other gas readings.

<b>Gas Type</b>	<b>Range (PPM)</b>	<b>Resolution (PPM)</b>
H <sub>2</sub> S	0-50	0.1
	0-200	1.0
CO	0-1000	1.0
SO <sub>2</sub>	0-20	0.1
	0-100	1.0
NO <sub>2</sub>	0-20	0.1
CL <sub>2</sub>	0-20	0.1
H <sub>2</sub>	0-1000	1.0
HCN	0-100	1.0

Gas pods are intended for use as an inexpensive detection means and not for regulatory reporting purposes. If the GEM™2000, fitted with a Gas Pod, indicates the presence of the selected gas, further testing should be performed with regulatory approved instrumentation. LANDTEC recommends that field calibration be performed using the relevant gas and concentration, prior to sampling with a gas pod.

## **2.9 Cold Start**

**THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.**

(For Gas Calibration Error Messages, confirm that Factory Setting and User Calibration is done).

A Cold Start should only be carried out to correct an instrument if no other course of action has proved successful. This function **WILL ERASE** the instrument memory entirely. After a cold start is performed the user will need to reset the instrument to factory settings, perform a field calibration and reset the internal time/date to the default settings. Please note that the time/date may only be updated through DataField software. It cannot be updated manually.

To carry out a cold start, turn the instrument on, during the self-test press and continue to hold the '↵' key until the self-test has been completed. Upon completion of the self-test, a pass code entry screen will be displayed. At this point the '↵' key may be released. Enter the code **12345** and press '↵' to confirm.

After the pass-code entry has been accepted, the instrument serial number will be displayed along with the hours of operation and two options:

- 1 - Cold Start
- 0 - Continue

ONLY select option '1' if a Cold Start is to be carried out. Press key '1' to confirm this operation. The cold start menu will be displayed again, press key '0' to continue with normal operation.

### **3 General Operations Menu**

The following features and functions are selectable from the main menu via key 'Ⓞ **Menu**' from the read gas levels screen. Various options are available to the user including:

#### **3.1 Zero Transducers**

This function allows the user to zero the pressure transducer(s). Upon selection, the current pressure reading is displayed. The operation will be carried out when the '↵' is pressed.

#### **3.2 Update Site Data**

Allows the user to answer questions (pre-defined in DataField software) relating to the site (e.g. name of operator, weather conditions, etc.). Site Questions are different from Site Comments.

This is covered in detail in Section 6 of this manual.

#### **3.3 Data Logging (GA mode only)**

Enables the user to leave the Instrument unattended to take samples at a pre-determined time. The reading interval and pump run time may be edited prior to commencing the logging cycle. The ID code may ONLY be set in DataField communication software.

Once the logging function is activated, the instrument will carry out a 30 second 'Warm-up' countdown (displayed bottom right) and begin the first sample. After each sample, the unit will shut down (sleep) to conserve power if the time between the pump ending and the next sample is greater than 30 seconds.

The instrument is reactivated (awakened) during a logging cycle, the company logo will be displayed for a few seconds and the read gas levels screen will be displayed. This will initiate a 30 second countdown to the next sample being taken unless the operator stops the logging function.

If for any reason during a logging cycle the inlet port were to become blocked the Instrument will sense this as a flow fail during the 'pump on' time and will automatically retry until a reading can be obtained. Therefore, position the sample hoses carefully to ensure no blockage due to water/moisture can occur.

#### **3.4 Print Data**

Allows ALL the data currently stored to be printed. This may ONLY be carried out with an appropriate RS232 cable (included with new instruments & available from LANDTEC) and a printer with a serial port connection.

#### **3.5 Adjust Contrast**

The GEM™2000 automatically adjusts the screen contrast according to the ambient temperature to maintain normal viewing.

The contrast can be manually adjusted by using the '<' and '>' cursor keys. The manual contrast setting is stored when the instrument is switched off.

#### **3.6 Field Calibration**

Whenever carrying out a user calibration function it is important to ensure the correct value is entered. Additionally, in the case of a zeroing function, ensure only ambient air is used and no connection is made to a probe or wellhead fitting. The calibration cylinders sold by LANDTEC have a volume of 17 liters. The regulator, sold by same, is set to 0.5 liters per minute and 15 psig maximum. A normal field calibration usually requires the gas to be running for about two minutes.

Upon selecting this option, the Field Calibration screen is displayed. A brief description of the user span calibration procedure and the current reading (row 'R') and user span calibration gas values (row 'S') are displayed.

The span gas values may be changed via the '③ **Edit Target Concentrations**' option. Once this option has been selected, **all** the gas values will require entry. Each entry is to be confirmed by pressing the '↵' key.

### 3.6.1 Zero Channels

Selected from the 'Field Calibration' - '↵-Calibration Menu' allows the relevant reading to be zeroed. When selected, a list of the available options will be displayed, this usually includes CH<sub>4</sub>, and O<sub>2</sub>, also the Gas Pod (if fitted).

Supply a zero gas mixture to the instrument for the gas to be zeroed. Ensure the reading for the selected gas has settled to its lowest value before selecting the zero function. When the required option is selected, the user zero function will be carried out automatically. The operation will be carried out when the '↵' key is pressed.

### 3.6.2 Span Channels

Spanning Channels should be carried out prior to use or when the ambient operating temperature changes greater than +/- 20 degrees. Selected from the 'Field Calibration' - '↵-Calibration Menu', allows the relevant reading to be span calibrated (in accordance with the calibration value entered). When selected, a list of the available options will be displayed, which includes CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub>, (CO & H<sub>2</sub>S for the Plus) and Gas Pod (if fitted).

When the required option is selected from the list, the span calibration function will be carried out automatically. When carrying out this procedure, ensure the span calibration procedure (as outlined below) is followed:

1. Apply the relevant known certified gas concentration through the inlet port of the Instrument.
2. Wait until the current gas reading has stabilized.
3. Select the required calibration option via the '↵-Calibration Menu'.

### 3.6.3 Factory Settings

This will clear any user zero and span calibration data. It will also restore the pre-programmed factory settings for **ALL** channels – CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub> (CO & H<sub>2</sub>S for the Plus) or Gas Pod (if fitted) and pressure transducers.

### 3.6.4 Last Field Cal

Displays the date the last field calibration was carried out (zero or span).

## 3.7 Mode of Operation

Allows changing instrument between GA mode and GEM mode of operation.

## 4 Taking Probe Readings (GA Mode)

LANDTEC classifies non-extraction wells as Probes when **NOT** connected to an active vacuum extraction system. Probes, (commonly known as migration probes), may be placed on the perimeter of the landfill to test for gas migration or may be placed next to a building or road to test for the presence of Methane. The GEM™2000 / GEM™2000 Plus instrument may be configured as a Gas Analyzer (GA mode) for sampling probes. To access this function from the gas read screen press 'Ⓚ' for menu and scroll down to **Mode of Operation**, press the '↵' key and highlight **Landfill Gas Analyzer**, pressing the '↵' key again will select GA mode of operation.

### 4.1 Preliminary Checks

Prior to going to the test site, it is good practice to ensure:

- All necessary ID codes and readings have been uploaded via DataField software.
- The time and date are correct.
- The water trap has a clean and dry filter fitted.
- The inlet-port particulate filter is clean and dry.
- A supply of spare filters is available in case of accidental water blockage or contamination.
- The battery has a good charge (minimum 25% charge, even if only a few readings are required).
- The memory has sufficient space available.
- The CH<sub>4</sub>, CO<sub>2</sub>, and O<sub>2</sub> readings have been auto-zeroed, without gas concentration present.
- Check the span calibration with a known concentration calibration gas.

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast.

**Always use the water trap!** If the water trap becomes flooded, change the filter immediately and ensure all hoses are clear before re-use.

### 4.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data should be updated (if programmed). This is accessed via the General Menu 'Ⓚ **Update Site Data**'. This function removes the need for the site conditions to be recorded manually.

A series of up to five questions can be pre-programmed with the use of DataField and answered at this time. The answers to these questions are stored and appended to each reading stored thereafter, until the site data is updated for another site.

### 4.3 Taking Readings – With ID

For this function to be used it is essential that the relevant ID and if required, previous readings are uploaded to the Instrument. An ID **cannot** be entered from the Instrument.

1. When the read gas levels screen is displayed, option 'Ⓚ **Next ID**' should be selected. A list of stored IDs is displayed for selection via the '↑' and '↓' cursor keys, the 'next' ID on the list is automatically highlighted. To confirm selection, press the '↵' key. The display may be toggled to display any relevant ID information such as a description of the probe location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once the '↵' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the 'ⓧEXIT' key.
3. The ID number selected and the pump runtime is displayed in the upper left corner of the read gas levels display.
4. At this point, connect the sample hose (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' into place. Then connect the sample hose to the probe sample port. **Do not connect the sample hose to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
5. As soon as the connection is made, the relative/static pressure reading will be displayed. No sample is taken from the probe at this time. Once the reading stabilizes and the pump starts, the relative/static pressure reading is stored. The relative/static reading will remain displayed as the pressure last taken.
6. The pump will run for the pre-programmed time and a countdown timer will be displayed. The pump may be stopped or started at anytime by way of the 'Ⓢ' (pump) key. The reading may be stored at anytime with the use of the '↵' key. When the pump automatically stops this should be used as a prompt to store the reading.
7. Upon storing the reading, any pre-programmed questions will be displayed for response. This may require a numeric, alphanumeric selectable comment, or exclusive comment answer. A maximum of eight selectable and exclusive comments may be entered.
8. Disconnect the sample hose from the probe and proceed to Step 1 for the next probe.

For each reading, the following information will be stored:

- ID code.
- Current time/date.
- Site data (if entered).
- All gas readings and balance (CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub> (, CO and H<sub>2</sub>S for the Plus)).
- LEL CH<sub>4</sub>.
- Barometric Pressure.
- Relative Pressure.
- Questions/comments.
- Temperature (if temperature probe is connected).
- Gas Pod (if connected).

When the instrument is switched off, a clean air purge is automatically started for a pre-determined period. This may be aborted with the use of the '↵' key, although it is not recommended.

A tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

#### 4.4 Taking Readings – Without ID

1. From the ID list press 'Ⓢ Select No ID' or, if ID information has not been uploaded to the instrument, an ID list will not be available. In either case, the ID will be displayed and stored as '-----'.
9. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once '↵' is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the 'ⓧEXIT' key.
2. At this point, connect the sample hose (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' in to place.

3. Now connect the sample hose to the probe sample port. **Do not connect the sample hose to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
4. The pump may be started or stopped at anytime by way of the '⊕' (pump) key and a 'time-on' timer will be displayed. The pump should always be stopped using the '↵' key, before storing a reading.
5. Upon storing the reading, a virtual keyboard will be displayed for any alphanumeric comments to be entered.
6. Disconnect the sample hose from the probe and proceed from step 1 for the next probe.

Except for the ID code information, which will be stored as '-----', and probe questions, for each reading the information stored will be the same as that for a reading with an ID.

A tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

### 4.5 Temperature Probe Reading

The GEM™2000 / GEM™2000 Plus has the facility to automatically display and record the probe temperature via an optional temperature probe (TP-2000). When a temperature probe is fitted to the RS232 Communication Socket, the temperature will be displayed in the read gas levels screen and recorded with all other data. The temperature probe is part of the GEM™2000 UL certification and is therefore certified for use under the same conditions as the instrument.

### 4.6 Cross-Gas Effects

#### 4.6.1 Methane, Carbon Dioxide and Oxygen

The Methane reading is filtered to an infrared absorption frequency of 3.41 $\mu$ m (nominal), the frequency specific to hydrocarbon bonds. Instruments are calibrated using certified Methane mixtures and will give correct readings provided there are no other hydrocarbon gasses present within the sample (e.g. ethane, propane, butane, etc.). If there are other hydrocarbons present, the Methane reading will be higher (never lower) than the actual Methane concentration being monitored.

The extent to which the Methane reading is affected depends upon the concentration of the Methane in the sample and the concentration of the other hydrocarbons. The effect is non-linear and difficult to predict.

The Carbon Dioxide reading is filtered to an infrared absorption frequency of 4.29 $\mu$ m (nominal), the frequency specific to Carbon Dioxide. Therefore, any other gases usually found on landfill sites will not affect the Carbon Dioxide reading.

The Oxygen sensor is a newly developed galvanic cell type and suffers virtually no influence from CO<sub>2</sub>, CO, H<sub>2</sub>S, NO<sub>2</sub>, SO<sub>2</sub> or H<sub>2</sub>, unlike many other types of Oxygen cell.

The infrared sensors will not be "poisoned" by other hydrocarbons. Normal operation will resume as soon as the gas sample has been purged.

Note - there has been one reported incident of a high reading due to the presence of Carbon Disulfide, which has a similar absorption frequency to Carbon Dioxide.



**4.6.2 H<sub>2</sub>S, CO and other Optional Gas Pods**

The Gas Pods used to measure H<sub>2</sub>S and CO do suffer from cross-gas effects. Such effects are not accurately specified. However, the following table may be useful as a guide. This table represents how many ppm would be read by a Gas Pod if 100ppm of the interfering gas was applied, (with no other cross-contaminates being present in the sample).

Cell	CO	H <sub>2</sub> S	SO <sub>2</sub>	NO <sub>2</sub>	CL <sub>2</sub>	H <sub>2</sub>	CH <sub>4</sub>	CO <sub>2</sub>
CO	100	<3	0	<-20	0	<40	0	0
H <sub>2</sub> S	<0.5	100	~20	~-20		~0.1	0	0

**NOTE:** All readings are given in parts per million (ppm). The life of an electrochemical cell is determined by exposure to gasses, typical life being one to two years. It is recommended that Gas Pods be field calibrated at regular intervals.

NOTE: Cross-gas effects can be mitigated by employing a filter for the gas not being tested. The GEM™2000 Plus has a built-in H<sub>2</sub>S filter to protect the CO sensor.

**4.7 Memory**

The instrument's memory is volatile. It is maintained by a battery back-up system, which will maintain the memory while the battery is being changed.

The memory is not to be used as a permanent storage medium and any data should be transferred to a more permanent storage medium as soon as possible. An Instrument should never be stored for prolonged periods with valuable data in its memory.

Although unlikely, sudden shocks, high levels of electromagnetic interference or static discharge may cause memory corruption or loss. If this occurs, the instrument should be Cold Started and the calibration reset to factory settings before further use. **Cold starting will erase all data in the instrument including resetting the time and date to the default value.**

**4.8 RF Interference**

The gas sensors, especially the Methane sensor, are sensitive to RF interference.

Any device that transmits radio waves can cause your gas readings to fluctuate. Cell phones are the most common cause of the problem. You should never use your cell phone while you are taking gas readings.

## 5 Taking Extraction Well Readings (GEM Mode)

LANDTEC classifies gas-producing penetrations on landfills as wells when used with vacuum extraction systems and flow determining devices such as the Accu-Flo wellheads, orifice plates or pitot tubes. The GEM™2000 / GEM™2000 Plus may be configured as a Gas Extraction Monitor (GEM mode) for the purpose of sampling wells and obtaining flow measurements. To access this function from the gas read screen press 'Ⓞ' and scroll down to **Mode of Operation**, press the '↓' key and highlight **Gas Extraction Monitor**, pressing the '↓' key again will select GEM mode of operation.

### 5.1 Preliminary Checks

Prior to going on site, it is good practice to ensure:

- All necessary ID codes and readings have been uploaded via DataField software.
- The time and date are correct.
- The water trap has a clean and dry filter fitted.
- The inlet-port particulate filter is clean and dry.
- A supply of spare filters is available in case of accidental water blockage or contamination.
- The battery has a good charge (minimum 25% charge, even if only a few readings are required).
- The memory has sufficient space available.
- The CH<sub>4</sub>, CO<sub>2</sub> and O<sub>2</sub> readings have been auto-zeroed without gas concentration present.
- Check the span calibration with a known concentration calibration gas.

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast.

**Always use the water trap!** If the water trap becomes flooded, change the filter immediately and ensure all hoses are clear before re-use.

### 5.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data should be updated (if programmed). This is accessed via the General Menu 'Ⓞ'. This function removes the need for the site conditions to be recorded manually. A series of up to five questions can be pre-programmed with the use of DataField and answered at this time. The answers to these questions are stored and appended to each reading stored thereafter, until the site data is updated for another site.

### 5.3 Taking Gas and Flow Readings (GEM Mode)

The GEM mode of operation is designed to allow for gas flow (SCFM) and energy measurements (BTU) to be calculated at the wellhead. This function requires the use of an ID that has been uploaded from DataField software with the type of flow device defined. **Gas flow and BTU will not be calculated if this action has not been performed.**

1. When the gas read screen is displayed select '**Ⓞ Next ID**'. A list of stored IDs will be displayed for selection via the '∧' and '∨' cursor keys, the 'next' ID is automatically highlighted, to confirm the selection press the '↓' key. The screen may be toggled to display any relevant ID information such as a description of the well location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once the '↵' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the 'ⓀEXIT' key.
3. Connect the sample hoses (with water trap filter) to the wellhead ensuring the gas sample hose and impact pressure hose are properly oriented. Insert the temperature probe if used.
4. Press the 'Ⓜ' key to start the sample pump; a countdown timer will be displayed in the upper left area of the display. The pump may be stopped and restarted any time by pressing the 'Ⓜ' key. The pump run time is set in DataField software. Allow the gas readings to stabilize and press 'ⓂMeasure Flow' key, this will store the gas level readings and display the 'PRESSURE READINGS' screen. Note; a flashing bell will be displayed next to the appropriate gas and a beeping tone will be heard, if a preset alarm condition has been exceeded.
5. The 'PRESSURE READINGS' screen will prompt the user to disconnect the sample hoses and allow the pressure to stabilize. Once the pressure has stabilized press '↵ Zero Transducers'. Press 'Ⓜ' to continue. **Note**; if Accu-Flo wellheads are used this zero function may be performed prior to connecting the sample hoses to the well head by selecting 'Ⓜ MENU' and highlighting 'ZERO TRANSDUCERS'. This eliminates the need to disconnect and re-connect the sample hoses on the same wellhead.
6. If a temperature probe is not connected, the user is prompted to manually input the gas temperature, press the '↵' key when entry is finished.
7. The gas flow and energy screen is now displayed showing all the gas level readings taken in the gas read screen as well as the level of gas flow (SCFM) and power (BTU). In addition, Adjusted, Current and Previous (if downloaded) readings are displayed so modifications may be made to the well if required.
8. Pressing '↵ STORE' will save the readings to memory. Then, the comments screen (if comments were loaded) will display and allow you to answer questions or select comments about the condition of the well. A total of seven comments and one exclusive comment may be stored with each ID.
9. Press 'Ⓜ NEXT ID' and proceed to the next wellhead. An automatic purge will be performed at this time to ensure the sample has been exhausted from the instrument.

For each reading, the following information will be stored:

- ID code.
- Current time/date.
- Site data (if entered).
- All gas readings and balance gas (CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub> (CO & H<sub>2</sub>S for the Plus)).
- Barometric Pressure.
- Temperature.
- Gas Pod (if connected).
- Gas flow (SCFM) and Power (BTU).
- Comments and exclusive comment.

When the Instrument is switched off, a clean air purge is automatically started for a pre-determined global period. This may be aborted by pressing the '↵' key, although we do not recommend this action.

## 6 DataField CS Software

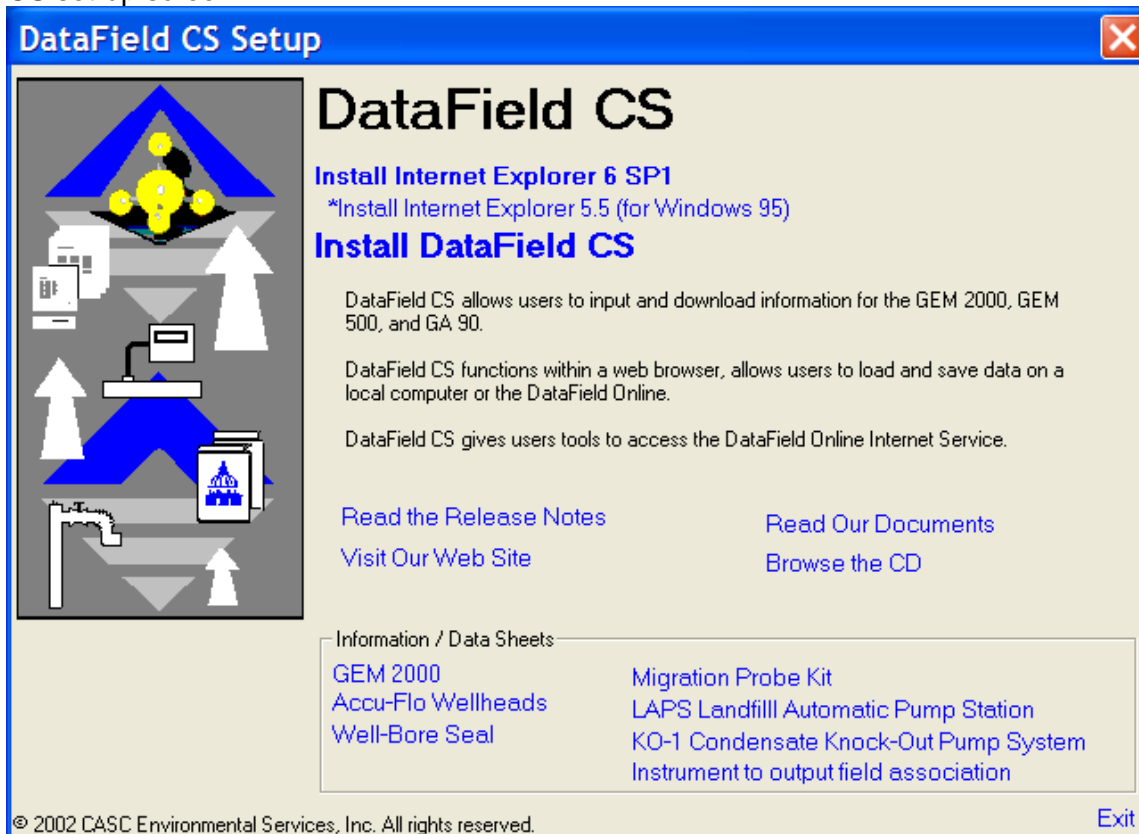
DataField CS is an integrated software program designed to communicate with the GEM™2000, Plus, GEM™2000, GEM™500 and GA-90 instruments. The software will create files used for storing gas read data, ID data, comments and instrument configuration data. The files created are significantly different from the files created with GEM\_COMM or GA\_COMM software and are not compatible with these versions of software.

DataField CS is browser based (Java enabled) and will operate on Windows 98/ME/NT/2000/XP operating systems. Recommended hardware requirements are:

- Pentium III 500 MHz microprocessor or equal.
- 64 MB RAM.
- 120 MB of free hard disk space.
- CDROM drive.
- Mouse or pointer system.
- Standard keyboard.
- Installed printer.

### 6.1 Installing DataField CS

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 CS will self start and display the DataField CS set-up screen.\*



**Install** the Internet Explorer 6 SP1 by clicking on the corresponding link in the DataField CS set-up screen. If you are using Windows 95, install the Internet Explorer 5.5. Follow the onscreen instructions until the Internet Explorer is installed successfully.

**Reboot** the computer after the installation of the Internet Explorer is completed.

Re-insert CD Rom to start autorun again.

Install the DataField CS by clicking on the corresponding link in the DataField CS set-up screen. Follow the onscreen instructions.\*

Other useful links on the DataField CS set-up screen:

**Read the DataField CS Overview link will open a presentation with an overview of DataField CS.**

**Read the Release Notes** link has information on the system requirements, application compatibility and other important issues.

**Visit Our Web Site** link will open the LANDTEC web site.

**Read Our Documents** link will open a new window with manuals and user guides for GEM Instruments, as well as several viewers and 3<sup>rd</sup> party tools that can be downloaded.

**Browse the CD** link will open a file browser.

**Information / Data Sheets** set of links provides information on various Landfill instruments.

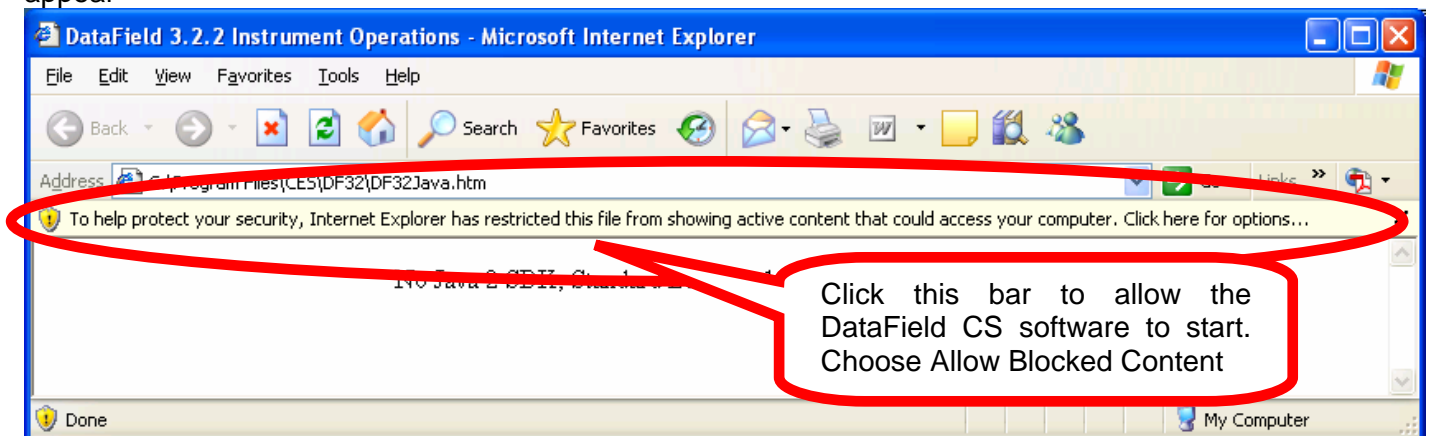
\* If the DataField CS set-up screen hasn't appeared, open a file browser (ex. right-click on the Start button on your desktop and choose open) and navigate to your CD-ROM drive. Double-click on the **Autorun.exe**.

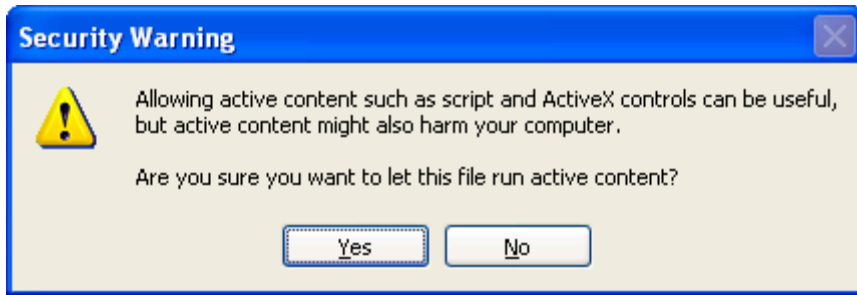
## 6.2 Establishing Communications

Connect the RS-232 download cable to an open COM port on your computer. Connect the other end of the RS-232 download cable to the GEM™2000 / GEM™2000 Plus data port. DataField CS has the ability to automatically scan the different COM ports on your computer to find where the instrument is connected.

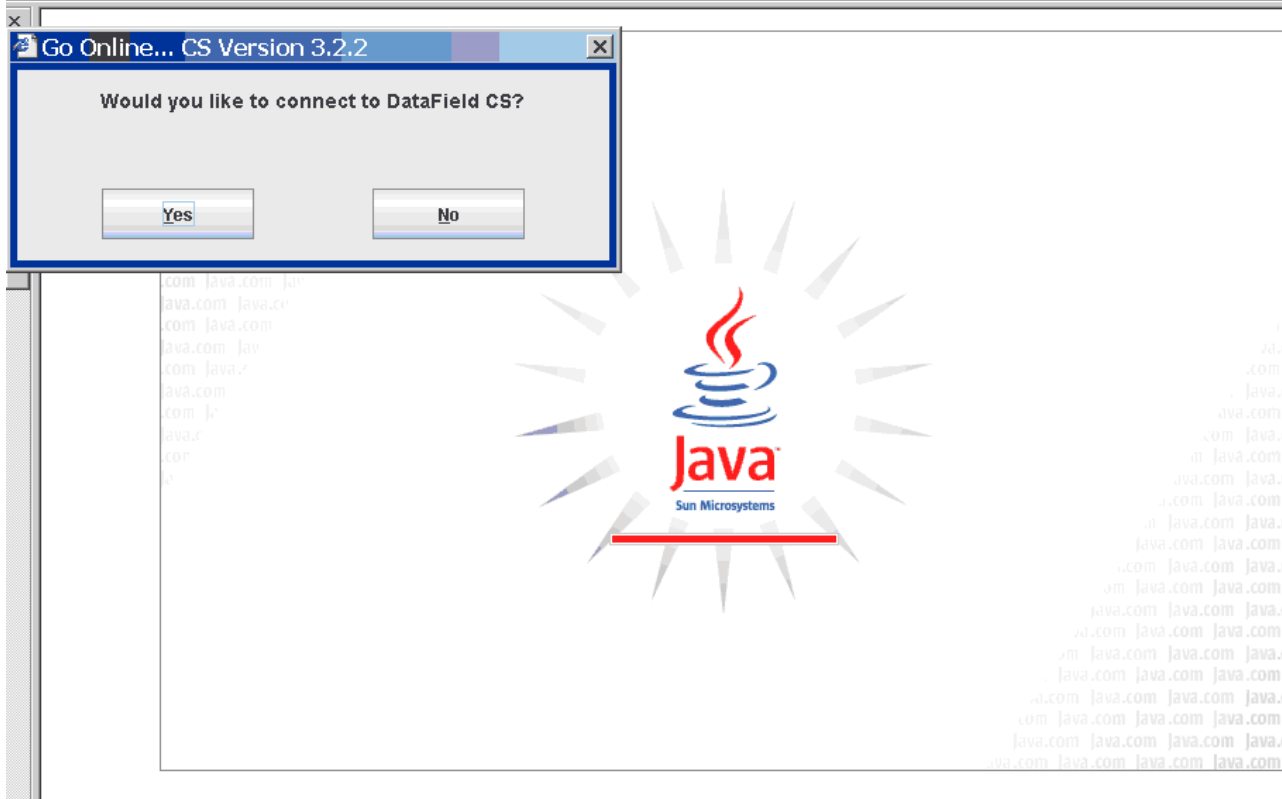
Turn the instrument on, wait for the self-test function to finish. The Gas Readings screen will display, if not, then turn off the GEM and re-start the instrument. The GEM™2000 / GEM™2000 Plus must be in the Gas Reading screen in order to establish communications.

Once the instrument is in the proper communications mode, click on the Start menu then All Programs menu. Scroll to DataField and then DataField CS to initialize the software. The following screen may appear





Answer yes to **allow** the Active Content to load.

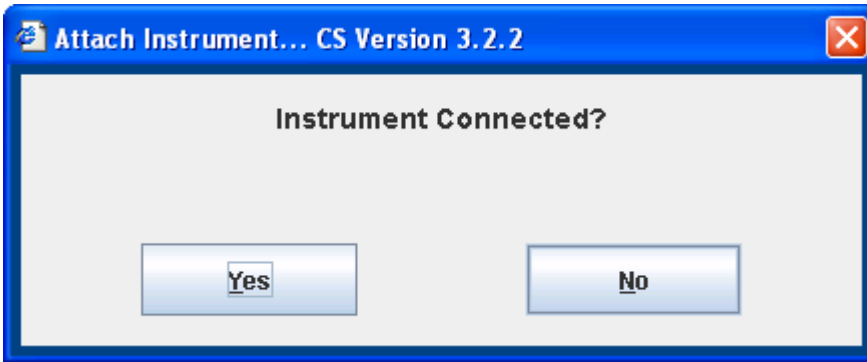


This is the Java screen and it part of the DF program.

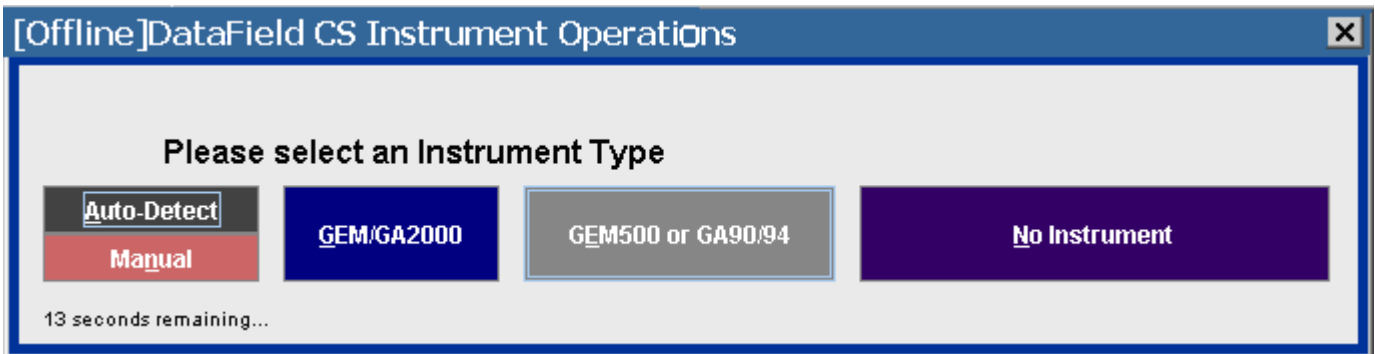
The DataField CS here in the pop up window is the internet service from CES LANDTEC.



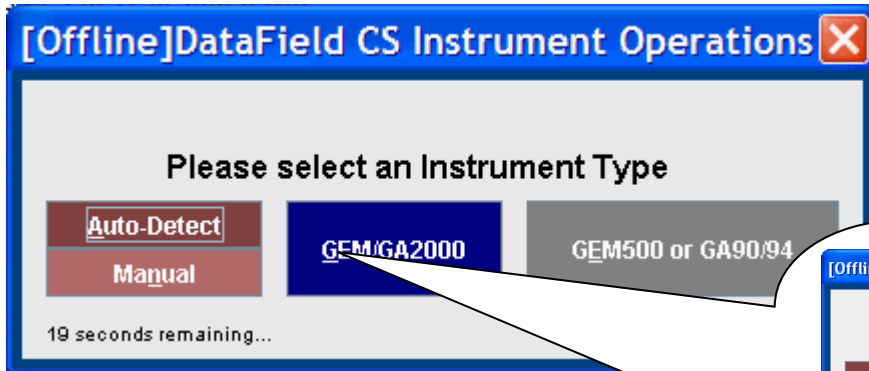
Click Yes to connect DataField CS to the online EnviroComp Report Service or No to run it offline.



Select Yes If your Instrument is connected with the RS-232 Cable

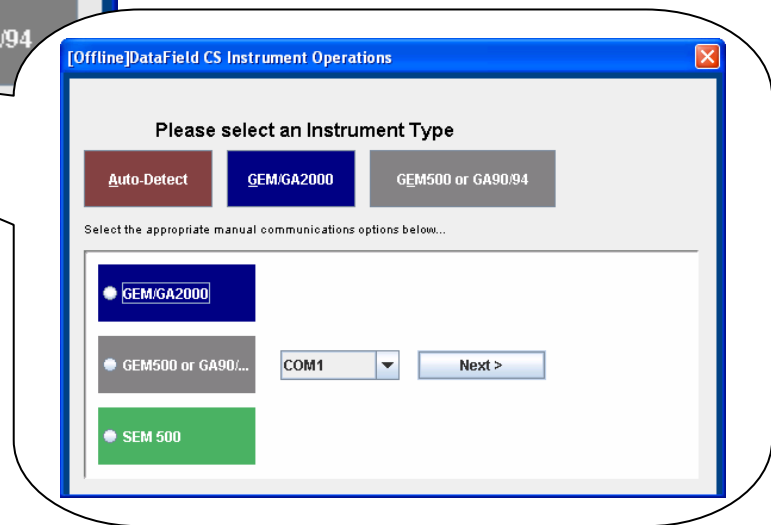


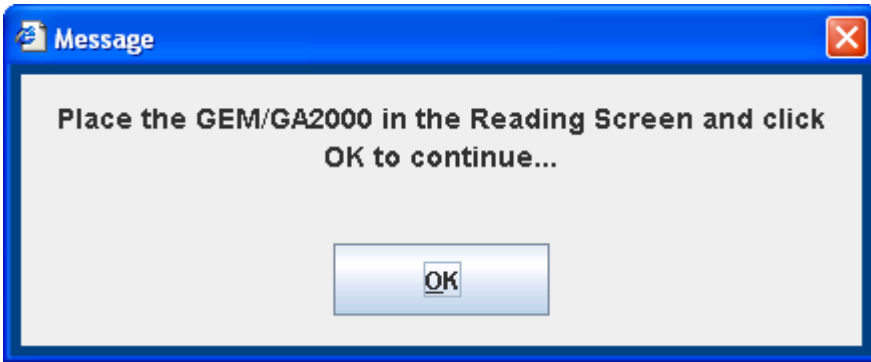
Please select an Instrument type. Click on Gem 2000  
OR



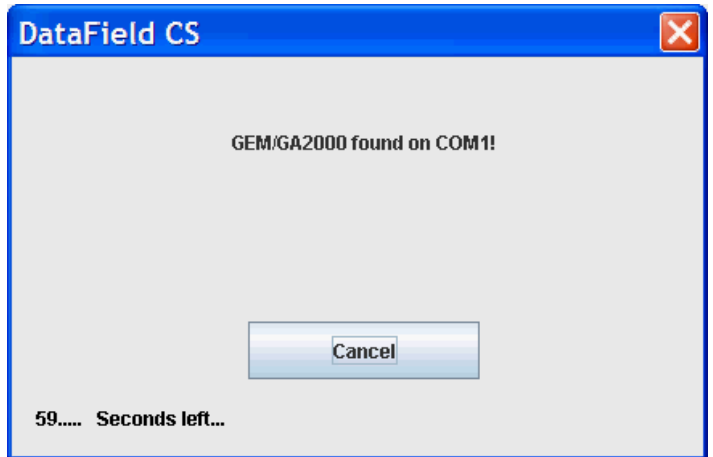
If you choose manual and the com port from the pull down and next

Click on the GEM/GA2000 button. You can also click on the Auto-Detect button for the DataField CS to automatically detect the instrument.



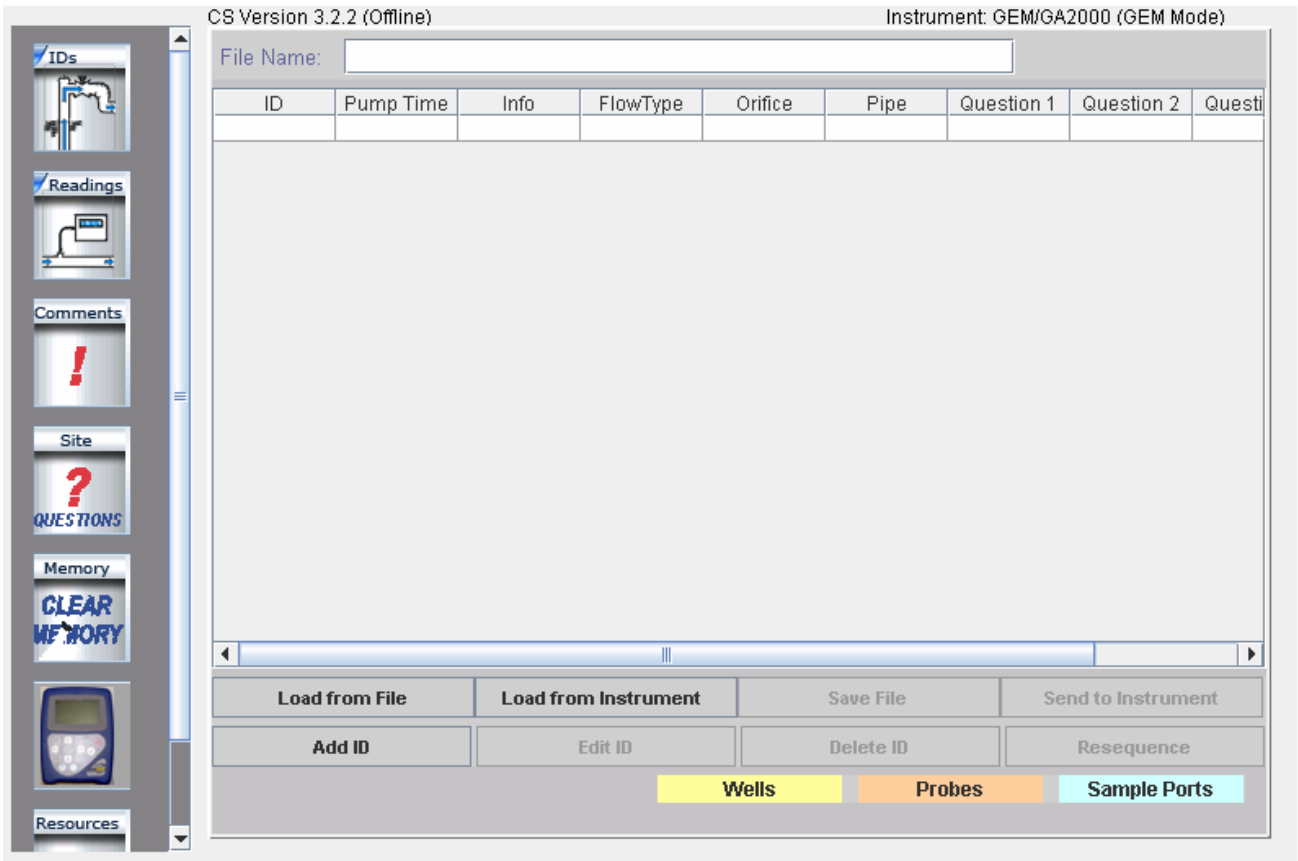


Click OK and DataField CS will automatically search for the instrument. This may take a few minutes. When the instrument is found and the communication is established, the software will display a box that indicates what type of instrument was found. If the software does not find the instrument, it will display a box that indicates that no instrument was found.





### 6.3 Main Screen



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

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

### 6.4 Close the program

Clicking on the **Close** button in the top right corner of the screen will exit the program. This will close all files and exit the program.

### 6.5 Communications

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

## 6.6 Functions

Each button has a specific function as listed below:

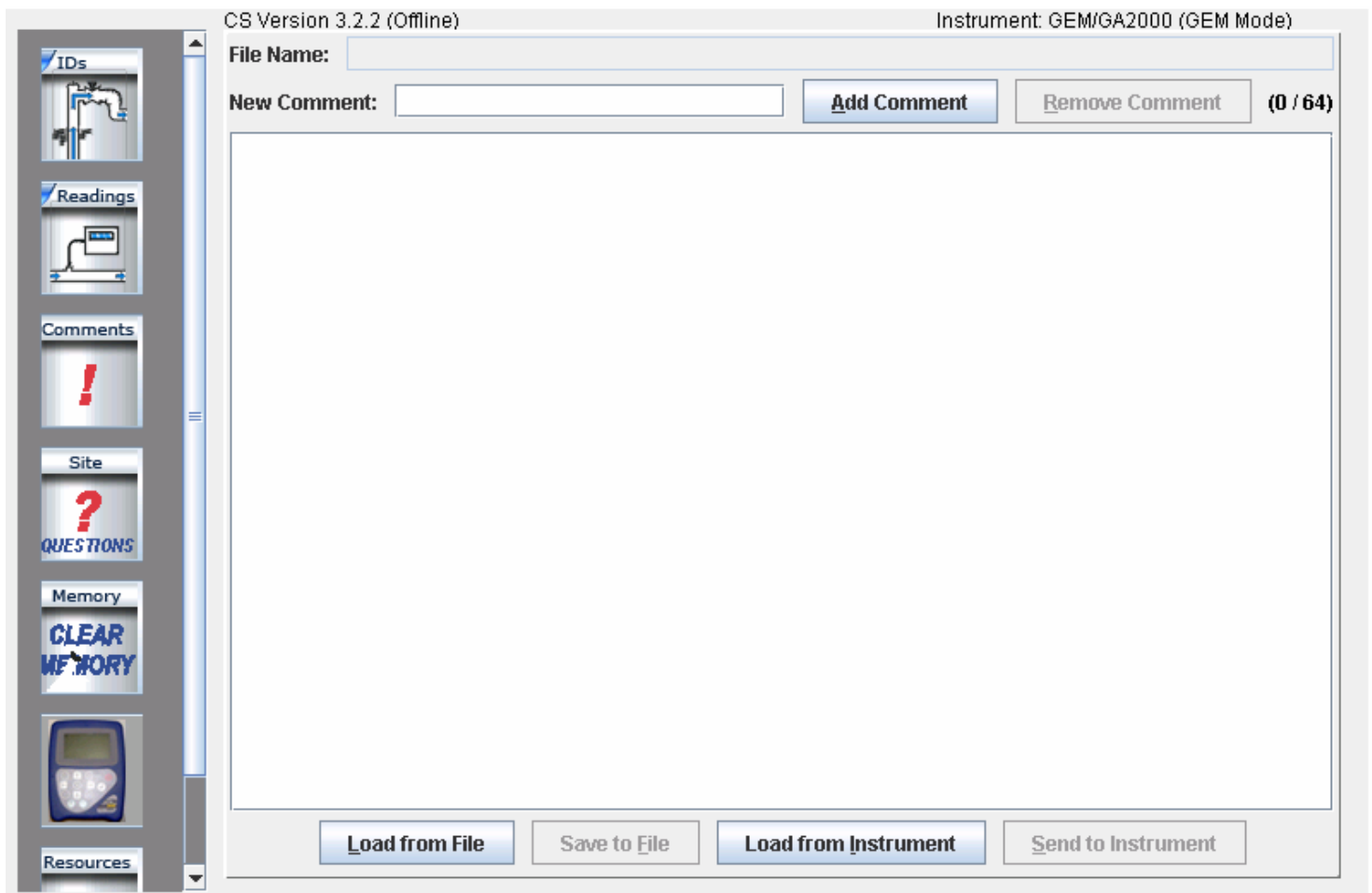
1. **Comments** – Allows entry of comments that may be selected for the IDs. A total of seven comments and one exclusive comment may be selected for each ID.
2. **IDs** – Used for adding new IDs, editing IDs or deleting IDs and entry of ID parameters such as pump run time, flow device, comments and questions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

### 6.6.1 Comments



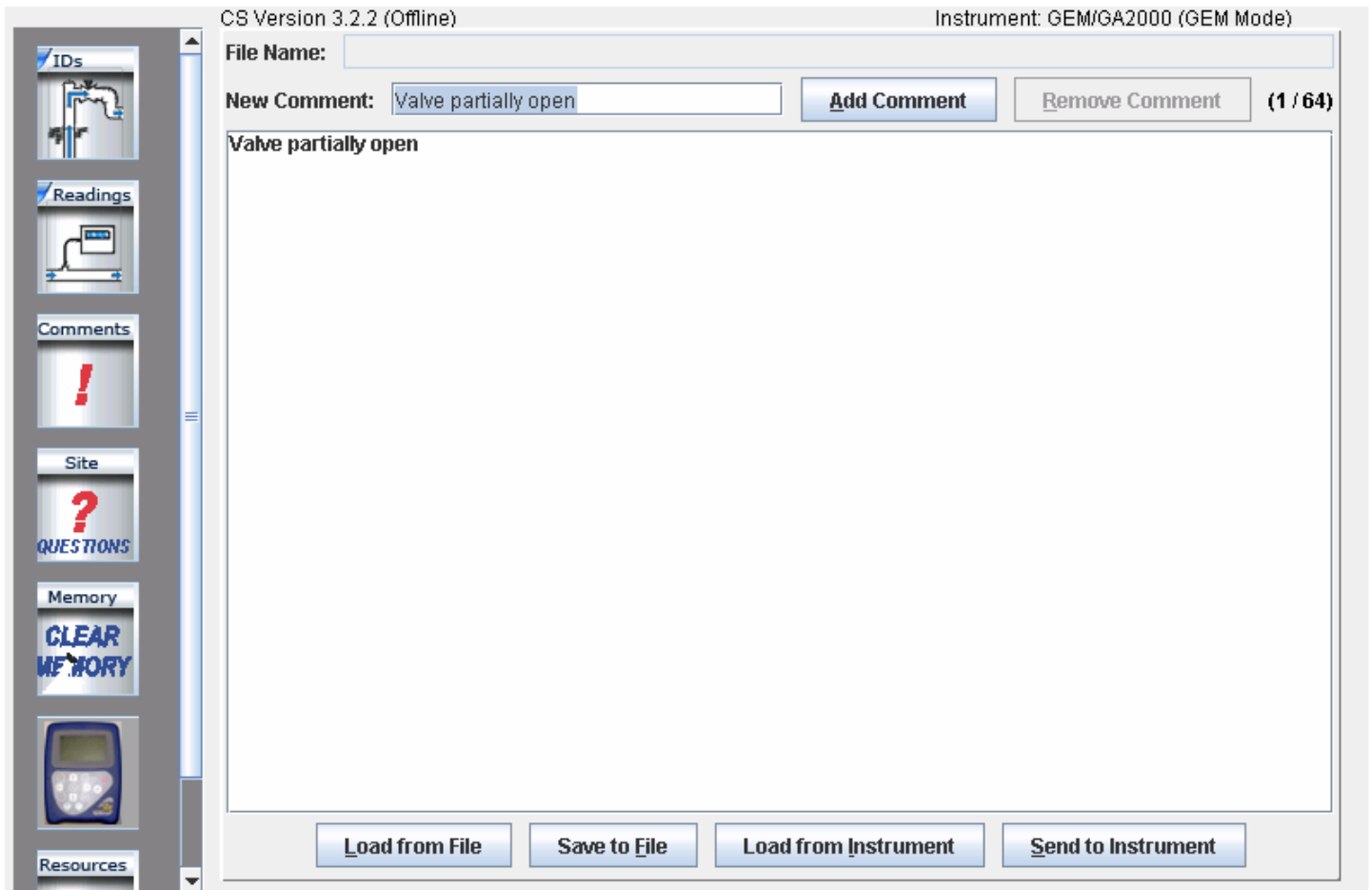
DataField CS allows up to 64 comments to be created for upload to the GEM™2000. Each comment may be up to 36 characters in length and may be alphanumeric or any character on the computer keyboard. **Select Comment** or **Exclusive Comment** must be turned on for comments to be selected for that ID. See section 6.6.2. 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.

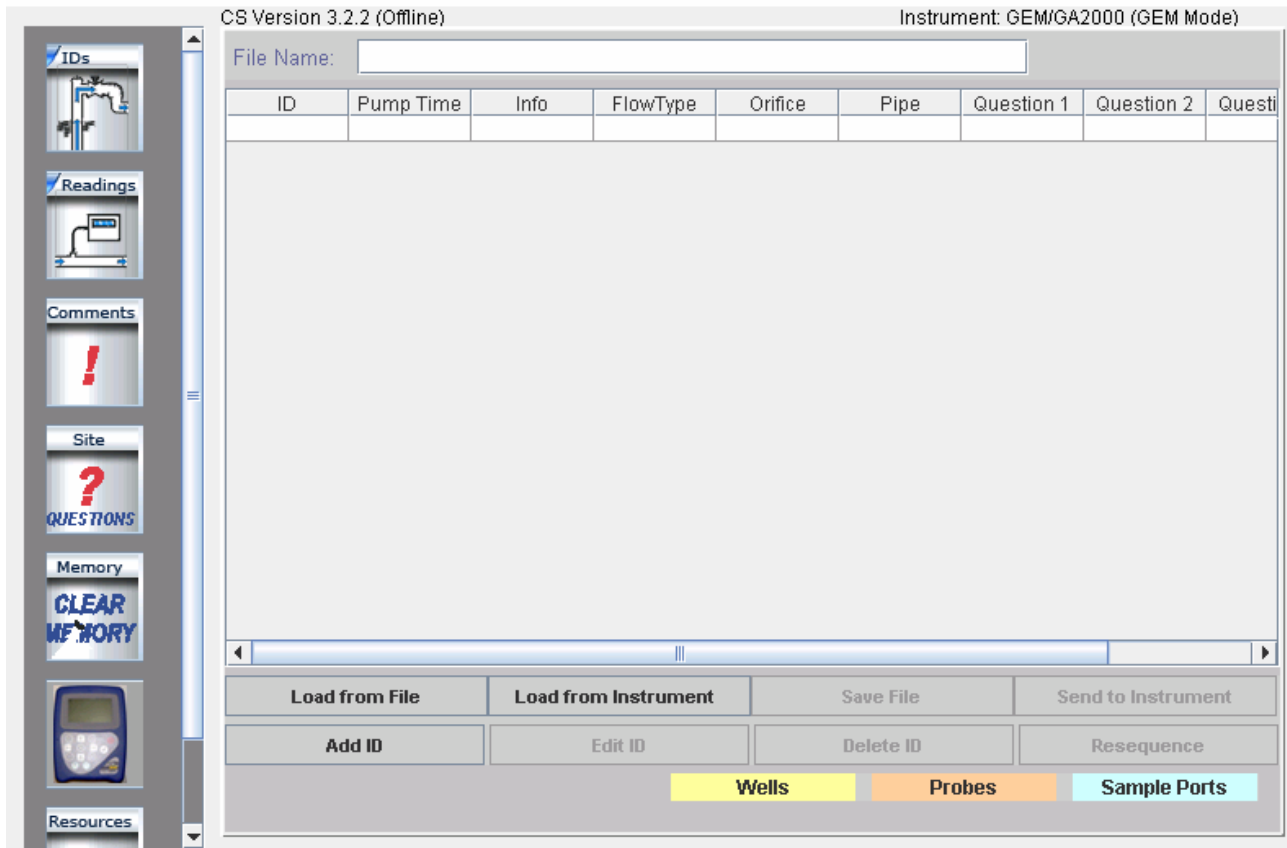
**Note:** Comments must be created and sent to the instrument through the software. They can not be hand input into the instrument in the field.



### 6.6.2 Entering IDs



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



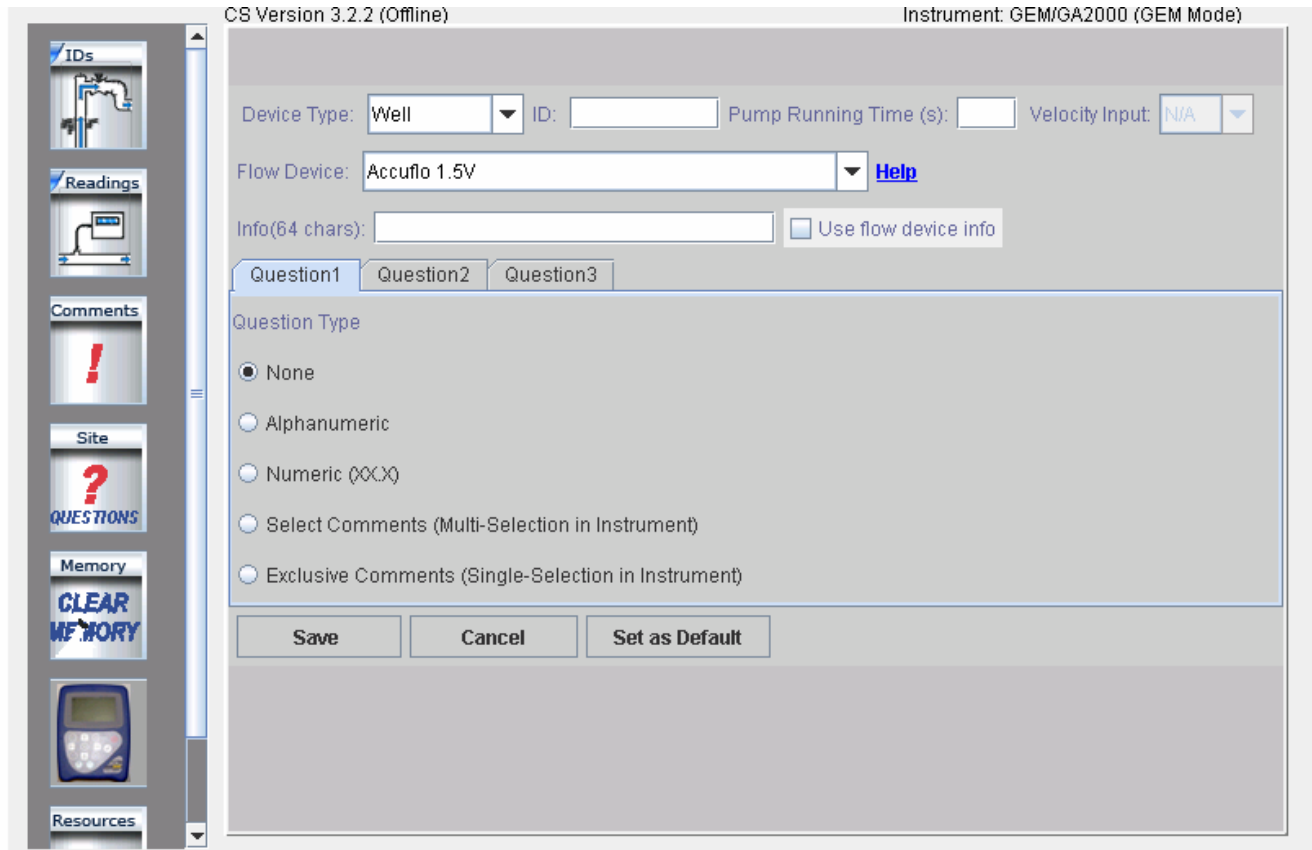
Selecting the **Save File** button will allow you to enter the name for the file you wish to save. The naming of files follows the extended naming convention for Windows (255 characters maximum, all characters allowed except \ / : \* ? " < > |).

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 IDs in the instrument to be downloaded for modification such as increasing the pump run time or adding additional comments to a specific ID. **CAUTION:** Loading IDs from an instrument can be a dangerous practice and is not recommended if using DF online service. The possibility exists of introducing into a project IDs from another project. When the IDs are downloaded from the instrument and stored online all IDs that are present in the instrument will be stored to the current project **IRRESPECTIVE** of if the IDs belong to the project.

**Add ID** button is used for the creation of a new ID or multiple IDs 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 pump run time in seconds (maximum of 999 seconds); pump run time must be entered in order for the pump to be turned on for gas sampling. Enter information about the well, such as its location, previous problems, etc or leave blank. Enter the type of flow device used with the well (Accu-Flo wellhead, Pitot tube, or orifice plate); user input may also be selected. If Pitot tube or orifice plate is selected, the **inside** pipe diameter and **orifice diameter** must be entered. If the pump run time and the flow device are going to be the same for multiple wells, click on **Set as Default** to lock these two values. Three questions may be asked about the well for reply by the technician at the time a sample is taken. These can take the form of alphanumeric, numeric, selected comments or exclusive comments. If none is selected then no questions will be asked for this ID. Note: **If Select Comments or Exclusive Comments is selected, Comments must be created and sent to the instrument.** See section 6.6.1.

## GEM™2000 & GEM™2000 Plus Operation Manual

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

CS Version 3.2.2 (Offline) Instrument: GEM/GA2000 (GEM Mode)

File Name:

ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Question 3
SITE0001	120	Just off the ...	Accuflo 2V	0	0	N/A	N/A	N/A

Load from File    Load from Instrument    Save File    Send to Instrument

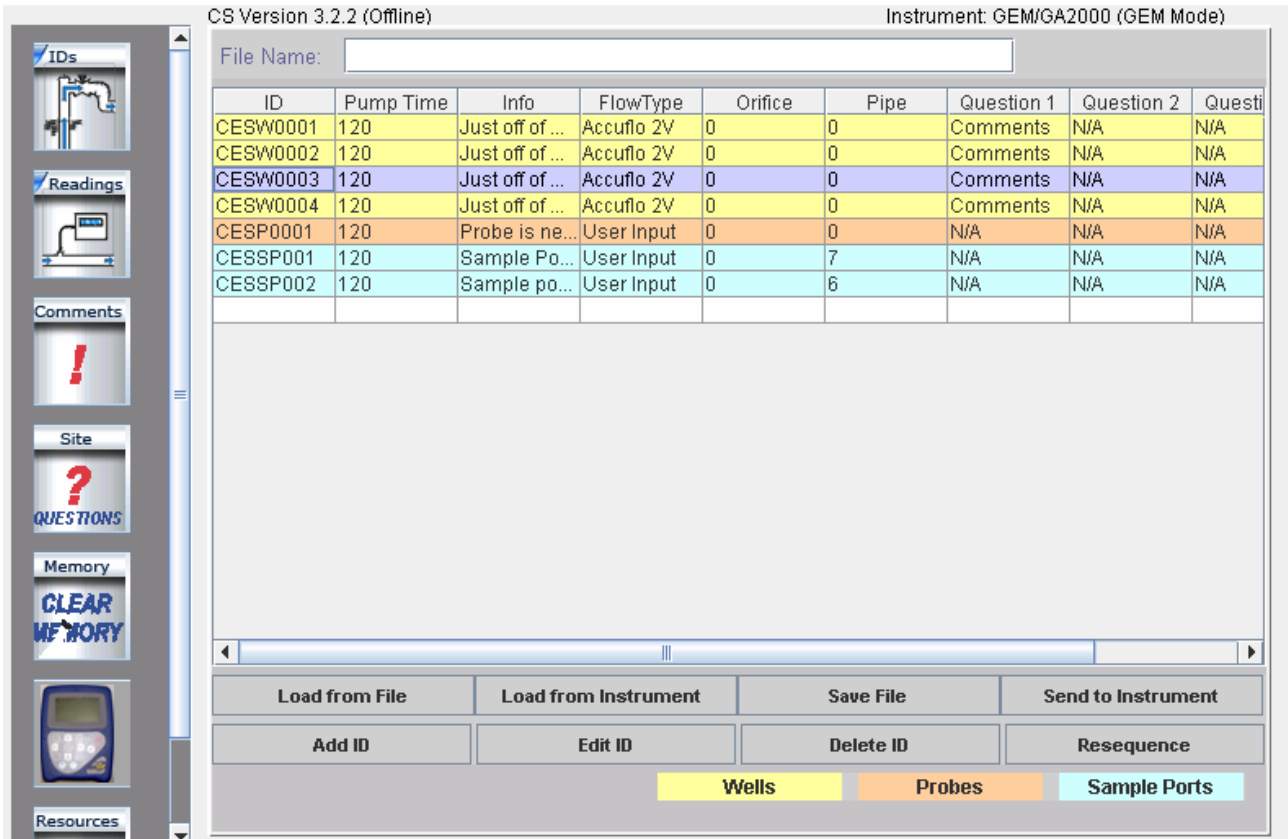
Add ID    Edit ID    Delete ID    Resequence

Wells    Probes    Sample Ports

Once all the IDs have been entered, click **Save 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.

### 6.6.3 Editing IDs

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



To select an ID for editing, click on the ID to highlight the ID, and then click on the **Edit ID** button. 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.

CS Version 3.2.2 (Offline) Instrument: GEM/GA2000 (GEM Mode)

Device Type:  ID:  Pump Running Time (s):  Velocity Input:


Flow Device:  [Help](#) Pipe Diameter:

Info(64 chars):   Use flow device info

**Question1** Question2 Question3

Question Type

- None
- Alphanumeric
- Numeric (XXX)
- Select Comments (Multi-Selection in Instrument)
- Exclusive Comments (Single-Selection in Instrument)

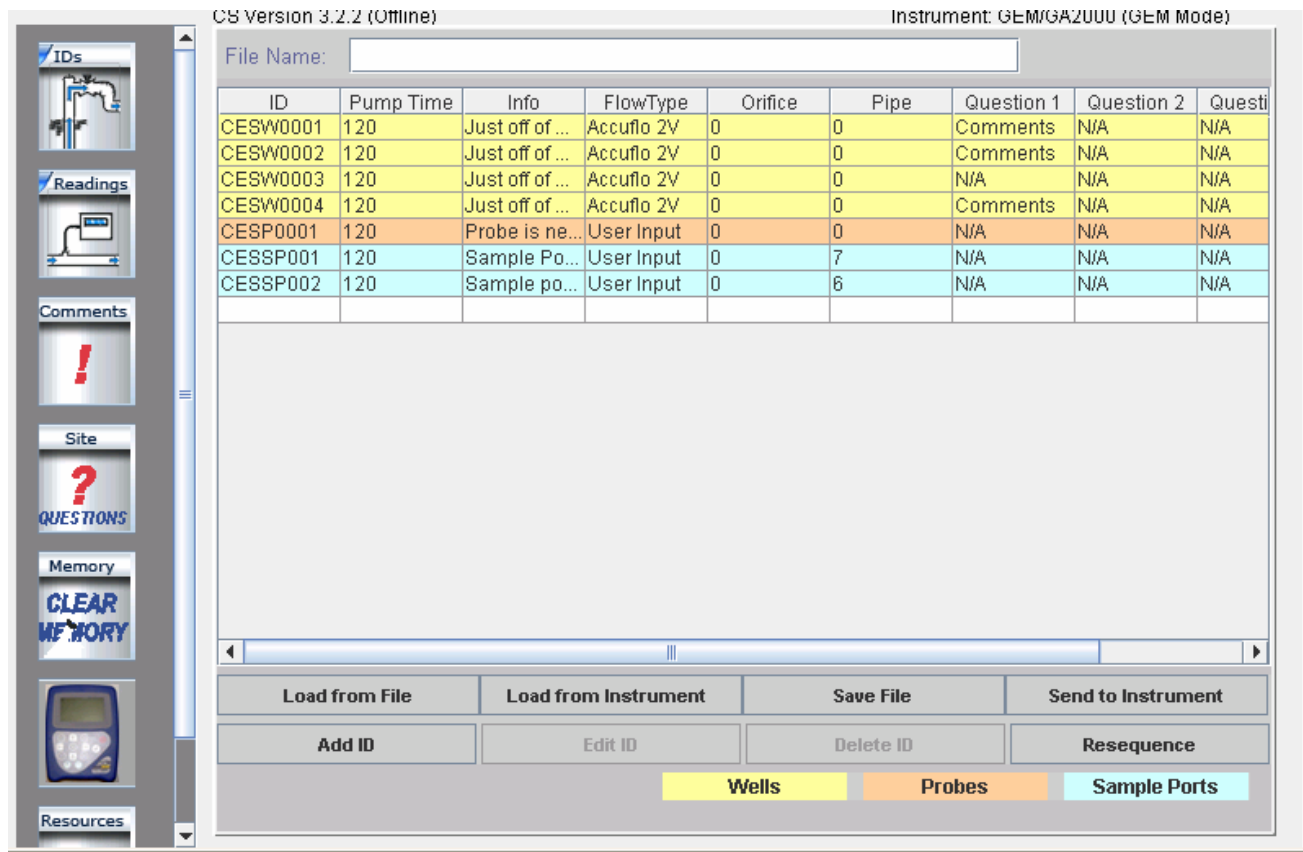


When editing is completed, click on **Save** to return to the previous screen. Click on **Save File** to save the edited data to disk or click on **Send to Instrument** to append the IDs to the IDs in the instrument.

**Note:** IDs are only appended to the unit. It is strongly recommended to erase/clear IDs from unit prior to sending new IDs to the unit. One obvious exception is in the case of loading IDs for multiple sites in an instrument.

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### 6.6.4 Delete IDs

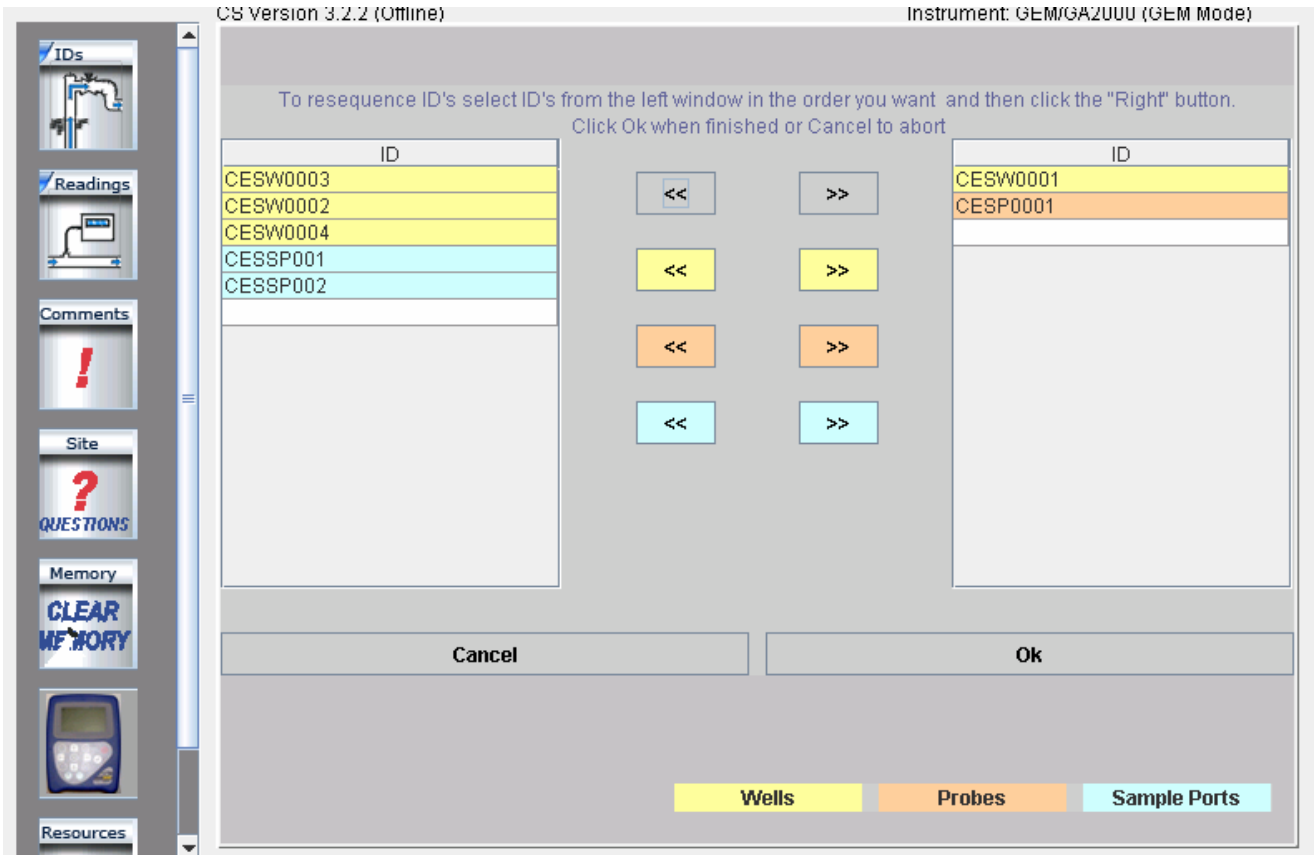
Select an ID to delete and click on it to highlight it. Click on the **Delete ID** button. A prompt will appear to verify the action. Clicking **Yes** will delete the ID. To select multiple IDs use **Ctrl** and **Shift** buttons on your keyboard. When deleting multiple IDs after clicking on the **Delete ID** button a prompt will appear: “Would you like to verify each deletion?” Clicking **No** will delete all the selected IDs. Clicking **Yes** will prompt on the deletion of each ID in the selection. In this case the deletion of some IDs in the selection can be cancelled.

Click on **Save File** to save the updated file to disk or click on **Send to Instrument** to update the instrument for field sampling.

**Note:** We suggest clearing the ID information from the instrument prior to uploading the revised ID list. Otherwise the new ID list will be appended to the existing list. Clearing IDs in the instrument will clear IDs in the both GEM & GA modes of operation.

### 6.6.5 Re-sequencing

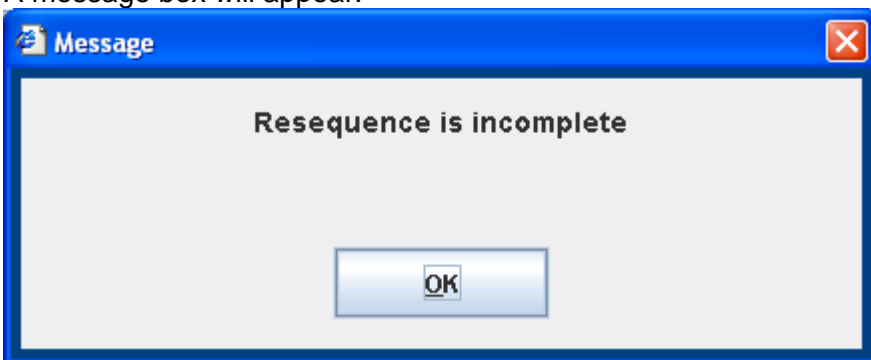
With DataField CS it is possible to change the order of the IDs in a file to put them in the same order as they are sampled in the field. This is called **Re-sequencing**. To re-sequence an ID data set, click on the **ID** button to open the ID editor. Load the ID data set from a file or download the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



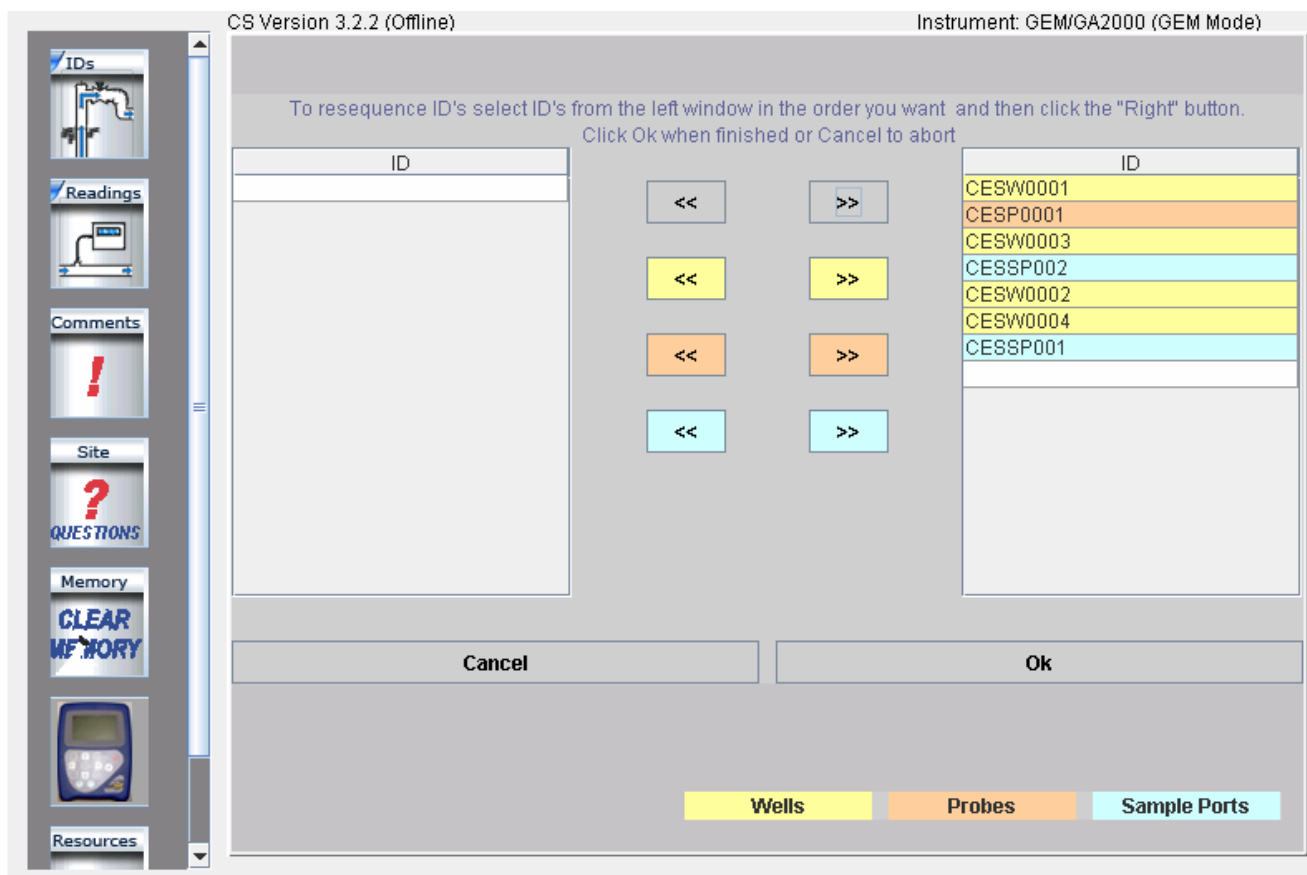
Select the ID from the left side window and click on the **Right** button to move ID to the right window to create the new sequence order. Repeat this process moving all IDs to the right side in the desired order.

If you click OK before all ID's are moved to the right hand side of the screen, you'll get a message indicating that the sequence is Incomplete.

A message box will appear.



Once all of the ID's are in the right hand window, Click OK



Clicking OK, returns you to the well ID screen and you'll see the ID's in your new sequence.

CS Version 3.2.2 (Offline) Instrument: GEM/GA2000 (GEM Mode)

File Name:

ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
CESW0001	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESP0001	120	Probe is ne...	User Input	0.0	0.0	N/A	N/A	N/A
CESW0002	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0003	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0004	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESSP001	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A
CESSP002	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A

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.

### Saving the ID File to disk:

Save

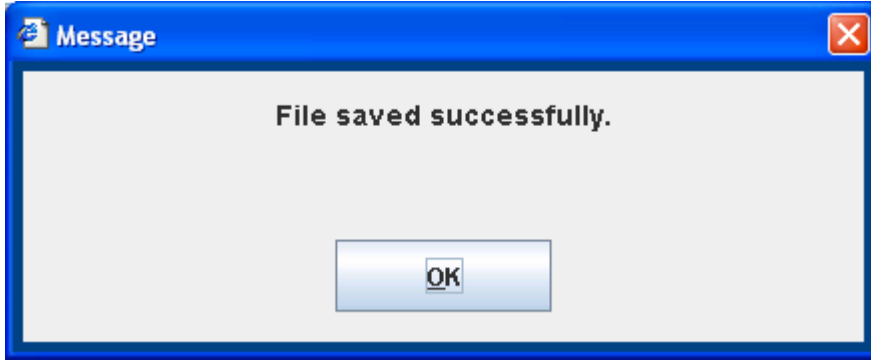
Save In:

My Music  
 My Pictures

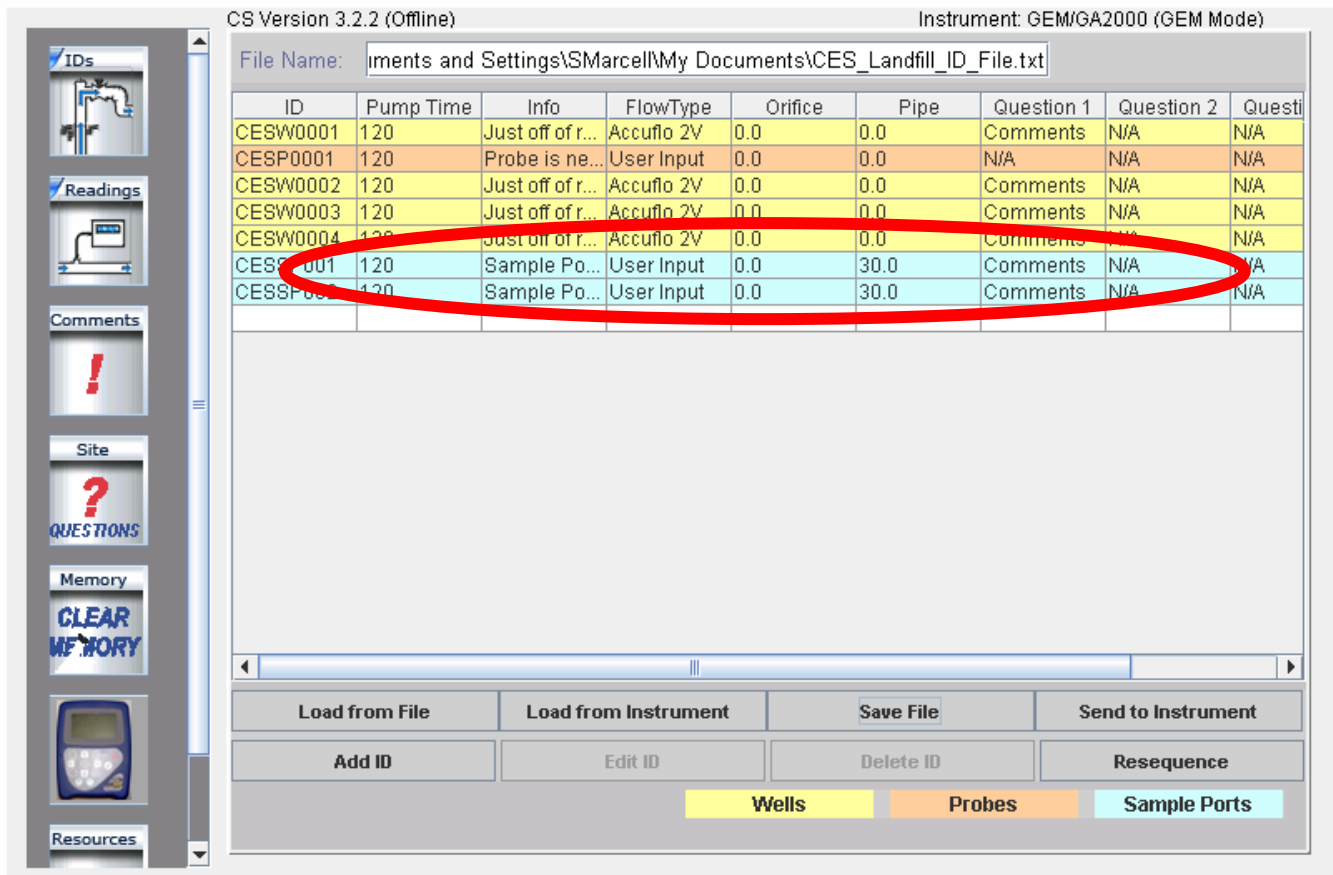
File Name:

Files of Type:

Enter in a name for the file and then click on the Save Button.



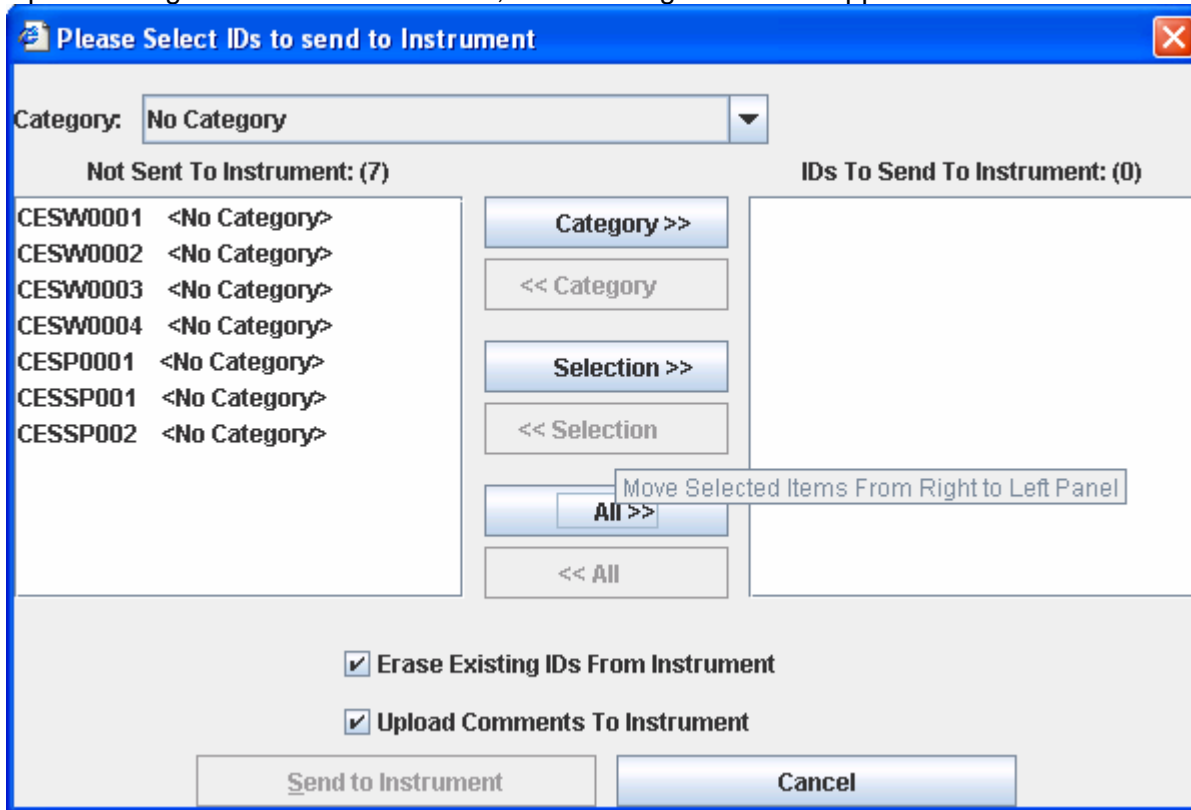
Once Saved, the main ID screen will now show the name of your ID file.



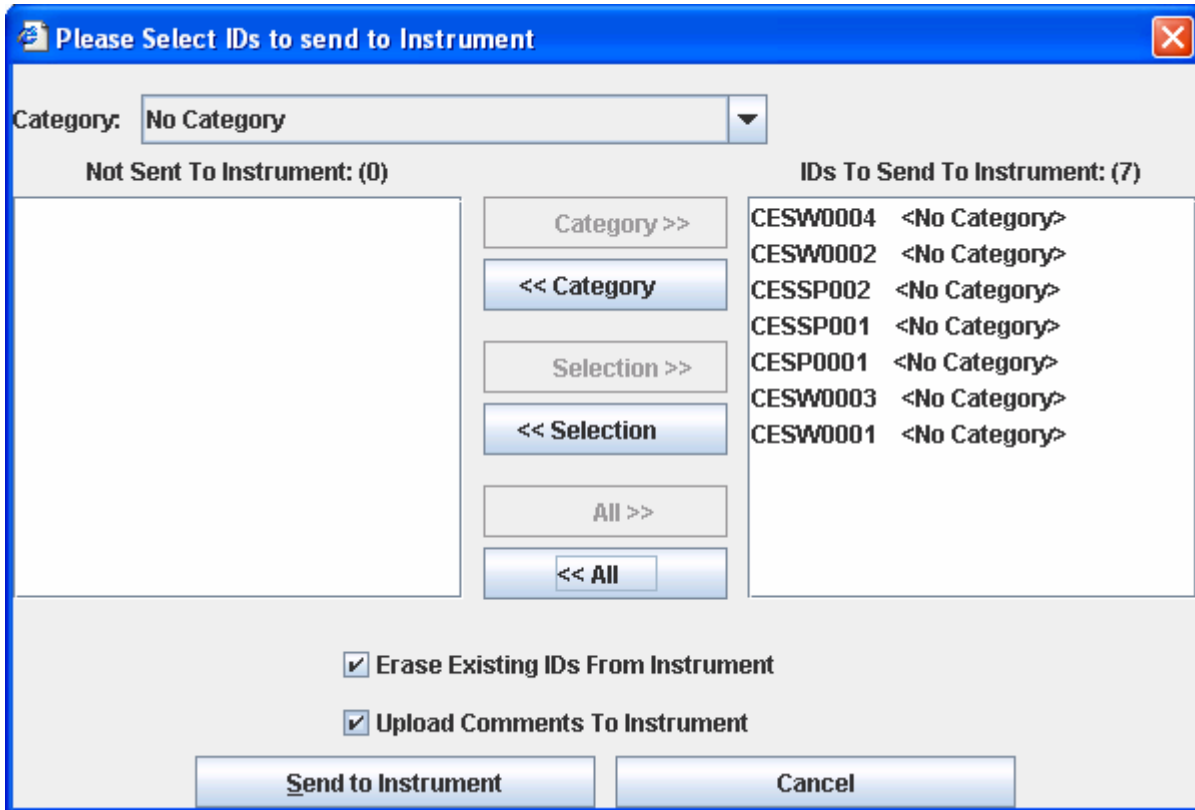
**Note:** It is suggested to clear ID information from the instrument prior to uploading the re-sequenced ID list. Otherwise the new ID list will be appended to the existing list. Clearing IDs in the instrument will clear IDs in the both GEM & GA modes of operation.

## Sending ID's to the Instrument

Upon clicking Send ID's to Instrument, the following screen will appear.



You can choose ID's on the left side and send them to the right side one at a time by clicking on **Selection>>** or the ID's can all be sent by clicking on the **All>>** button.

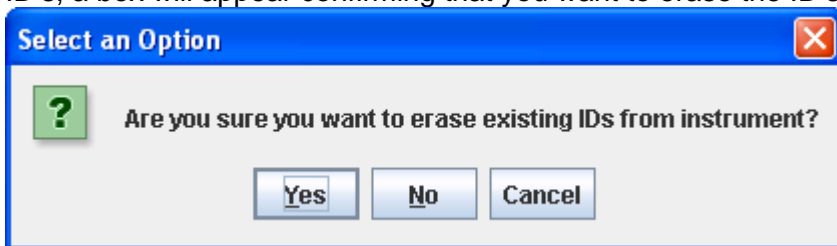


Once the ID's have been selected, they appear in the right hand window. Once all desired ID's are in the right hand window they will need to be sent to the instrument.

Two options exist:

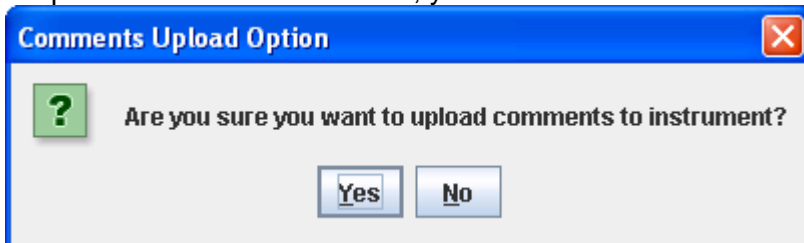
- Erase Existing ID's will erase the existing ID's from the instrument if any ID's are present in the instrument.
- Upload Comments to the Instrument.

Once the options are selected, click on the **Send to Instrument** button. If you selected the Erase Existing ID's, a box will appear confirming that you want to erase the ID's that are in the instrument.

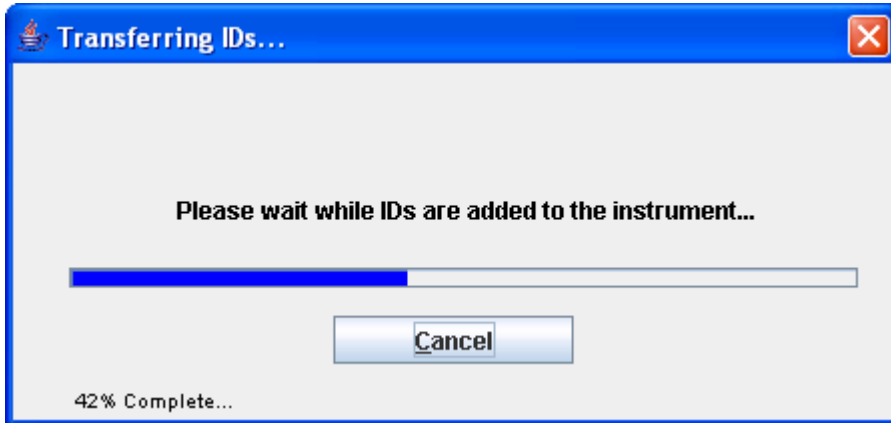


Answer Yes if you wish to erase the ID's.

If Upload comments is checked, you'll need to click on Yes when the comments upload appears.



A progress bar will appear during the upload process.



Once complete, a message will appear indicating the upload status.



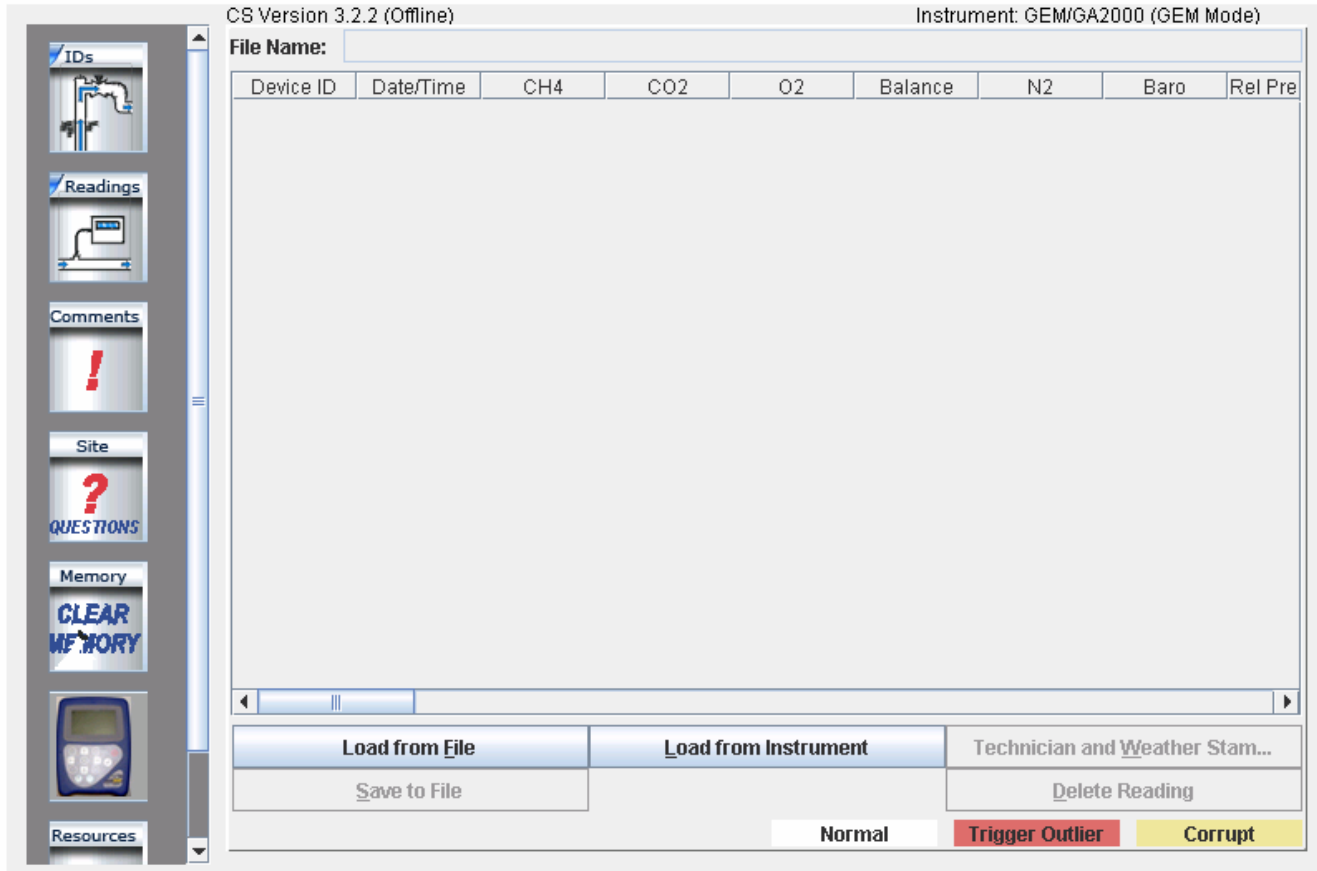
Click OK to continue.



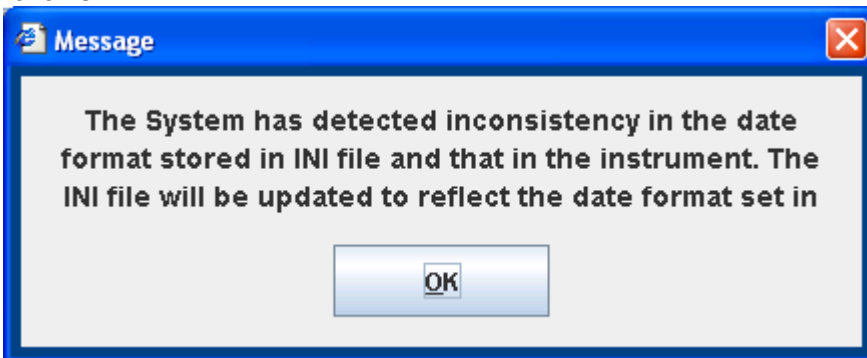
### 6.6.6 Readings



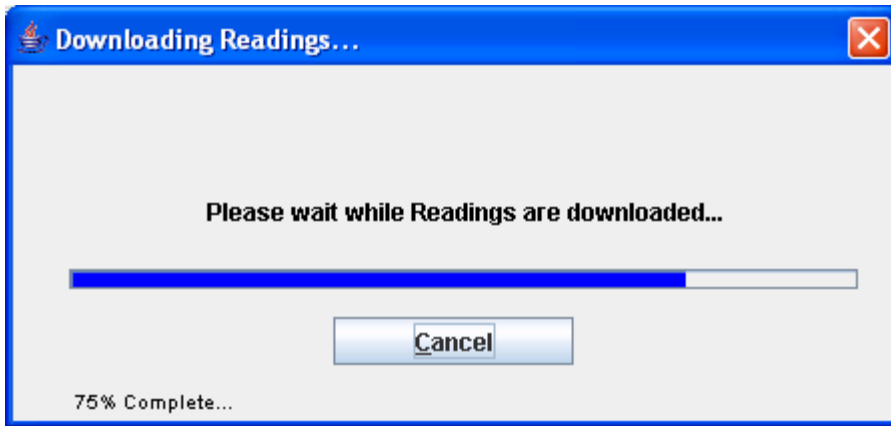
The Readings screen provides the capability to download, upload, view, save data to a file and delete individual or multiple readings from a data set. Click on the **Readings** button to open the screen shown below.



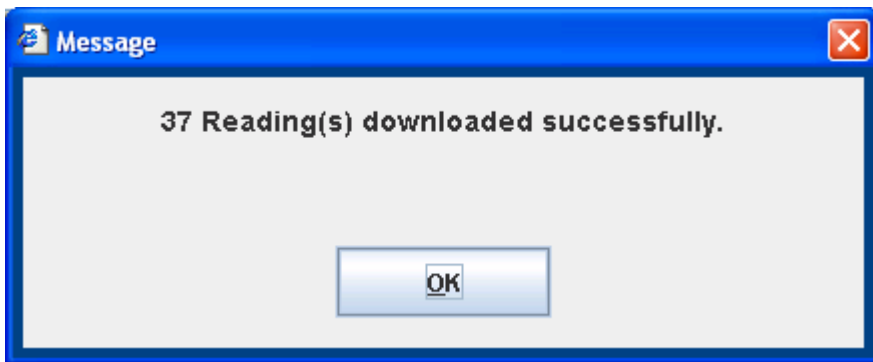
Click on the load from instrument button. The first time you click on this button you'll get a message as follows:



Click OK to update the INI file settings to match your instrument.



Readings will be downloaded from your instrument and a message box will appear indicating the number of readings downloaded.



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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. All readings should be downloaded on a daily basis. While the instrument can hold readings for an extended period of time, it is recommended to download them to a non-volatile memory device (e.g. hard drive, CD, etc.).

CS Version 3.2.2 (Offline) Instrument: GEM/GA2000 (GEM Mode)

File Name: \_\_\_\_\_

Device ID	Date/Time	CH4 [%]	CO2 [%]	O2 [%]	Balance [%]	N2 [%]	Baro [in Hg]	Rel Pres
TEQUW001	6/8/06 12:1...	38.9	26	8.7	26.39	N/A	29.06	N/A
TEQUW095	6/8/06 12:3...	43.2	26.3	1.3	29.2	N/A	29.03	N/A
TEQUW002	6/8/06 12:4...	40	26.2	0.9	32.89	N/A	29.03	N/A
CESW0001	6/22/06 9:4...	0	0	20.9	79.1	N/A	28.89	N/A

Left sidebar: IDs, Readings, Comments, Site, Memory, Resources

Buttons: Load from File, Load from Instrument, Technician and Weather Stam..., Save to File, Delete Reading

Reading Status: Normal, Trigger Outlier, Corrupt

Once the file has been opened or data downloaded from the instrument, the readings can be either **stored online** (only with the online version) or **saved to a file** (only with the offline version). When the instrument is in the GA Mode the readings can also be **sent to the instrument**. **Send to Instrument** button will be disabled when the instrument is in the GEM Mode. The screenshot above shows the online version with the instrument in the GEM mode.

### 6.6.7 Delete Readings

Highlight the row you wish to delete. Click **Delete Readings**.

[message] "are you sure you want to delete" Click **Yes**. This will remove the reading in the highlighted row.

After verifying your readings Click on **Save File** button if you wish to save the file for future use.

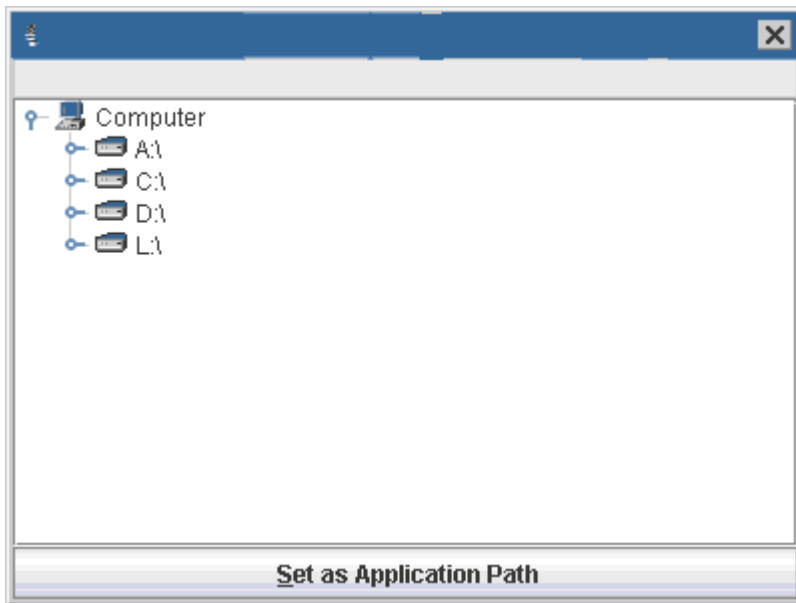
This will bring up a screen for TECHNICIAN AND WEATHER STAMPING

THE Instrument ID will already be entered. Enter the Technician initials Next enter applicable information [all entries must be numbers except Technician initials]. Click **Stamp Readings** at the bottom

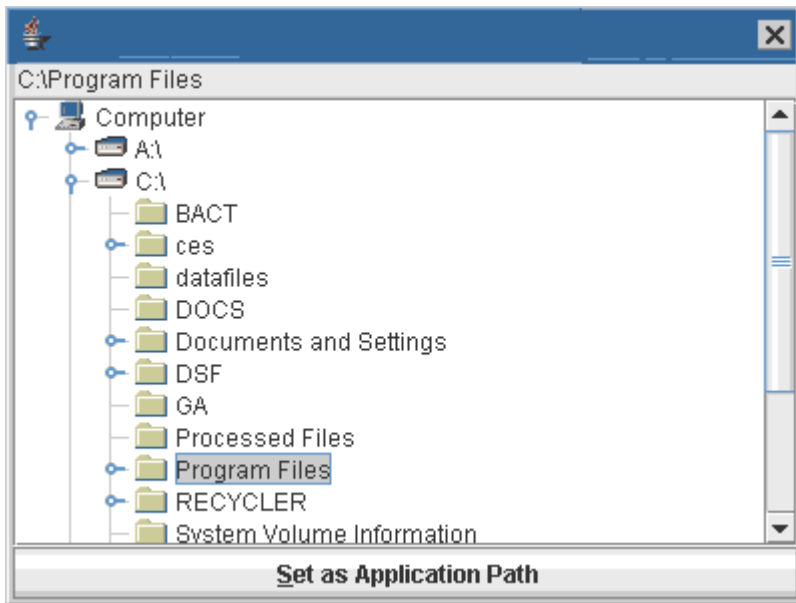
If this is the first time you are saving a readings file you will see this message

We suggest the path C:\Program Files\CES\DF32

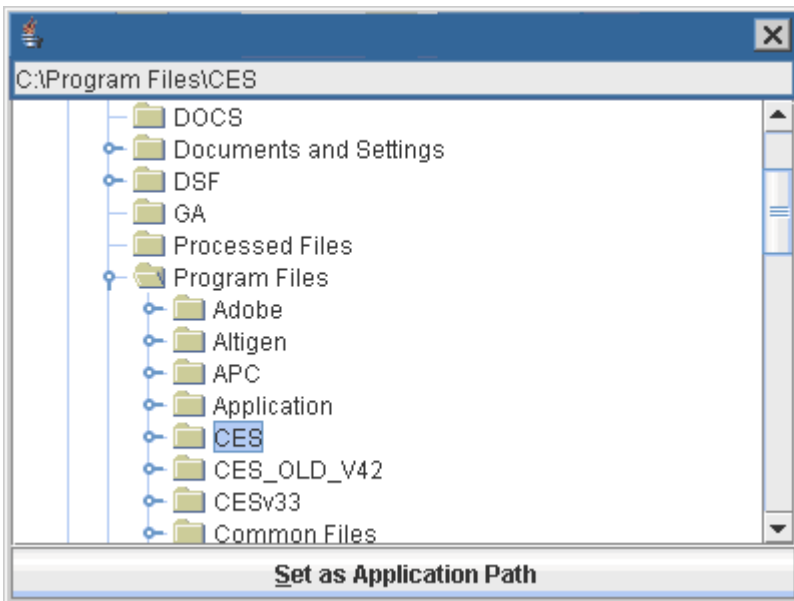
Click OK



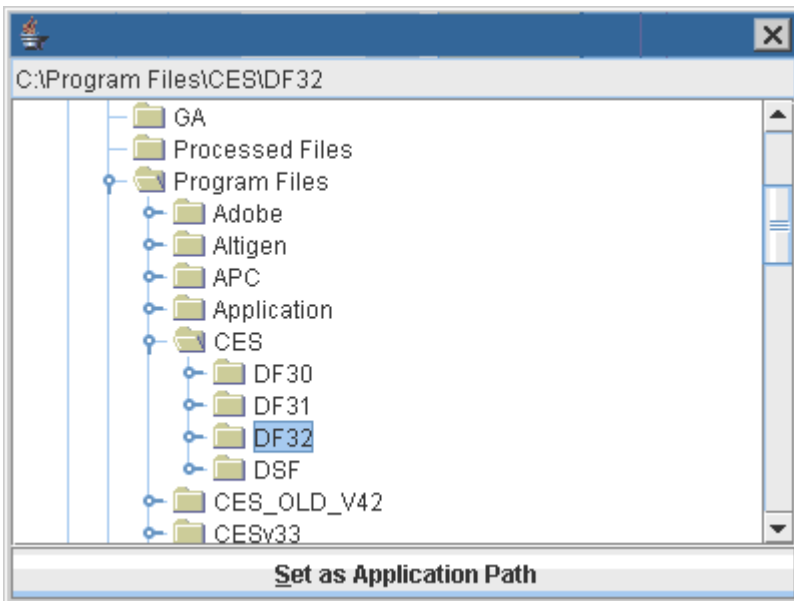
Select C double click



Select Program Files



Select CES

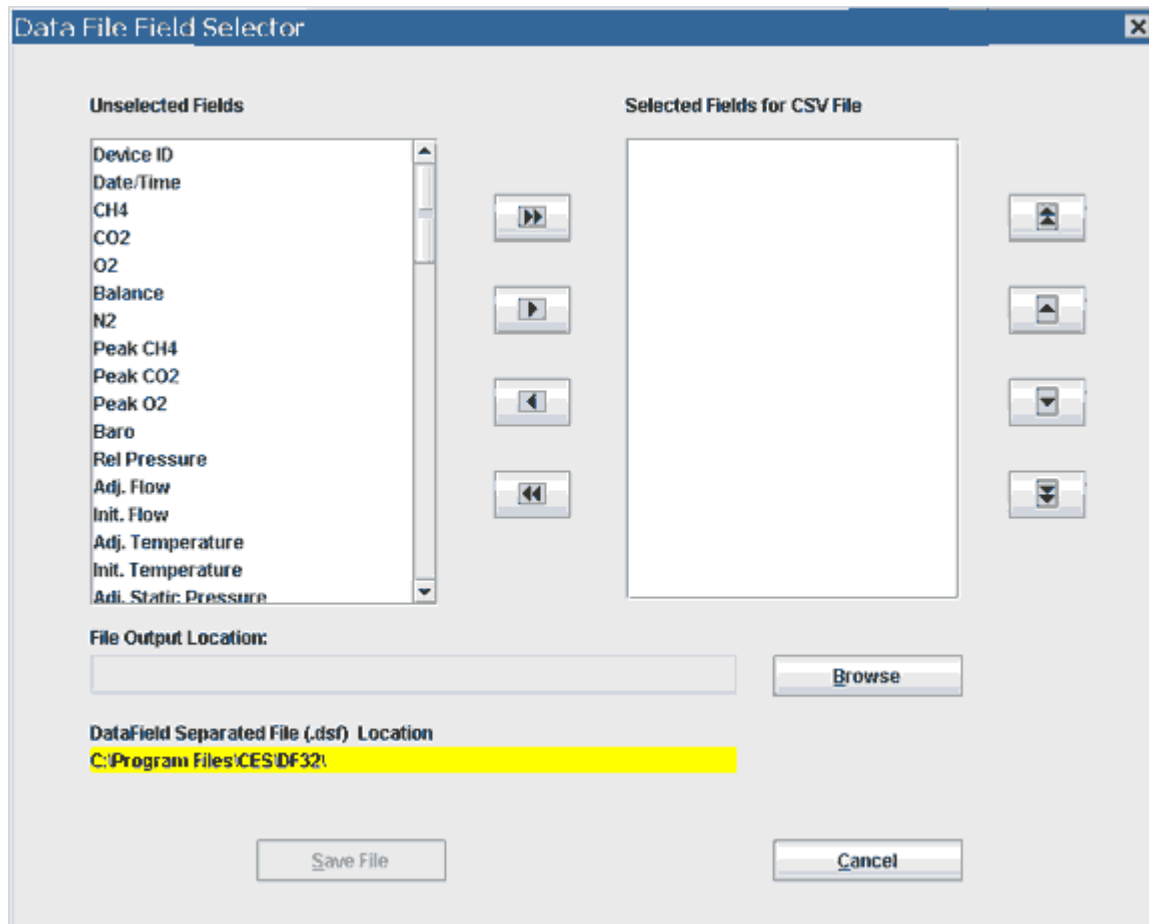


Select DF32



Click on Set as Application Path

Now you will go to the screen where you select only the headings you want



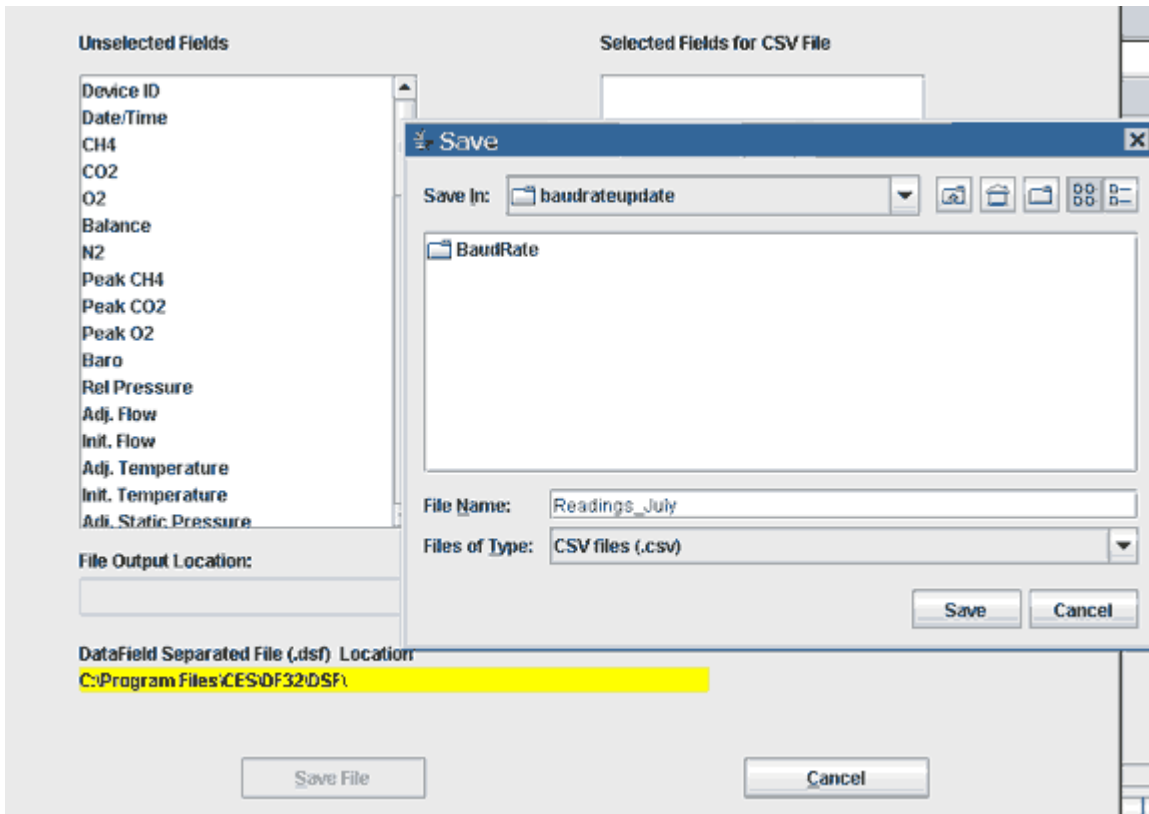
You will see the path set in the dsf location address

You only set this path one time after setting this when you Click **Save to File**. This will open a new window.

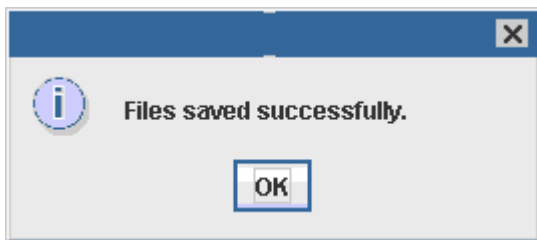
The raw data file will be saved as a dsf file, for which you have set the path the first time you save after that the dsf path will be in the highlighted box so all your dsf files will be saved to this location this is the raw data file that will load back to the readings page when you use load from file, we suggest the path be C:\PROGRAM FILES\CES\DF32 from the pull downs.

For your report sheet choose the headings you wish to use on the field selector page move headings to the right hand side then they may be move up or down in order by highlighting and using the up and down arrows on the left.

After all headings have been selected and order has been completed click **browse**, as with the ID function this will open a new window (this will save the location of the csv file that opens in excel). Choose the location and folder enter the name you wish to save the file with, **then click save file button**, but you have **only saved the location**. You will be returned to the field selector page at the bottom of the page **click on the save file** The program will prompt you with the file saved click OK [The csv and dsf file are now both saved



Note: If you load from file and you must be sure and load the dsf original file. The dsf files will all be save at the location you have set the path for

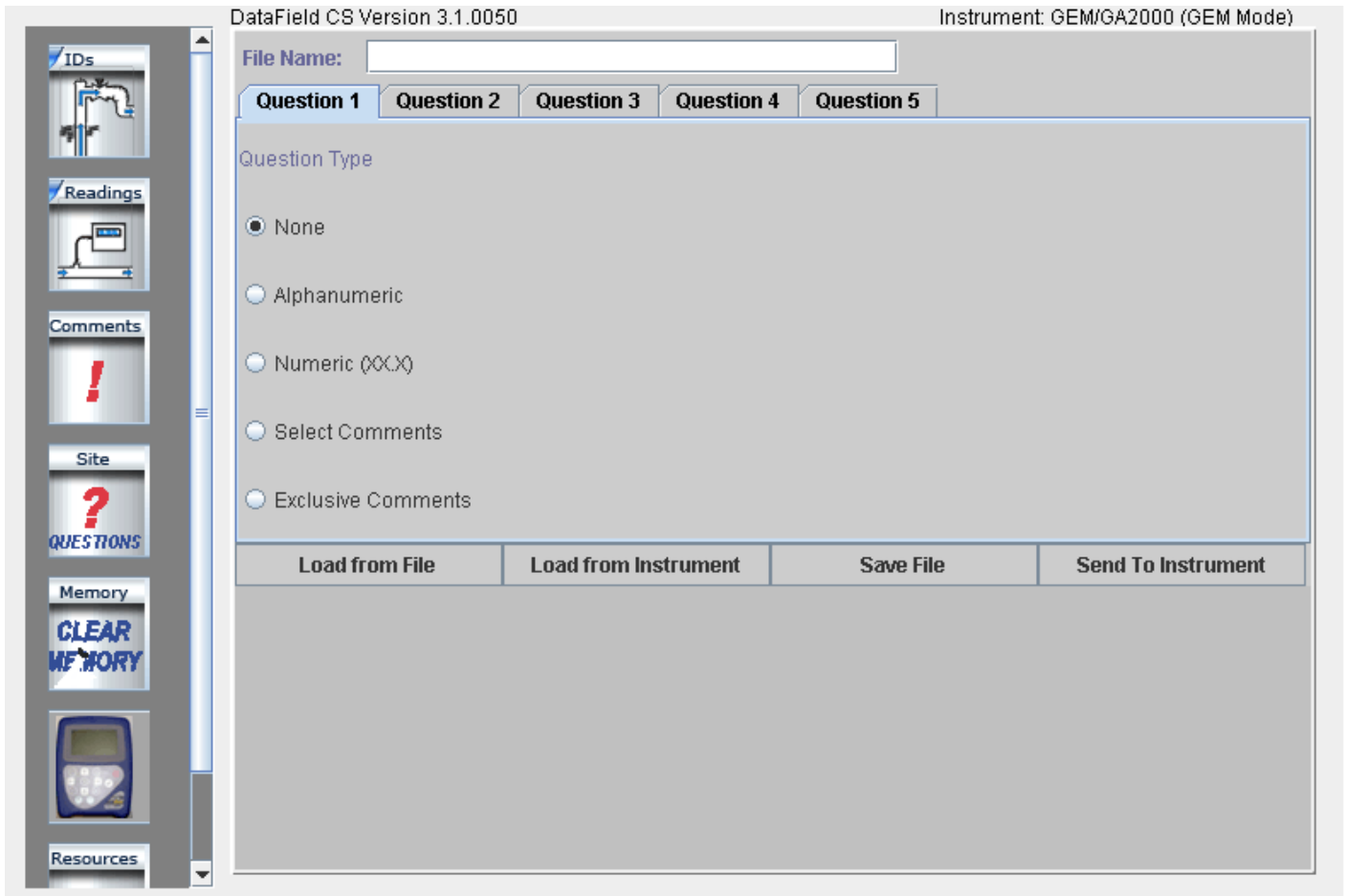




6.6.8 Site Questions



DataField CS supports up to five site questions. Site questions are answered only when **Update Site Data** is selected from the GEM menu screen and appended to all IDs taken thereafter until Update Site Data is selected again. This is a useful feature if conditions change in various locations on the landfill site or for selected wells/probes. Site questions can be either alphanumeric, numeric, select comment (the technician selects the comment from a list of ten answers) or exclusive comments (the technician may select only **ONE** exclusive question from a list of 10 answers). From the opening screen, click on the **Site Questions** button to open the following screen.



**Note:** Site questions must be created and sent to the instrument by the software prior to going into the field. They can not be hand inputted into the instrument in the field.

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Click on the open spot, to the left of the alphanumeric category in **Question Type** to define Question 1 and type in the question.

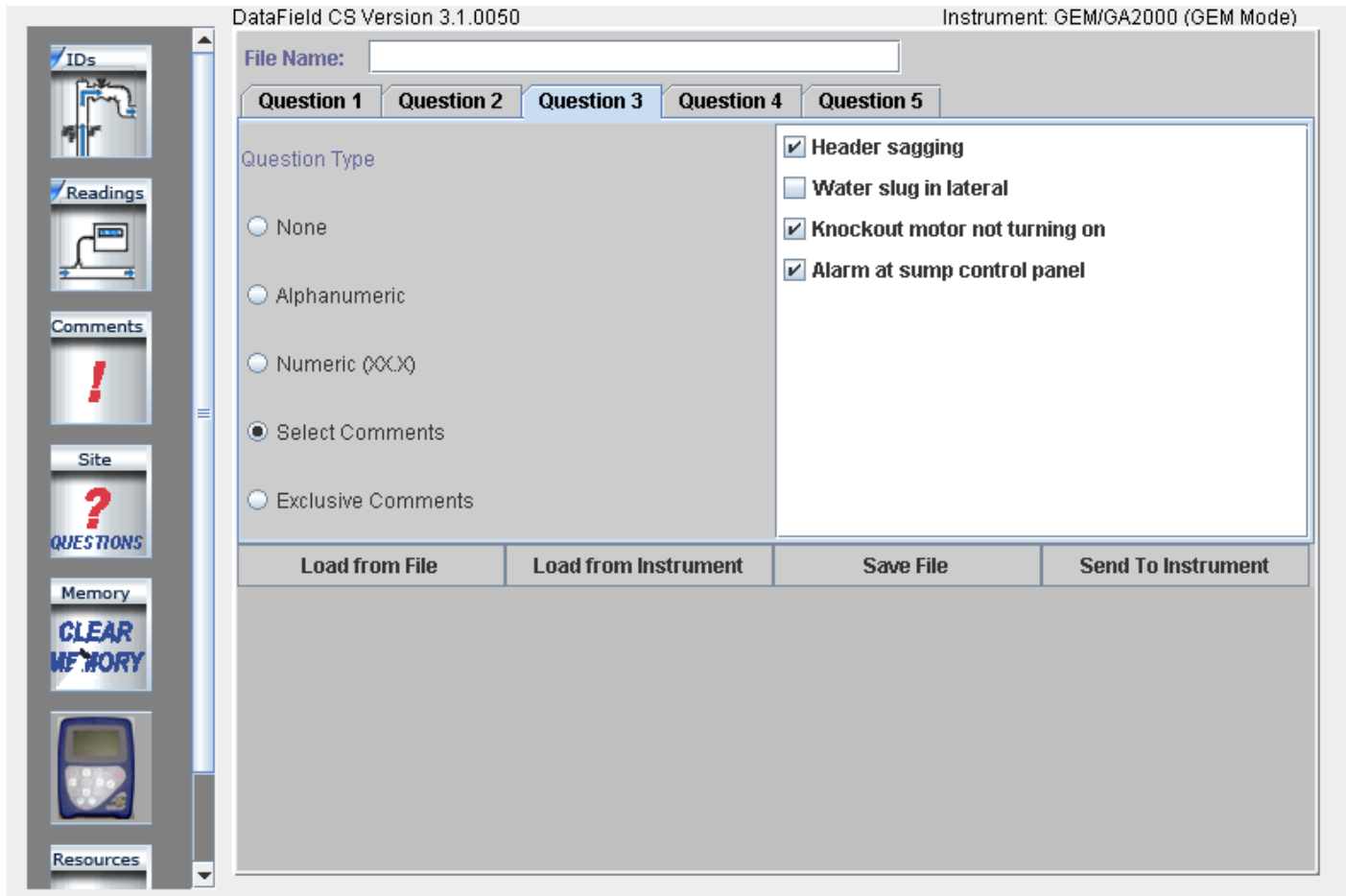
The screenshot shows the DataField CS software interface. At the top, it displays "DataField CS Version 3.1.0050" and "Instrument: GEM/GA2000 (GEM Mode)". Below this is a "File Name:" field. The main area is divided into five tabs: "Question 1", "Question 2", "Question 3", "Question 4", and "Question 5". The "Question 1" tab is active. Underneath the tabs, there is a "Question Type" section with several radio button options: "None", "Alphanumeric" (which is selected), "Numeric (XXX)", "Select Comments", and "Exclusive Comments". To the right of these options, there is a "Question:" label followed by a text input field containing the text "What is the wind direction?". Above this input field, there is a note: "Question: (up to 70 characters total for all fields)". At the bottom of the question definition area, there are four buttons: "Load from File", "Load from Instrument", "Save File", and "Send To Instrument". On the left side of the interface, there is a vertical toolbar with icons for "IDs", "Readings", "Comments" (with a red exclamation mark), "Site" (with a red question mark), "Memory" (with a "CLEAR MEMORY" button), and "Resources".

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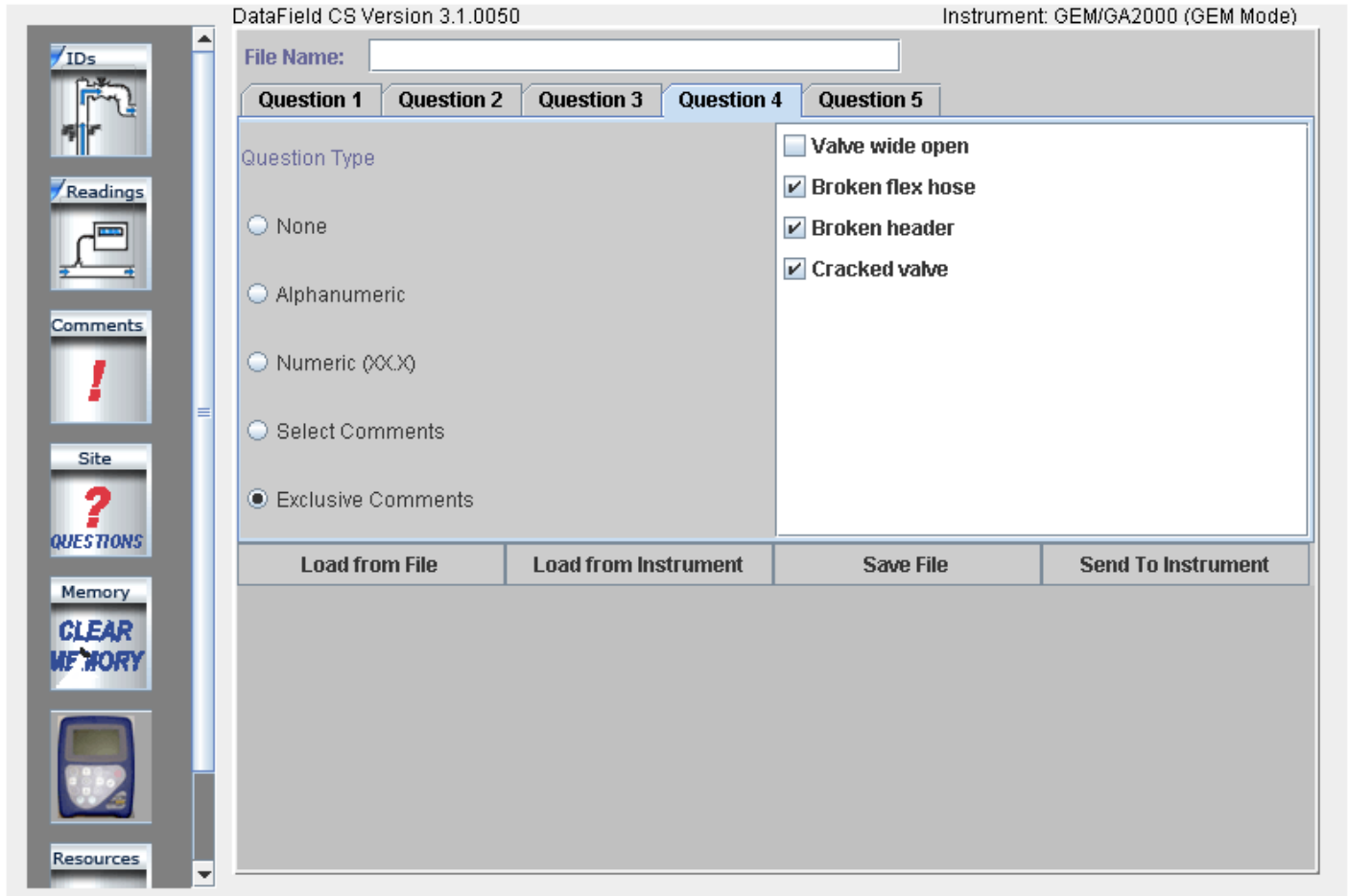
Click on Question 2 and then select Numeric as the Question Type. Note that Answer Format and Unit of Measurement fields appear for this type of question. Answer format refers to the number of digits and decimal places required for the answer. Unit of Measurement refers to inches, feet, yards, etc. for the answer. In this example, XX.X could be equal to 20.5 inches as per the question 'What is the leachate depth in tank?'

The screenshot displays the DataField CS software interface. At the top, it shows 'DataField CS Version 3.1.0050' and 'Instrument: GEM/GA2000 (GEM Mode)'. A 'File Name:' field is present. Below this are tabs for 'Question 1', 'Question 2', 'Question 3', 'Question 4', and 'Question 5', with 'Question 2' selected. The main area is divided into two columns. The left column, labeled 'Question Type', contains radio buttons for 'None', 'Alphanumeric', 'Numeric (XXX)', 'Select Comments', and 'Exclusive Comments'. The 'Numeric (XXX)' option is selected. The right column, labeled 'Question: (up to 70 characters total for all fields)', contains a text input field with the text 'What is the leachate depth?'. Below this, the 'Answer Format:' field contains 'XXX' and a 'Help' link. The 'Unit of Measurement:' field contains 'inches'. At the bottom of the main area are four buttons: 'Load from File', 'Load from Instrument', 'Save File', and 'Send To Instrument'. On the left side of the interface is a vertical toolbar with icons for 'IDs', 'Readings', 'Comments', 'Site', 'Memory', and 'Resources'. The 'Comments' icon is a red exclamation mark, and the 'Memory' icon says 'CLEAR MEMORY'.

Comments may also be used as a site question; however, comments must be downloaded from an instrument that already has comments loaded in it. Connect the GEM™2000 / GEM™2000 Plus and be sure it is in the read gas screen. Click on Select Comments and the list of comments from the instrument will open in the window for selection. Ten comments may be selected from the list to become **Site Questions**. Click on the box to the left of the comment to select it. The operator may choose any or all of the ten comments when **Update Site Data** is selected on the instrument.



Exclusive comments are treated in a similar manner as select comments in that they also must be downloaded from the instrument. Ten exclusive comments may be selected, however only **ONE** may be chosen by the operator to become an **Exclusive Comment**.



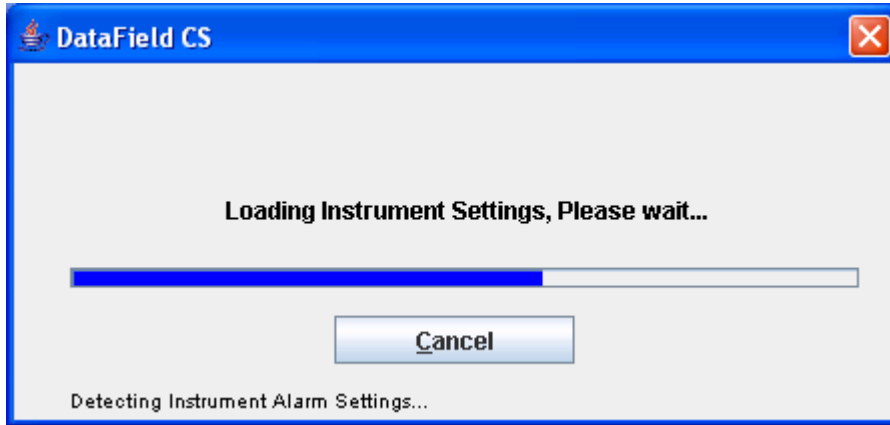
When all the desired questions have been entered, click on **Save File** to retain the information for later use and then click on **Send to Instrument** to update site data in the instrument.

## 6.7 Settings



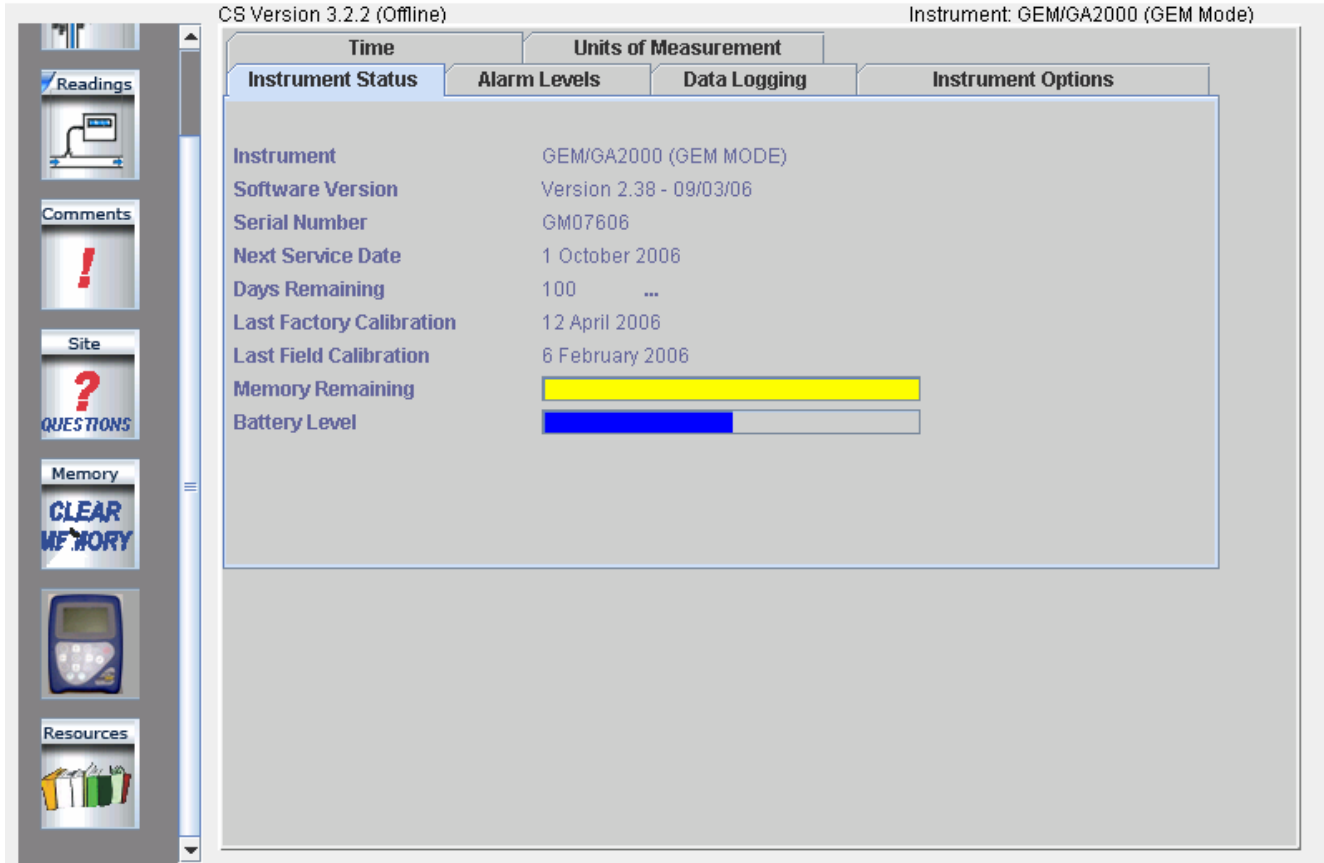
Clicking on the **Settings** button on the main screen will display the **Instrument Settings**. The Instrument settings provide the capability to set or change optional controls in the instrument, such as time/date, data logging (GA mode only), purge times, etc.

Clicking on the Instrument Icon to access the Instrument settings will take a few moments to download all of the instrument.



### 6.7.1 Instrument Settings

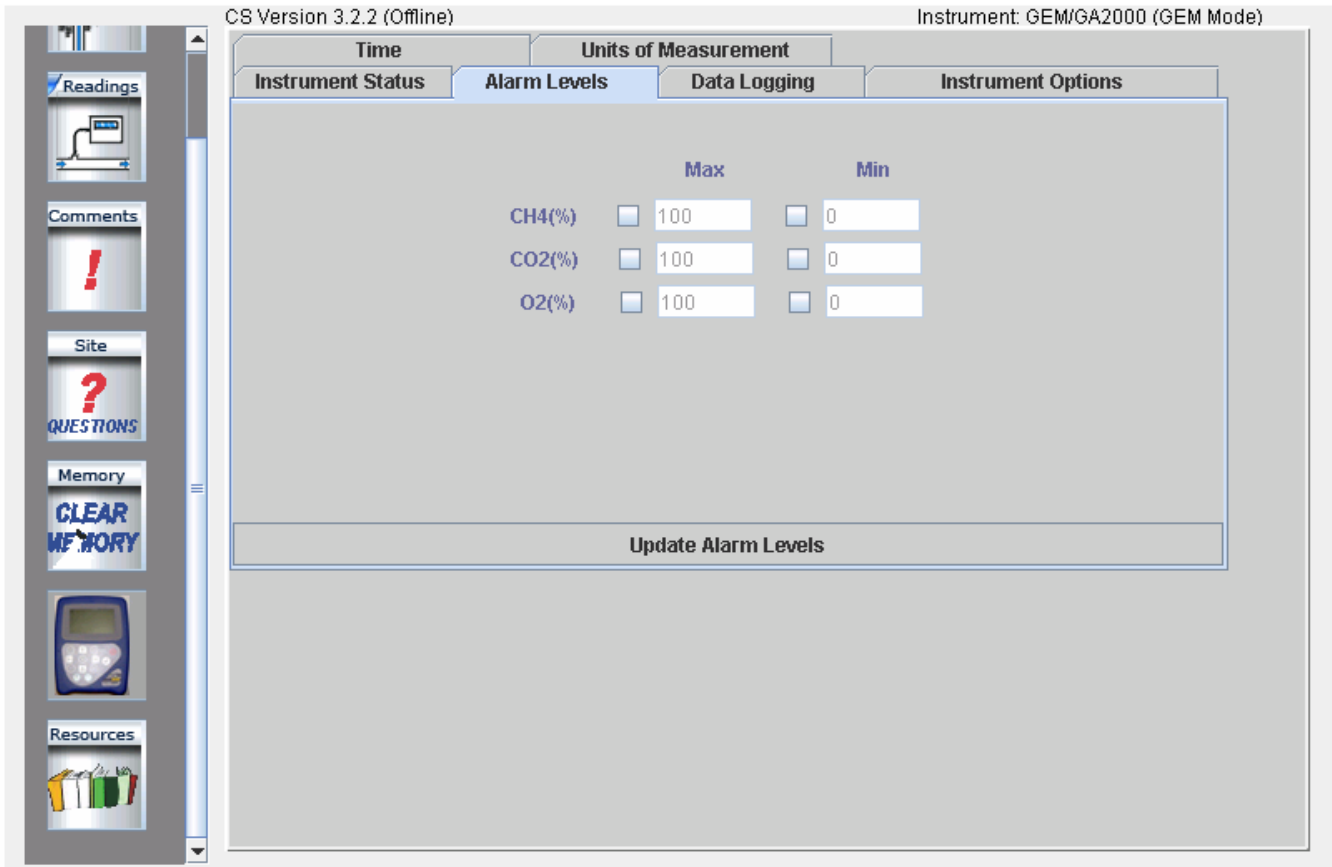
Set the instrument for RS-232 communications and click on the **Settings** button and the following screen will open. The software will establish communications and download the current instrument settings.



Once the current settings have been obtained, the following screen will open.

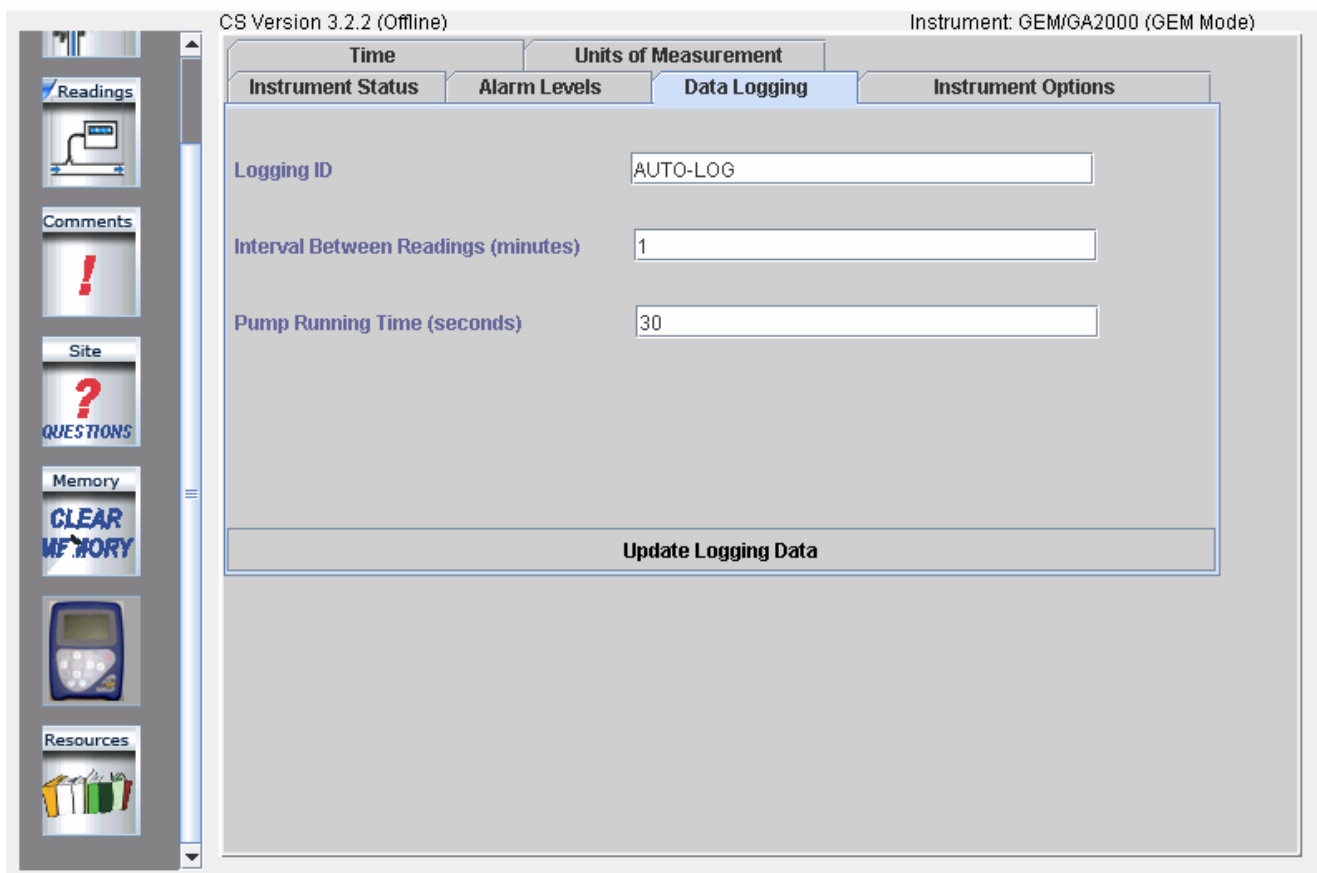
There are six different “Menu Cards” under instrument settings. Each card provides different information or instrument settings that may be changed to update the operation of the GEM™2000 / GEM™2000 Plus. The instrument status card will always be shown first, providing calibration and maintenance information in addition to instrument serial number and software version number.

Click on the card tab for **Alarm Levels** to open the alarm levels screen. Both a maximum alarm and a minimum alarm may be set. Note these are global settings and will be the same for all IDs entered in the instrument. Turn off the alarm by clicking off the check mark next to the gas. Click on **Update Alarm Levels** to send the new settings to the instrument.

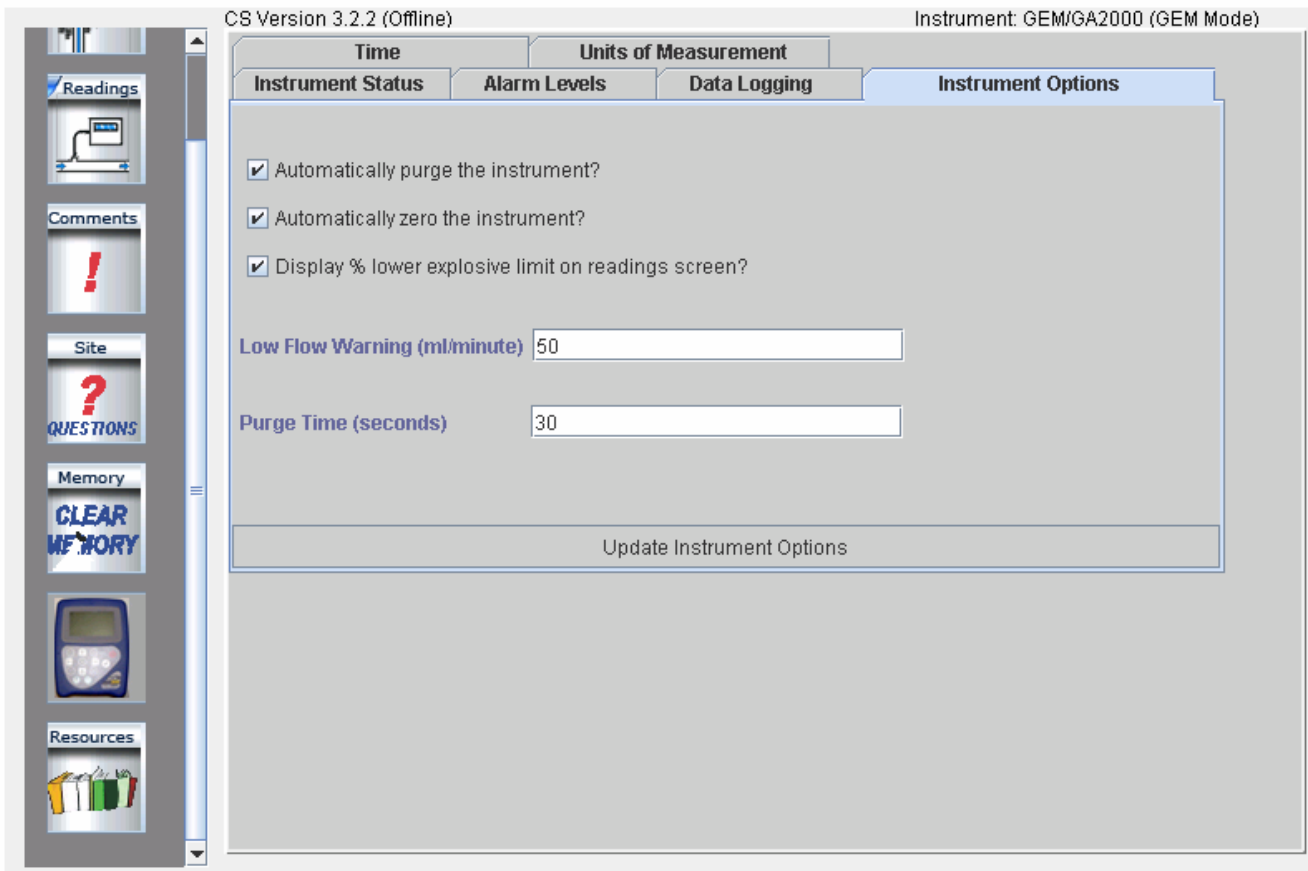




Click on the **Data Logging** card tab to open the data-logging screen. In this screen enter the Logging ID; this may be any alphanumeric combination of eight characters. Enter the interval between readings in minutes and pump run time in seconds. Click on **Update Logging Data** to send to instrument. Only one logging ID may be loaded to the instrument.

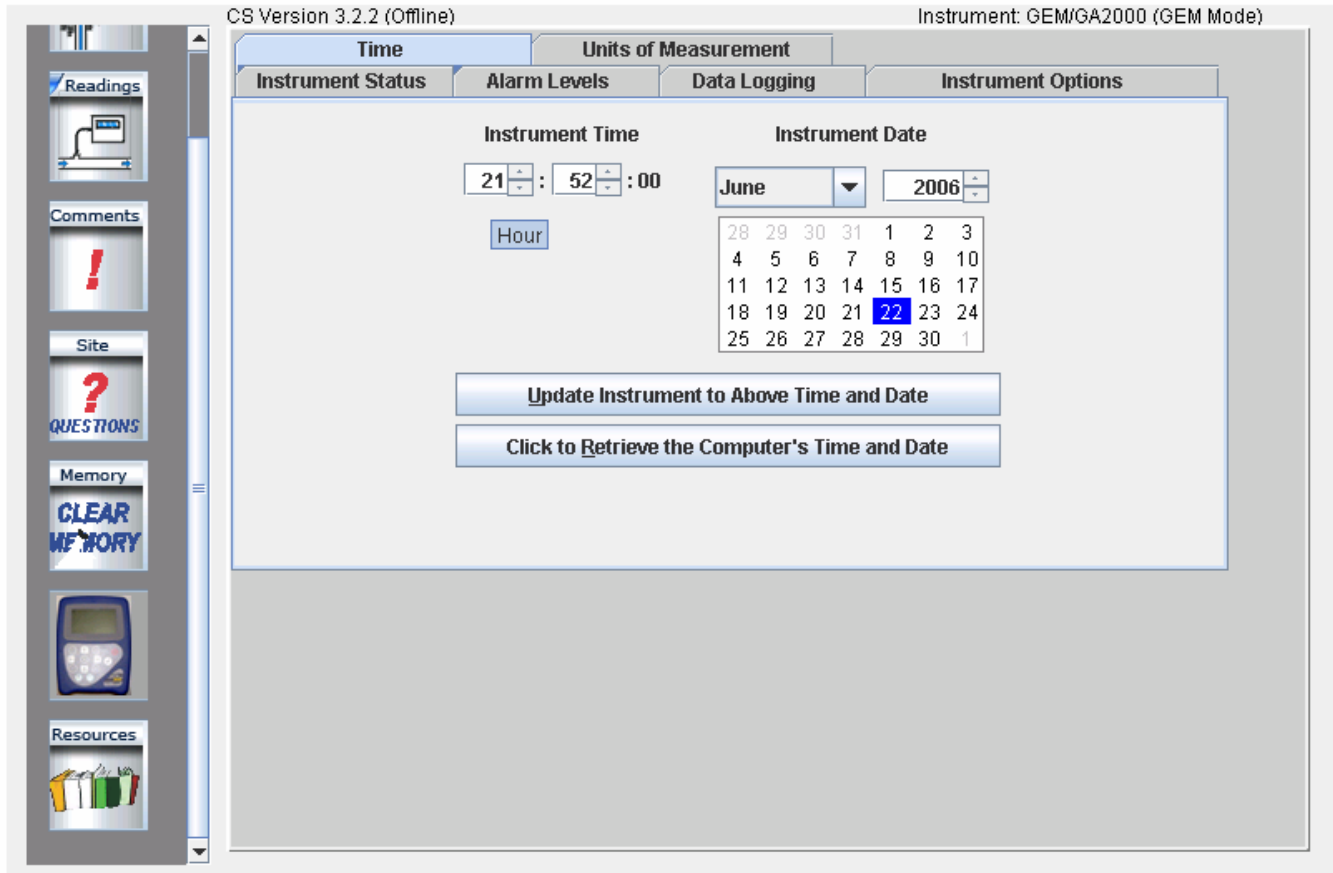


Click on the **Instrument Options** card tab to open the instrument options screen. The settings in this screen affect different global functions of the instrument. Check the corresponding boxes in order to do the following: automatically purge the instrument during a shut down, automatically zero the instrument, display the percent lower explosive limit on readings screen. **Unchecking the last feature will disable % LEL display in both GA and GEM modes of operation.** The **Low Flow Warning** setting controls the point at which the pump is shut off due to low flow conditions. The default setting for this feature is 50 milliliters per minute but may be set to a lower number or even to zero, if sampling on high vacuum systems. The default value for the **Purge Time** is 30 seconds and may be reset to any length required. Turning off this feature is not recommended. Click on the **Update Instrument Options** button to send the new settings to the instrument.



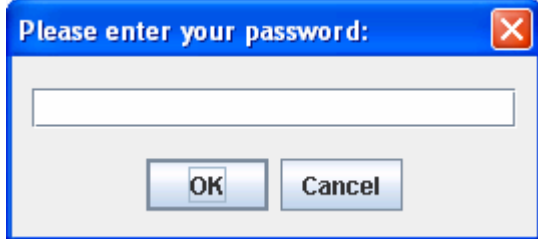
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Click on the Time card tab to open the time and date setting screen. Time and date may be set to the computer time and date settings by clicking on the **Click to Retrieve the Computer's Time and Date** button. Manual setting of the time and date may be accomplished by clicking on the **Update Instrument Time to Above Time and Date**. Any time updates must be done through the software. The instrument time can not be manually updated in the field.

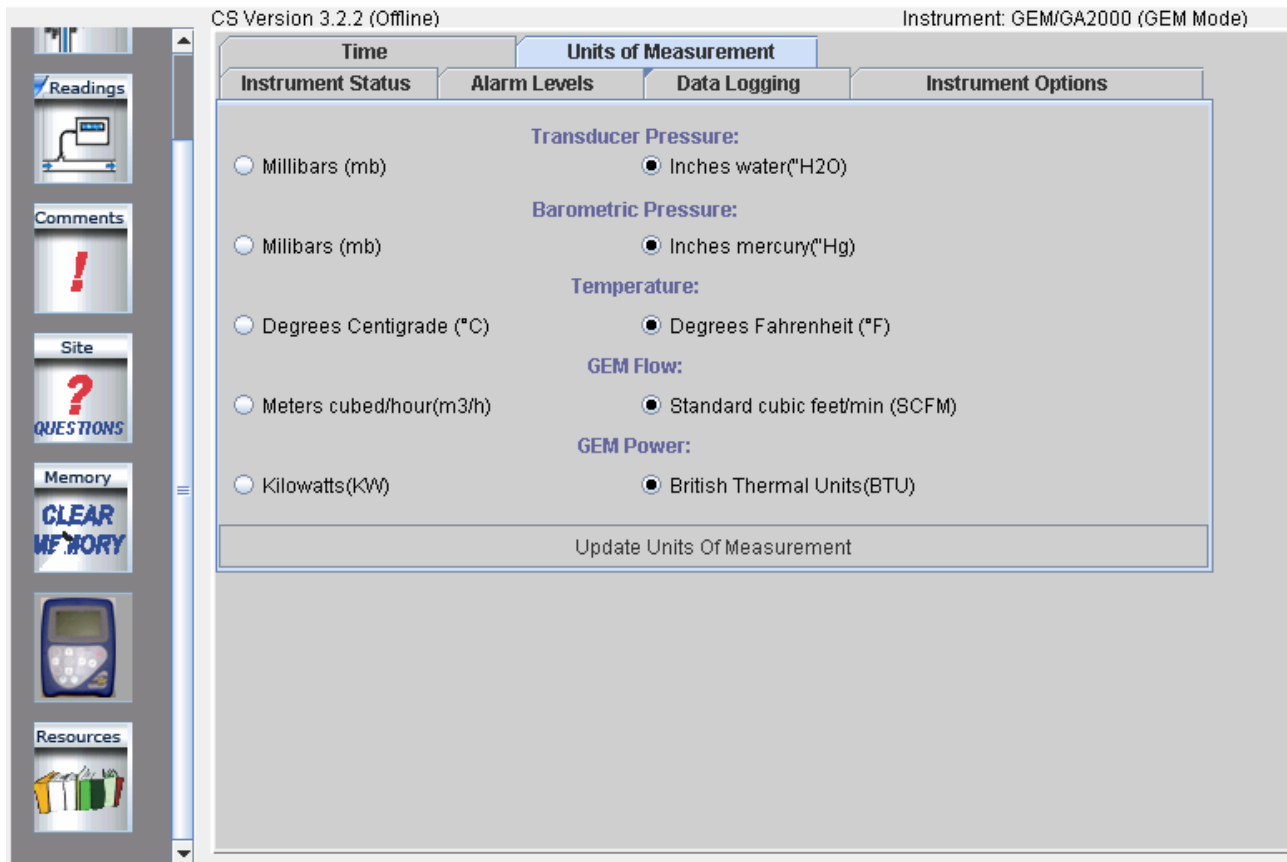


Units of Measurement screen allows the units to be changed.

This screen is protected by the password.



If you need to change the units of measurement, please contact our technical support team.

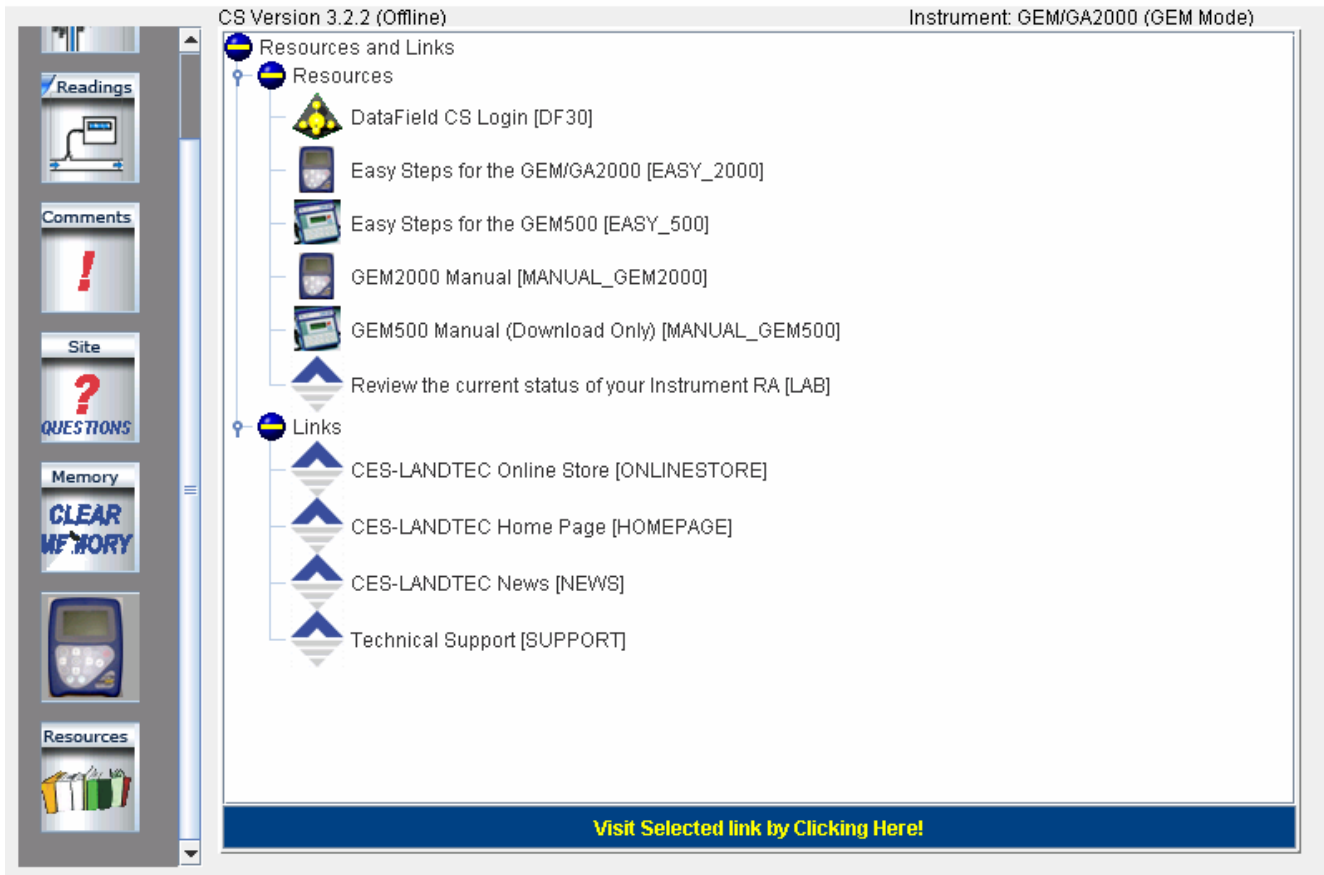


**Note:** EXTREME CAUTION should be taken if changing the Units of Measurement. All data from the instrument should be downloaded and stored in both, the GEM and the GA modes before updating the Units of Measurement. Updating Units of Measurement will erase readings from the instrument. The instrument should be turned off and restarted once the units of measurement have been updated.

### Resource Links



Clicking on the **Resource Links** button on the main screen will display the **Resources and Links** screen.



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

## **7 Field Operations**

### **7.1 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<sub>4</sub>.

If Oxygen is reintroduced into the landfill, those areas are returned to an aerobic (Oxygen present) state and the Methane-producing bacteria population is 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.

### **7.2 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.

### **7.3 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.

#### **7.3.1 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.

#### **7.3.2 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.

#### **7.3.3 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.

#### **7.3.4 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<sub>2</sub> 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.

### **7.4 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 cannot be overemphasized.

### **7.5 Typical Field Readings**

- Name of person taking readings
- Date/time of each reading
- Methane (CH<sub>4</sub>)
- Oxygen (O<sub>2</sub>)
- Carbon Dioxide (CO<sub>2</sub>)
- Balance Gas (primarily Nitrogen N<sub>2</sub>)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™2000 or magnehelic) or other device(anemometer/velometer)
- Velocity head (P or PT) (from GEM™2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM™2000, 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<sub>2</sub>S) 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.



## **7.6 Abbreviated Field Readings**

- Name of person taking readings
- Date/time of each reading
- Methane (CH<sub>4</sub>)
- Oxygen (O<sub>2</sub>)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™2000 or magnehelic)
- Velocity head (P or Pt) (from GEM™2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM™2000, 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.

## **7.7 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.

Conditions within the landfill favor Methane production. Following are well field adjustment criteria and typical conditions for consideration:

- Methane quality (ranging from 26 percent upwards)
- pH
- Temperature
- General overall quality
- Moisture conditions
- Waste stream characteristics
- Placement chronology
- Insulation characteristics
- Oxygen quality (ranging below 1 percent, preferably less than 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

### **7.8 Establishing Target Flows**

The goal is to establish a target flow which will likely produce the best possible Methane quality and minimum Oxygen levels 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.

### **7.9 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.

### **7.10 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.

### ***7.11 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.
- Avoid well “over-pull” and maintain of a healthy anaerobic state within the landfill.
- Optimize LFG recovery for energy recovery purposes.
- Control nuisance landfill gas 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.

## **8 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 Factory Service.

“Flow Fail” is displayed and an audible alarm is heard

The inlet is blocked.  
Remove blockage and retry.

Readings taken are not what was expected

The particulate filter or water trap filter needs replacing.  
Unit may be out of calibration. Calibrate unit with known gas concentration.  
Water trap or particulate filters are clogged. Replace filter(s).

Readings swing up or down wildly as they are being taken.

Cell phones and other sources of RF interference can affect Methane readings. Don't use your cell phone while taking readings.

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.

Unit will not download readings or an error occurs while downloading.

Field calibrate Oxygen channel.  
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.  
Contact Factory Service.

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.

Oxygen readings drift

Contact Factory Service.  
Perform a field calibration - zero and span.  
Contact Factory Service.

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.  
Contact Factory Service.

Nothing happens when the Gas Pod is installed

Remove and re-seat the Gas Pod.  
Contact Factory Service.

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 Factory Service.

## 9 Technical Specifications

### 9.1 Physical

Weight	4.4 lbs.
Size	L 2.48" x W 7.48" x D 9.92".
Case material	Anti-static ABS.
Keys	Membrane panel.
Display	Liquid Crystal Display 40 x 16 characters. Fiber optic woven backlight for low light conditions.
Filters	User replaceable integral fiber filter at inlet port and external PTFE water trap filter.

### 9.2 General

Certifications	UL Certified to Class 1, Zone 1, AEx Ib d IIa T4
Temperature measurement	With optional probe 14°F to 167°F.
Temperature accuracy	±0.4°F (± probe accuracy).
Visual and audible alarm	User selectable CO <sub>2</sub> , CH <sub>4</sub> and O <sub>2</sub> Min/Max levels via DataField CS software.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

### 9.3 Power supply

Battery type	Rechargeable Nickel Metal Hydride battery pack containing six 4AH cells. <b>Not user replaceable.</b> Lithium Manganese battery for data retention.
Battery life	Typical use 10 hours from fully charged condition.
Battery charger	Separate intelligent 2A battery charger powered from AC voltage supply (110-230V).
Charge time	Approximately 2 hours from complete discharge.
Alternative power	Can be powered externally for fixed-in-place applications only. Contact LANDTEC for further information.
Battery lifetime	Up to 1,000 charge/discharge cycles.

### 9.4 Gas Ranges

Detection principle	CO <sub>2</sub> and CH <sub>4</sub> by dual wavelength infrared cell with reference channel. O <sub>2</sub> by internal electrochemical cell.			
Oxygen cell lifetime	Approximately 18 months in air.			
Typical Accuracy 0 - Full Scale	<b>Gas</b>	<b>0-5% volume</b>	<b>5-15% volume</b>	<b>15%-FS</b>
	CH <sub>4</sub>	±0.3%	±1%	±3% (100%)
	CO <sub>2</sub>	±0.3%	±1%	±3% (60%)
	O <sub>2</sub>	±1%	±1%	±1% (21%)
Response time, T90	CH <sub>4</sub>	≤20 seconds		
	CO <sub>2</sub>	≤20 seconds		
	O <sub>2</sub>	≤20 seconds		
Range	CH <sub>4</sub>	0-70% to specification, 0-100% reading.		
	CO <sub>2</sub>	0-40% to specification, 0-100% reading.		
	O <sub>2</sub>	0-25%		

**9.5 Pump**

Typical flow	300 cc/min.
Flow fail point	50 cc/min approximately.
Flow with 200 mbar vacuum	250 cc/min approximately.
Vacuum	70 inches H <sub>2</sub> O.

**9.6 Operating Conditions**

Operating temp range	32°F to 104°F.
Relative humidity	0-95% non-condensing.
Atmospheric pressure range	700-1200 mbar. Displayed in Inches of Mercury (5.9 – 35.4"Hg). Not corrected for sea level.
Atmospheric pressure accuracy	±5 mbar approximately.
Case seal	IP65.

**9.7 Optional Gas Pods**

Typical Accuracy (Subject to User calibration).	<b>Gas</b>	<b>0-Full Scale</b>
	CO	±10% FS
	H <sub>2</sub> S	±10% FS
	SO <sub>2</sub>	±10% FS
	NO <sub>2</sub>	±10% FS
	CL <sub>2</sub>	±10% FS
	H <sub>2</sub>	±10% FS
	HCN	±10% FS
Response time, T90	CO	≤60 seconds
	H <sub>2</sub> S	≤60 seconds
	SO <sub>2</sub>	≤60 seconds
	NO <sub>2</sub>	≤60 seconds
	CL <sub>2</sub>	≤60 seconds
	H <sub>2</sub>	≤60 seconds
	HCN	≤60 seconds
	Range	CO
H <sub>2</sub> S		0-50 or 0-200ppm
SO <sub>2</sub>		0-20 or 0-100ppm
NO <sub>2</sub>		0-20ppm
CL <sub>2</sub>		0-20ppm
H <sub>2</sub>		0-1000ppm
HCN		0-100ppm