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OPERATIONS PLAN
LANDFILL GAS COLLECTION AND COMBUSTION SYSTEM

FRANCIS FARM LANDFILL
PERMIT NO. 44-03

HAYWOOD COUNTY, NORTH CAROLINA

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July 2012

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FRANCIS FARM LANDFILL
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HAYWOOD COUNTY, NORTH CAROLINA

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1.0 Introduction

The Francis Farm Landfill, Permit No. 44-03, is located in Haywood County, North Carolina on Francis Farm Road, (S.R. 1802), Waynesville, North Carolina. The Francis Farm Landfill began operation in the early 1970's and was operated as Haywood County's primary MSW landfill through 1994. The facility was officially closed per a Closure Certification prepared by RCF, Inc. Hazelwood, North Carolina dated September 14, 1994 and submitted to the North Carolina Department of Environment and Natural Resources (NCDENR). The original Permit for Closure was issued on December 13, 1995, with the most recent revision dated May 23, 2006. The facility encompasses approximately 33.1 acres as shown on Figure 1, Site Plan, Francis Farm Landfill, Landfill Gas Collection and Combustion System included as Appendix A. Within the Facility Boundary, in addition to the closed landfill, the Haywood County School System operates a maintenance facility. The Maintenance Facility includes a maintenance/bus garage building, equipment storage building, and maintenance storage building. The Maintenance Building consists of offices, carpentry shop and bus maintenance facility.

In March 2010 the County received approval from the North Carolina Department of Environment and Natural Resources (NCDENR), Division of Waste Management, Solid Waste Section (Section) to begin construction of a Landfill Gas Collection and Combustion System at the landfill. The initial phase of the project, referred to as Phase 1 was constructed in the fall of 2010 and involved the installation of twenty-one (21) landfill gas extraction wells strategically located within the waste mass. The location of these wells along with the as-built extraction well information is shown on Figure 1, Site Plan, Francis Farm Landfill, Landfill Gas Collection and Combustion System included as Appendix A.

In January 2011 the County initiated the design of the landfill gas collection and combustion system for the landfill referred to as Phase 2. In April 2010 the County received approval from the Solid Waste Section to include the landfill gas engine/generator in the overall landfill gas collection and combustion project.

The Phase 2 portion of the project involved the construction and installation of the landfill gas flare system (Phase 2A) and the landfill gas collection piping system (Phase 2B). Phase 2A was bid in April 2011 and the skid-mounted landfill gas flare system was delivered to the site in late October 2011. Phase 2B, covering the landfill gas collection piping system, was bid in June 2011 and completed in January 2012. Phase 2B also included the installation of liquid extraction pumps in strategically located landfill gas extraction wells and the associated discharge collection piping. These extraction pumps were installed to assist in the removal of liquid apparently trapped within the landfill's waste mass thereby enhancing the removal of landfill gas. Upon completion of the Phase 2 portion of the project, the landfill gas collection system and the skid-mounted landfill gas flare system were placed into operation.

Phase 3 of this project covered the installation of a landfill gas engine/generator package capable of producing electrical power for sale to the local electric utility serving Haywood County. This project was initially bid in August 2011. However, this portion of the project was subsequently broken into Phase 3A which included the landfill gas engine generator system capable of operating on a low Btu fuel supply (i.e., landfill gas) and Phase 3B which covered the utility interconnection switchgear equipment. Phase 3A and 3B are scheduled to be completed and commissioned into operation by during the spring of 2012.

2.0 Inspections – Landfill Facility

The County will perform inspections of the final cover and the condition of the facility will be recorded along with notes, maps, and photographs as needed. The County and/or a contractor/representative will be operating the landfill gas collection and combustion system and will have authorized personnel on site on a frequent basis. These operators will be monitoring and checking the landfill gas extraction system and will simultaneously observe the general condition of the final cover.

3.0 Maintenance – Landfill Facility

The vegetative cover will be trimmed at least two (2) times a year. The site will be maintained in accordance with the applicable rules and regulations.

4.0 Access and Security

Access to the site is through the main entrance road to the Haywood County School System Maintenance Facility. This entrance is gated to control access during hours when the maintenance facility is not in operation. The landfill gas flare station site is fenced and gated to prevent unauthorized access to this portion of the landfill gas collection and combustion system. Security lights are strategically located within the landfill gas flare station site.

5.0 Personnel

The landfill gas collection and combustion facility is owned by Haywood County and will be operated by the County and/or a contractor or a representative of the County. Trained County staff or contract operators will be responsible for the overall operation of the landfill gas extraction well field and the landfill gas collection and combustion system. The County employees and/or contract staff will be properly trained in safety procedures associated with the various collection and combustion equipment. The operating staff will receive continuing education through a variety of resources in order to remain proficient in the operation of the facility and up to date on the latest rules and regulations governing the collection and combustion of landfill gas.

6.0 Storm Water Management

Stormwater management will be handled through the maintenance of existing stormwater management basins, collection inlets, piping, and conveyance channels.

7.0 Liquid Dewatering System

The Francis Farm Landfill is an unlined facility and is not equipped with a means of leachate collection. However, as a part of the construction of the landfill gas collection and combustion system, strategically located landfill gas extraction wells were equipped with the down-hole assembly portion of electrically operated piston-type liquid removal pumps. All landfill gas extraction wells that were equipped to accept the piston-type liquid removal pumps have been equipped with the electric pump driver motors and controllers. These pumps should facilitate the removal of accumulated liquid from within the waste mass. The liquid will be pumped to a gravity collection system installed in conjunction with the landfill gas collection lines. The liquid will flow to a central pump station whereby it will be pumped through a metered force main to the City of Waynesville's sanitary sewer system for ultimate treatment at the City's wastewater treatment plant. The volume of liquid pumped through the central pump station will be monitored to ensure compliance with the discharge permit approved by the City of Waynesville. This pump station will also handle the landfill gas condensate removed from the landfill gas collection piping and flare system. A copy of Permit No. WQ0035486, Francis Farm Leachate Pump Station, issued by the NCDENR Division of Water Quality for the construction and operation of the wastewater collection system extension is included in Appendix B. In addition, a copy of the Flow Tracking/Acceptance for Sewer Extension Permit Application, executed by the City of Waynesville is also included in Appendix B.

The liquid removal pumps and the pump station are served by the same power feed from Haywood EMC. In other words, both systems would be out of service simultaneously in the event of a general power failure. The central pump station has adequate capacity to safely store the volume of liquid in the collection system at the time of power failure. However, the pump station will be monitored regularly to ensure wet well capacity is not exceeded. Standby generator power will be brought in to operate the system on an as needed basis. The pump station is equipped with a visual and audible alarm system in the event of a problem with the pump station.

8.0 Explosive Gas Control

The Landfill Gas Monitoring Plan for the Francis Farm Landfill was developed to comply with the Methane Gas Remediation Conditions section of the Permit for Closure. A copy of the Landfill Gas Monitoring Plan is included in Appendix C.

9.0 Air Criteria

An Air Quality Permit was not required by the NCDENR, Division of Air Quality as noted in the Air Permit Applicability Determination, Applicability Determination Application No. 1756, dated July 14, 2011. A copy of the referenced letter is included in Appendix D.

10.0 Flare Operation

The flare system is designed to operate efficiently at specified temperatures, pressures and flow rates. Routine monitoring and maintenance ensures optimal performance and run time for the flare facility. The goal of the flare operator is to maintain the flare system and the landfill gas extraction system such that the entire system operates compatibly and optimally at all times. Adjustments will be made to the well field and/or extraction system and the flare station as needed. This flare station is equipped with auto-shutoffs in the event of an equipment malfunction.

This flare system is designed to provide a controlled flow of landfill gas to the engine-generator and/or flare burner depending on how the system is programmed by the operator. The operator will be able to select which component (engine/generator or flare) is to serve as the primary operating component. The system is designed to serve that component as the primary recipient with excess landfill gas, if available, being directed to the other component within the system. Should a malfunction occur with both system components (engine-generator and/or flare) the controller will shut the entire system down until such time as the problem is corrected and the system restarted.

To monitor and maintain the flare station, a Flare Station / Engine-Generator Data Sheet listing commonly monitored components and data, a copy of which is included in Appendix E, will be completed for at least the initial site visit made on a daily, weekly or biweekly basis depending on system efficiency or whenever adjustments are made to the flare system controls. A copy of the data sheet will be maintained in the facility records. The data form may be modified as necessary to accommodate the collection of data required to efficiently operate the landfill gas flare system.

If problems or a shutdown occurs, the cause of the malfunction should be investigated.

The flare operator may make adjustments to the flare system controls based on the data collected and the operating protocols for the system components. Adjustments are made to ensure compatibility between the blower flare system and the wellfield production capabilities.

Preventative maintenance will be performed based on the flare manufacturer/supplier's recommendations for the various flare system components. Preventative maintenance will be performed by the manufacturer/supplier on an as-needed basis or as operating conditions warrant.

11.0 Wellfield Operations

Data is collected to evaluate conditions within the landfill and adjust the collection wells as needed to maintain optimum operating conditions. The data must be collected with sufficient care, accuracy and frequency to provide for informed decisions relative to operating the collection and combustion system. The frequency of landfill gas extraction well monitoring will vary depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring session with full field readings will typically vary from once a week to once a month depending on operating efficiency.
Typically a complete set of field readings consists of the following:

- Name of person taking the readings
- Date
- Weather Conditions to include ambient temperature and atmospheric pressure
- At the Flare: LFG temperature, line pressure and percent volume of methane (CH_4) and oxygen (O_2)

For each well that a full set of field readings will be taken should generally include the following items: (Not all wells may read during each monitoring event nor shall all data fields be collected each time)

- Methane (CH_4) percent by volume
- Oxygen (O_2) percent by volume
- Carbon dioxide (CO_2) percent by volume
- Nitrogen (N_2) percent by volume (if applicable)
- Wellhead gas temperature (flowing, degrees F)
- Static pressure (Ps, inches H_2O)
- Impact pressure (Pi, inches H_2O)
- Wellhead valve position (initial and adjusted, % open)
- Observations and comments

An abbreviated form of field readings may sometimes be used for supplemental field balancing. Supplementary monitoring once to several times a week may be performed using an abbreviated form of field readings. The determination of which readings to include in the abbreviated set is based on field monitoring needs and or conditions.

Line vacuum and gas composition may also be taken at key points along the main gas collection header and subordinate branches on an as needed basis. This type of monitoring helps to identify location of poor performance, excessive pressure drop or leakage. The data collected as a part of the wellfield monitoring process will be logged on the Wellfield Data Sheet, Francis Farm Landfill, a copy of which is included in Appendix F. This form will be modified as necessary to accommodate the collection of data required to operate the landfill gas collection and combustion system. The County presently owns or has access to a gas analyzer and extraction monitor which will be used to monitor the system and collect data on the landfill gas wellfield.

The Operation Manual for a LANDTEC GEM 2000 Plus is included in Appendix G of this Operations Plan.

Field readings should be kept in a chronological log or data base.

12.0 Wellfield Adjustment

The objective of wellfield adjustment is to achieve steady-state operation of the gas collection system by stabilizing the rate and quality of extracted landfill gas. While there are numerous criteria used in wellfield adjustment, the primary one is methane quantity and quality. Methane quality is a primary indicator of the healthy anaerobic state of the landfill and thus the proper operation of the landfill gas collection system. The decline in the healthy productive state of the landfill is usually not immediately apparent from methane quality. Because of this the operator must consider various criteria as a part of the well adjustment process. The following criteria should generally be considered:

- Methane quality
- Oxygen quantity
- Temperature
- Gas well construction characteristics
- Seasonal, climatic and geographical considerations
- Proximity of the well to side slopes
- Design and objective of the landfill gas collection system
- Fluctuation in the diurnal cycle of atmospheric pressure

Typically small adjustments are made in flow to arrive at and maintain quality objectives. Generally the adjustment increment of the existing flow should be in the range of 10% or less. Overall adjustments to the wellfield landfill gas extraction rate are normally made at the line control valves or the blower-flare station inlet suction throttling valve.

13.0 Engine - Generator

The engine-generator system is designed to operate efficiently at specified landfill gas pressures and flow rates. Routine monitoring and maintenance ensures optimal performance and run time for the engine-generator system. The goal of the flare operator is to maintain the flare system, engine-generator system and the landfill gas extraction system such that the entire system operates compatibly and optimally at all times. The flare station controls are equipped with auto-shutoffs should an engine-generator malfunction occur.

This flare system is designed to provide a controlled flow of landfill gas to the engine-generator and/or flare burner depending on how the system is programmed by the operator. The operator will be able to select which component (engine/generator or flare) is to serve as the primary operating component. The system is designed to serve that component as the primary recipient with excess landfill gas, if available, being directed to the other component within the system. Should a malfunction occur with both system components (engine-generator and/or flare) the controller will shut the entire system down until such time as the problem is corrected and the system restarted.

To monitor and maintain the engine/generator, a Flare Station / Engine-Generator Data Sheet listing commonly monitored components and data, a copy of which is included in Appendix E, should be completed for at least the initial site visit made on a daily, weekly or biweekly basis depending on system efficiency or whenever adjustments are made to the engine/generator system controls. A copy of the data sheet will be maintained in the facility records. The data form may be modified as necessary to accommodate the collection of data required to efficiently operate the engine/generator system.

If problems or a shutdown occurs, the cause of the malfunction should be investigated.

The flare operator may make adjustments to the engine-generator system controls based on the data collected and the operating protocols for the system components. Adjustments may be made to ensure compatibility between the engine-generator system and the blower flare system supplying the landfill gas.

Preventative maintenance will be performed based on the engine and generator manufacturer/supplier's recommendations for the various system components. Preventative maintenance will be performed by the manufacturer/supplier on an as needed basis or as operating conditions warrant.

14.0 Fire Control

14.1 Flare Station / Engine-Generator

Fire control is provided by an appropriate number of portable hand-held fire extinguishers. Fire protection will also be provided by the local fire department, which is aware of the fire control needs of the flare station facility. In the event that a fire occurs, the local authorities will be notified immediately. The telephone numbers of the local fire, police, ambulance and hospital facilities are posted at the landfill gas flare station at all times. In the event of a fire at the facility the NCDENR Solid Waste Section's Senior Environmental Specialist in the Asheville Regional Office will be notified at (828) 296-4500 within 24 hours and written notification will be submitted within 15 days.

The flare station and the associated engine generator system are equipped with numerous automatic control devices to shut down the system or systems in the event of a detected malfunction, thereby minimizing the possibility of a fire. The main line to the flare stack is equipped with a flame arrestor to prevent any type of back flash should the pressure to the flare stack be lost.

14.2 Landfill

There are generally two types of fires encountered as a part of a landfill operation. One type of fire is an above-ground or surface fire that is usually associated with an active landfill operation. A surface fire is generally the result of the receipt of a "hot" load of waste at the working face. The second type of fire commonly associated with a landfill is an underground or subsurface fire and is usually the result of air intrusion into the waste mass.

14.2.A Surface Fire

Since this landfill is closed to the receipt of waste material the occurrence of a surface fire would generally be limited to the combustion of the landfill cover material. Should this type of fire occur, the local authorities will be notified immediately. Fire extinguishers are available at the landfill gas flare station. The telephone numbers of the local fire, police, ambulance and hospital facilities are posted at the landfill gas flare station at all times. In the event of a fire at the facility the NCDENR Solid Waste Section's Senior Environmental Specialist in the Asheville Regional Office will be notified at (828) 296-4500 within 24 hours and written notification will be submitted within 15 days.

14.2.B Subsurface Fire

While subsurface fires may occur at any time within a landfill, prevention is the best policy. Prevention entails attempting to eliminate conditions which can initiate subsurface fires. Air is essential for combustion. Control a fire's air supply and the fire can be smothered. Minimizing the chance for a subsurface landfill fire can best be done by:

- Operating the landfill gas extraction system to prevent over pull and air intrusion at each of the landfill gas extraction wells.

Subsurface fires generally start out small and localized; however, left unattended the fire can spread and may become extremely difficult to extinguish. If the operator suspects a subsurface fire they should:

- Check local ground temperatures in the area of the suspected fire. If elevated, perform a surface soil temperature survey to determine the spatial distribution of the elevated temperatures with respect to background temperatures.
- Inspect the surface of the landfill in the vicinity of the suspected fire for fissures, cracks, erosion or other areas where air/oxygen may be entering the landfill.

- Monitor the gas temperature of the extraction wells in the suspected fire area to determine if elevated gas temperatures are present.
- Inspect the impacted landfill gas wellhead components for the presence of soot and combustion odors.
- Inspect the suspected area for signs of smoke or vapor.

- Inspect the ground surface around the impacted area for signs of accelerated subsidence. Use caution as subsurface fires may undermine areas of the landfill resulting in a collapse of the surface. Areas of the landfill showing signs of accelerated subsidence should be barricaded and safety precautions taken until the reason for the subsidence is determined.
- Inspect the gas extraction system for signs of damage due to heat or combustion. Turn off, isolate or bypass the affected areas of the collection system. Seal off damaged wells. Reduce the landfill gas extraction rates or shut down the wells in the affected area to minimize atmospheric intrusion.

Once the operator has confirmed the probable existence of a subsurface fire the local authorities will be notified. The telephone numbers of the local fire, police, ambulance and hospital facilities are posted at the landfill gas flare station at all times. The NCDENR Solid Waste Section's Senior Environmental Specialist in the Asheville Regional Office will be notified at (828) 296-4500 within 24 hours and written notification will be submitted within 15 days. A proposed site or incident specific plan to address the suspected subsurface fire situation will be presented to the NCDENR within sixty (60) days. During the research of and the preparation of the site or incident specific fire suppression plan, the facility operator may implement the following general fire suppression plans for shallow and deep subsurface fires depending on site conditions:

Shallow Subsurface Fires – In the event of a shallow subsurface fire the operator may attempt to cautiously excavate the fire zone and begin attempting the removal of combustible materials. The operator would inspect the area to determine that temperatures within the excavation are at or have returned to background levels. If so, the area would then be backfilled with clean inert material and the cover material replaced to its original integrity. The operator would continue to monitor the surface soil temperatures to ensure they remain at normal background levels.

Deep Subsurface Fires – In the event a subsurface fire is suspected to be a deep fire the operator should attempt to eliminate all potential sources of atmospheric intrusion and reduce the landfill gas extraction rates in the vicinity of the suspected fire. In addition, the operator should continue to monitor the landfill gas extraction rates and gas temperatures to determine if the fire is diminishing. Any noted surface subsidence would be filled in and the landfill cover material restored to its original integrity.

15.0 Weather Related Issues

The primary weather related issue pertains to ice and snow accumulation during the winter months. During inclement weather periods the operator may delay accessing the flare and collection system facilities until such time as the access roads have been adequately cleared and/or treated to provide safe ingress and egress to the various system components. The operations will be suspended should conditions deteriorate to the point that continued operations become unsafe for the operator. The facility will remain closed until such time as weather conditions improve and/or safe access to the site can be restored.

The landfill gas collection and combustion equipment and components (i.e., flare, engine generator, etc.) are equipped with sufficient safeguards to safely shut themselves and the entire system down in the case of critical component failure or other emergencies should no one be able to immediately respond due to inclement weather conditions. In the case of an equipment malfunction the system will not restart itself automatically. It must be restarted by the operator once the cause of the shutdown is determined and corrected.

16.0 Power Failure

The landfill gas collection and combustion equipment and components (i.e., flare, engine generator, etc.) are equipped with sufficient safeguards to safely shut themselves and the entire system down in the case of a power failure. The system will not restart itself automatically. It must be restarted by the operator once the power to the facility is restored.

The on-site leachate pump station will be monitored regularly to ensure the wet well capacity is not exceeded. The pump station control panel is equipped with a manual transfer switch to allow standby generator power to be brought in to operate the systems on an as needed basis.

17.0 Record Keeping Requirements

The facility will record and retain at the facility, or at an alternative location near the facility approved by the Division of Solid Waste Management, in an operating record the following information as it becomes available.

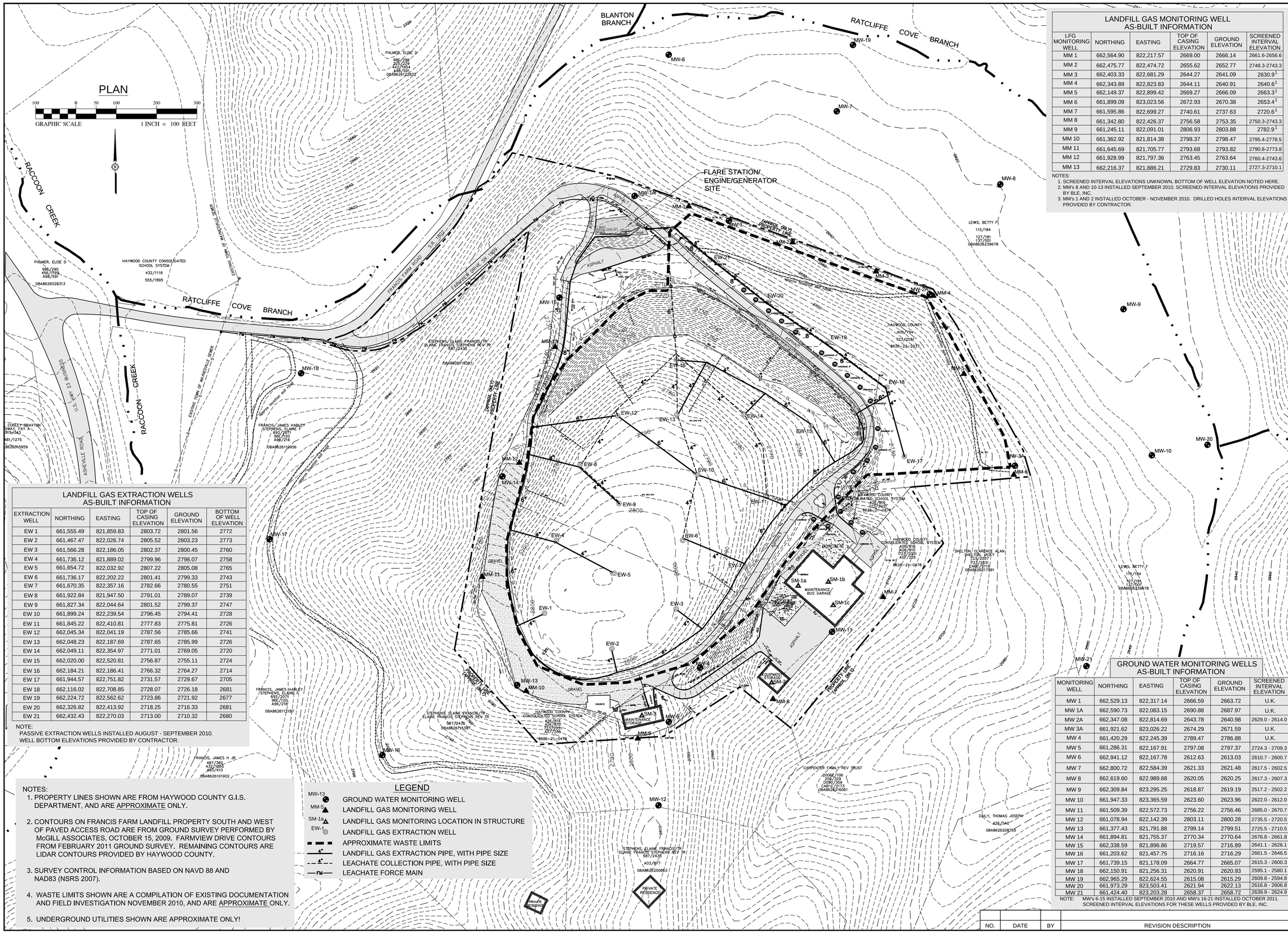
- Inspection records and training procedures
- Landfill gas collection and combustion system operating records
- Leachate sampling data, leachate flow records, meteorological data
- Gas monitoring results and any remediation plans
- Any demonstration, certification, findings, monitoring, testing or analytical data required for surface and/or groundwater monitoring
- Any monitoring, testing or analytical data required for closure or post-closure
- Any cost estimates and financial assurance documentation

All information contained in the operating record will be furnished upon request to the Division of Solid Waste Management or be made available at all reasonable times for inspection by the Division.

The County will maintain a copy of the Operations Plan at the office of the Solid Waste Director.

Appendix A

Figure 1
Site Plan
Francis Farm Landfill
Landfill Gas Collection and Combustion System
January 2012



LANDFILL GAS MONITORING WELL AS-BUILT INFORMATION

LFG MONITORING WELL	NORTHING	EASTING	TOP OF CASING ELEVATION	GROUND ELEVATION	SCREENED INTERVAL ELEVATION
MM 1	662,564.90	822,217.57	2669.00	2666.14	2661.6-2656.6
MM 2	662,475.77	822,474.72	2655.62	2652.77	2748.3-2743.3
MM 3	662,403.33	822,681.29	2644.27	2641.09	2630.9[1]
MM 4	662,343.89	822,823.83	2644.11	2640.91	2640.6[1]
MM 5	662,149.37	822,899.42	2669.27	2666.09	2663.3[1]
MM 6	661,899.09	823,023.56	2672.93	2670.38	2653.4[1]
MM 7	661,595.86	822,699.27	2740.61	2737.63	2720.6[1]
MM 8	661,342.80	822,426.37	2756.58	2753.35	2750.3-2743.3
MM 9	661,245.11	822,091.01	2806.93	2803.88	2782.9[1]
MM 10	661,362.92	821,814.38	2798.37	2798.47	2795.4-2778.5
MM 11	661,645.69	821,705.77	2793.68	2793.82	2790.8-2773.8
MM 12	661,928.99	821,797.36	2763.45	2763.64	2760.4-2743.6
MM 13	662,216.37	821,886.21	2729.83	2730.11	2727.3-2710.1

NOTES:
1. SCREENED INTERVAL ELEVATIONS UNKNOWN, BOTTOM OF WELL ELEVATION NOTED HERE.
2. MM's 8 AND 10-13 INSTALLED SEPTEMBER 2010, SCREENED INTERVAL ELEVATIONS PROVIDED BY BLE, INC.
3. MM's 1 AND 2 INSTALLED OCTOBER - NOVEMBER 2010. DRILLED HOLES INTERVAL ELEVATIONS PROVIDED BY CONTRACTOR.

LANDFILL GAS EXTRACTION WELLS AS-BUILT INFORMATION

EXTRACTION WELL	NORTHING	EASTING	TOP OF CASING ELEVATION	GROUND ELEVATION	BOTTOM OF WELL ELEVATION
EW 1	661,555.49	821,859.83	2803.72	2801.56	2772
EW 2	661,467.47	822,026.74	2805.52	2803.23	2773
EW 3	661,566.28	822,186.05	2802.37	2800.45	2760
EW 4	661,736.12	821,889.02	2799.96	2798.07	2758
EW 5	661,654.72	822,032.92	2807.22	2805.08	2765
EW 6	661,736.17	822,202.22	2801.41	2799.33	2743
EW 7	661,670.35	822,357.16	2782.66	2780.55	2751
EW 8	661,922.84	821,947.50	2791.01	2789.07	2739
EW 9	661,827.34	822,044.64	2801.52	2799.37	2747
EW 10	661,899.24	822,239.54	2796.45	2794.41	2728
EW 11	661,845.22	822,410.81	2777.83	2775.81	2726
EW 12	662,045.34	822,041.19	2787.56	2785.66	2741
EW 13	662,048.23	822,187.69	2787.65	2785.99	2726
EW 14	662,049.11	822,354.97	2771.01	2769.05	2720
EW 15	662,020.00	822,520.81	2756.87	2755.11	2724
EW 16	662,184.21	822,186.41	2766.32	2764.27	2714
EW 17	661,944.57	822,751.82	2731.57	2729.67	2705
EW 18	662,116.02	822,708.85	2728.07	2726.18	2681
EW 19	662,224.72	822,562.62	2723.86	2721.92	2677
EW 20	662,326.82	822,413.92	2718.25	2716.33	2681
EW 21	662,432.43	822,270.03	2713.00	2710.32	2680

NOTE:
PASSIVE EXTRACTION WELLS INSTALLED AUGUST - SEPTEMBER 2010.
WELL BOTTOM ELEVATIONS PROVIDED BY CONTRACTOR.

GROUND WATER MONITORING WELLS AS-BUILT INFORMATION

MONITORING WELL	NORTHING	EASTING	TOP OF CASING ELEVATION	GROUND ELEVATION	SCREENED INTERVAL ELEVATION
MW 1	662,529.13	822,317.14	2666.59	2663.72	U.K.
MW 1A	662,590.73	822,083.15	2690.88	2687.97	U.K.
MW 2A	662,347.08	822,814.69	2643.78	2640.98	2629.0 - 2614.0
MW 3A	661,921.62	823,026.22	2674.29	2671.59	U.K.
MW 4	661,420.29	822,245.39	2789.47	2786.88	U.K.
MW 5	661,286.31	822,167.91	2797.08	2797.37	2724.3 - 2709.3
MW 6	662,941.12	822,167.78	2612.63	2613.03	2610.7 - 2600.7
MW 7	662,800.72	822,584.39	2621.33	2621.48	2617.5 - 2602.5
MW 8	662,619.60	822,989.68	2620.05	2620.25	2617.3 - 2607.3
MW 9	662,309.84	823,295.25	2618.87	2619.19	2517.2 - 2502.2
MW 10	661,947.33	823,365.59	2623.60	2623.96	2622.0 - 2612.0
MW 11	661,509.39	822,572.73	2756.22	2756.46	2685.0 - 2670.7
MW 12	661,078.94	822,142.39	2803.11	2800.28	2735.5 - 2720.5
MW 13	661,377.43	821,791.88	2799.14	2799.51	2725.5 - 2710.5
MW 14	661,894.81	821,755.37	2770.34	2770.64	2676.8 - 2661.8
MW 15	662,338.59	821,896.86	2719.57	2716.89	2641.1 - 2626.1
MW 16	661,203.62	821,457.75	2716.16	2716.29	2661.5 - 2646.5
MW 17	661,739.15	821,178.09	2664.77	2665.07	2615.3 - 2600.3
MW 18	662,150.91	821,256.31	2620.91	2620.93	2595.1 - 2580.1
MW 19	662,965.29	822,624.55	2615.08	2615.29	2609.8 - 2594.8
MW 20	661,973.29	823,503.41	2621.94	2622.13	2616.8 - 2606.8
MW 21	661,424.40	823,203.28	2658.37	2658.72	2639.9 - 2624.9

NOTE: MW's 6-15 INSTALLED SEPTEMBER 2010 AND MW's 16-21 INSTALLED OCTOBER 2011. SCREENED INTERVAL ELEVATIONS FOR THESE WELLS PROVIDED BY BLE, INC.

NOTES:
1. PROPERTY LINES SHOWN ARE FROM HAYWOOD COUNTY G.I.S. DEPARTMENT, AND ARE APPROXIMATE ONLY.
2. CONTOURS ON FRANCIS FARM LANDFILL PROPERTY SOUTH AND WEST OF PAVED ACCESS ROAD ARE FROM GROUND SURVEY PERFORMED BY McGILL ASSOCIATES, OCTOBER 15, 2009. FARMVIEW DRIVE CONTOURS FROM FEBRUARY 2011 GROUND SURVEY. REMAINING CONTOURS ARE LIDAR CONTOURS PROVIDED BY HAYWOOD COUNTY.
3. SURVEY CONTROL INFORMATION BASED ON NAVD 88 AND NAD83 (NSRS 2007).
4. WASTE LIMITS SHOWN ARE A COMPILATION OF EXISTING DOCUMENTATION AND FIELD INVESTIGATION NOVEMBER 2010, AND ARE APPROXIMATE ONLY.
5. UNDERGROUND UTILITIES SHOWN ARE APPROXIMATE ONLY!

LEGEND

MW-13	GROUND WATER MONITORING WELL
MM-5	LANDFILL GAS MONITORING WELL
SM-1a	LANDFILL GAS MONITORING LOCATION IN STRUCTURE
EW-1	LANDFILL GAS EXTRACTION WELL
	APPROXIMATE WASTE LIMITS
4"	LANDFILL GAS EXTRACTION PIPE, WITH PIPE SIZE
4"	LEACHATE COLLECTION PIPE, WITH PIPE SIZE
FM	LEACHATE FORCE MAIN

NO.	DATE	BY	REVISION DESCRIPTION

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
55 BROAD STREET ASHEVILLE, NC 28801 PH: (828) 252-0575 FIRM LICENSE # C-0459

FRANCIS FARM LANDFILL
LANDFILL GAS COLLECTION AND COMBUSTION SYSTEM
HAYWOOD COUNTY
HAYWOOD COUNTY, NORTH CAROLINA

JOB NO.: 09.00721
DATE: APRIL 2012
DESIGNED BY: DP
CADD BY: KS
DESIGN REVIEW: ____
CONST. REVIEW: ____
FILE NAME: 09.00721 - Site Plan.dwg

SITE PLAN

FIGURE
1

Q:\2009\09.00721\Design\Solid Waste\Drawings\Operations Plan - Figure 1\09.00721- Site Plan.dwg 7/23/2012 11:06 AM KELLY

Appendix B

NCDENR Division of Water Quality
Permit No. WQ0035486
Francis Farm Leachate Pump Station

Flow Tracking/Acceptance for Sewer Extension Permit Application

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Water Quality

Beverly Eaves Perdue
Governor

Coleen H. Sullins
Director

Dee Freeman
Secretary

July 29, 2011

Marty Stamey, County Manager
Haywood County, North Carolina
215 N. Main Street
Waynesville, NC 28786

Subject: Permit No. WQ0035486
Haywood County
Francis Farm Leachate Pump Station
Wastewater Collection System

Dear Mr.Stamey:

In accordance with your application received July 1, 2011, we are forwarding herewith Permit No. WQ0035486, dated July 29, 2011, to Haywood County for the construction and operation of the subject wastewater collection system extension. This permit shall be effective from the date of issuance until rescinded, and shall be subject to the conditions and limitations as specified therein. This cover letter shall be considered a part of this permit and is incorporated therein by reference. Please send Jeff Menzel or Don Price a copy of the "notice to proceed" issued to your contractor for this collection system extension.

Please pay particular attention to Permit Condition 3 which requires that the wastewater collection facilities be properly operated and maintained in accordance with 15A NCAC 2T .0403 or any individual system-wide collection system permit issued to the Permittee.

Permitting of this project does not constitute an acceptance of any part of the project that does not meet 15A NCAC 2T; the Division of Water Quality's (Division) Gravity Sewer Minimum Design Criteria adopted February 12, 1996 as applicable; and the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains adopted June 1, 2000 as applicable, unless specifically mentioned herein. Division approval is based on acceptance of the certification provided by the North Carolina-licensed Professional Engineer named in the application. It shall be the Permittee's responsibility to ensure that the as-constructed project meets the appropriate design criteria and rules. Failure to comply may result in penalties in accordance with North Carolina General Statute §143-215.6A through §143-215.6C, construction of additional or replacement wastewater collection facilities, and/or referral of the North Carolina-licensed Professional Engineer to the licensing board.

In accordance with the provisions of Article 21 of Chapter 143, General Statutes of North Carolina as amended, and other applicable Laws, Rules, and Regulations, permission is hereby granted to Haywood County for the construction and operation of approximately 1,212 linear feet of 2-inch force main and pump station with duplex pumps with on-site audible and visual high water alarms, as part of the Francis Farm Leachate Pump Station project, and the discharge of collected landfill leachate wastewater into the Town of Waynesville existing sewerage system, pursuant to the application received July 1, 2011 and in conformity with 15A NCAC 2T; the Division's Gravity Sewer Minimum Design Criteria adopted February 12, 1996 as applicable; the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains adopted June 1, 2000 as applicable; and other supporting data subsequently filed and approved by the Department of Environment and Natural Resources and considered a part of this permit;

The sewage and wastewater collected by this system shall be treated in the Town of Waynesville Wastewater Treatment Facility (Permit No. NC0025321) prior to being discharged into the receiving stream.

This permit shall become voidable unless the agreement between Haywood County and Town of Waynesville for the collection and final treatment of wastewater is in full force and effect.

If any parts, requirements, or limitations contained in this permit are unacceptable, you have the right to request an adjudicatory hearing upon written request within 30 days following receipt of this permit. This request must be in the form of a written petition, conforming to Chapter 150B of North Carolina General Statutes, and filed with the Office of Administrative Hearings, 6714 Mail Service Center, Raleigh, NC 27699-6714. Unless such demands are made, this permit shall be final and binding.

If you need additional information concerning this matter, please contact Jeff Menzel or Don Price at (828) 296-4500.

Sincerely,

Roger C. Edwards

for Coleen H. Sullins, Director
Division of Water Quality

cc: Town of Waynesville WWTP NC0025321
William Sperry, Project Manager/McGill Associated
Surface Water Protection Section Central Files
PERCS Files

S:\SWP\Haywood\Collection Systems\Waynesville Collection System\WQ0035486 Francis Farm Landfill 07-29-2011.doc

NORTH CAROLINA

ENVIRONMENTAL MANAGEMENT COMMISSION

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

RALEIGH

WASTEWATER COLLECTION SYSTEM EXTENSION PERMIT

This permit shall be effective from the date of issuance until rescinded and shall be subject to the following specified conditions and limitations:

1. This permit shall become voidable unless the wastewater collection facilities are constructed in accordance with the conditions of this permit; 15A NCAC .0200; the Division of Water Quality's (Division) Gravity Sewer Minimum Design Criteria adopted February 12, 1996 as applicable; the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains adopted June 1, 2000 as applicable; and other supporting materials unless specifically mentioned herein.

2. This permit shall be effective only with respect to the nature and volume of wastes described in the application and other supporting data.

3. The wastewater collection facilities shall be properly maintained and operated at all times. The Permittee shall maintain compliance with an individual system-wide collection system permit for the operation and maintenance of these facilities as required by 15A NCAC 2T .0403. If an individual permit is not required, the following performance criteria shall be met as provided in 15A NCAC 2T .0403:

   a. The sewer system shall be effectively maintained and operated at all times to prevent discharge to land or surface waters, and any contravention of the groundwater standards in 15A NCAC 2L .0200 or the surface water standards in 15A NCAC 2B .0200.

   b. A map of the sewer system shall be developed and shall be actively maintained.

   c. An operation and maintenance plan shall be developed and implemented.

   d. Pump stations that are not connected to a telemetry system shall be inspected every day (i.e. 365 days per year). Pump stations that are connected to a telemetry system shall be inspected at least once per week.

   e. High-priority sewer lines shall be inspected at least once per every six-month period of time.

   f. A general observation of the entire sewer system shall be conducted at least once per year.

   g. Inspection and maintenance records shall be maintained for a period of at least three years.

   h. Overflows and bypasses shall be reported to the appropriate Division regional office in accordance with 15A NCAC 2B .0506(a), and public notice shall be provided as required by North Carolina General Statute §143-215.1C.

4. **This permit shall not be transferable.** In the event there is a desire for the wastewater collection facilities to change ownership, or there is a name change of the Permittee, a formal permit request shall be submitted to the Division accompanied by documentation from the parties involved, and other supporting materials as may be appropriate. The approval of this request shall be considered on its merits and may or may not be approved.

5. Construction of the gravity sewers, pump stations, and force mains shall be scheduled so as not to interrupt service by the existing utilities nor result in an overflow or bypass discharge of wastewater to the surface waters of the State.

6. Upon completion of construction and prior to operation of these permitted facilities, a certification, a copy of the construction record drawings, as well as supporting design calculations for any pump stations permitted as part of this project shall be received from a North Carolina-licensed Professional Engineer certifying that the facilities have been installed in accordance with this permit; 15A NCAC 2T; the Division's Gravity Sewer Design Criteria adopted February 12, 1996 as applicable; the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Station and Force Main adopted June 1, 2000 as applicable; and other supporting materials. If this project is to be completed in phases and partially certified, you shall retain the responsibility to track further construction approved under the same permit, and shall provide a final certificate of completion once the entire project has been completed. A copy of the construction record drawings, indicating the facilities constructed in the phase being certified, shall be submitted with each partial certification. Mail the Engineer's Certification, one copy of the "Construction Record Drawings," and one copy of the supporting design calculations to the Non-Discharge Permitting Unit, 1617 Mail Service Center, Raleigh, NC 27699-1617.

7. A copy of the construction record drawings shall be maintained on file by the Permittee for the life of the wastewater collection facilities.

8. Failure to abide by the conditions and limitations contained in this permit; 15A NCAC 2T.; the Division's Gravity Sewer Design Criteria adopted February 12, 1996 as applicable; the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Station and Force Mains adopted June 1, 2000 as applicable; and other supporting materials may subject the Permittee to an enforcement action by the Division, in accordance with North Carolina General Statutes §143-215.6A through §143-215.6C.

9. In the event that the wastewater collection facilities fail to perform satisfactorily, including the creation of nuisance conditions, the Permittee shall take immediate corrective action, including those as may be required by this Division, such as the construction of additional or replacement facilities.

10. The issuance of this permit shall not exempt the Permittee from complying with any and all statutes, rules, regulations, or ordinances that may be imposed by other government agencies (local, state and federal) which have jurisdiction, including but not limited to applicable river buffer rules in 15A NCAC 2B .0200, erosion and sedimentation control requirements in 15A NCAC Ch. 4 and under the Division's General Permit NCG010000, and any requirements pertaining to wetlands under 15A NCAC 2B .0200 and 15A NCAC 2H .0500.

11. **Noncompliance Notification:**

The Permittee shall report by telephone to a water quality staff member at the Asheville Regional Office, telephone number (828) 296-4500, as soon as possible, but in no case more than 24 hours or on the next working day, following the occurrence or first knowledge of the occurrence of either of the following:

a. Any process unit failure, due to known or unknown reasons, that renders the facility incapable of adequate wastewater transport, such as mechanical or electrical failures of pumps, line blockage or breakage, etc.; or

b. Any failure of a pumping station or sewer line resulting in a by-pass directly to receiving waters without treatment of all or any portion of the influent to such station or facility.

Voice mail messages or faxed information is permissible but this shall not be considered as the initial verbal report. Overflows and spills occurring outside normal business hours may also be reported to the Division of Emergency Management at telephone number (800) 858-0368 or (919) 733-3300. Persons reporting any of the above occurrences shall file a spill report by completing Part I of Form CS-SSO (or the most current Division approved form), within five days following first knowledge of the occurrence. This report shall outline the actions taken or proposed to ensure that the problem does not recur. Per Condition I(2), Part II of Form CS-SSO (or the most current Division approved form) can also be completed to show that the SSO was beyond control.

Permit issued this the 29th day of July, 2011

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

Roger C. Edwards

for Coleen H. Sullins, Director
Division of Water Quality
By Authority of the Environmental Management Commission

Permit Number WQ0035486

ENGINEERING CERTIFICATION – POST CONSTRUCTION

System Description:

permission is hereby granted to Haywood County for the construction and operation of approximately 1,212 linear feet of 2-inch force main and pump station with duplex pumps with on-site audible and visual high water alarms, as part of the Francis Farm Leachate Pump Station project, and the discharge of collected landfill leachate wastewater into the Town of Waynesville existing sewerage system.

Complete and submit this form to the Asheville regional office with the following:

- One copy of the project record drawings (plan & profile views of sewer lines) of the wastewater collection system extension
- supporting design calculations (selected pumps, system curve, operating point, available storage if portable generator(s) or storage greater than longest past three year outage reliability option selected) for any pump stations permitted as part of this project
- Changes to the project should be clearly identified on the record drawings or in written summary form. Permit modifications are required for any changes resulting in non-compliance with this permit, regulations or minimum design criteria.

This project shall not be considered complete nor allowed to operate until this Engineer's Certification and all required supporting documentation have been received by the Division. **Therefore, it is highly recommended that this certification be sent in a manner that provides proof of receipt by the Division.**

ENGINEER'S CERTIFICATION

☐ Partial ☒ Final

I, William H. Sperry, as a duly registered Professional Engineer in the State of North Carolina, having been authorized to observe (☒ periodically, ☐ weekly, ☐ full time) the construction of the above referenced project for the Permittee hereby state that, to the best of my abilities, due care and diligence was used in the observation of the construction such that the construction was observed to be built within substantial compliance of this permit; 15A NCAC 2T; the Division of Water Quality's (Division) Gravity Sewer Minimum Design Criteria adopted February 12, 1996 as applicable; the Division's Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains adopted June 1, 2000 as applicable; and other supporting materials.

North Carolina Professional Engineer's seal, signature, and date:

NORTH CAROLINA PROFESSIONAL SEAL 36132 ENGINEER WILLIAM H. SPERRY 7/23/12

SEND THIS FORM & SUPPORTING DOCUMENTATION WITH REQUIRED ATTACHMENTS TO THE FOLLOWING ADDRESS

ROGER C. EDWARDS
SURFACE WATER PROTECTION SUPERVISOR
ASHEVILLE REGIONAL OFFICE
2090 US HIGHWAY 70
SWANNANOA, NC 28778

The Permittee is responsible for tracking all partial certifications up until a final certification is received. Any wastewater flow made tributary to the wastewater collection system extension prior to completion of this Engineer's Certification shall be considered a violation of the permit and shall subject the Permittee to appropriate enforcement actions.

Francis Farm Landfill
Haywood County, North Carolina

Permit No. WQ0035486

The Francis Farm Landfill pump station is a packaged unit with dual pumps specified to operate at 30 gpm at 23 feet TDH. The pumps as installed operate at ±32 gpm at ±23 feet TDH or ±30 gpm at ±25.8 feet TDH. A copy of the applicable pump curve is attached to this project description. Also attached is data on the pumps. The pumps are controlled to operate as alternating pumps under normal conditions. If needed to handle the flow the pumps will operate as "lead on" then "lag on". The pump station is equipped with an auto-dialer and both audible and visual alarm systems should the pumps fail to operate and the level of liquid in the wet well continues to rise.

The package pump station receives its flow from six (6) down-hole variable speed piston pumps specifically designed to remove leachate from water logged landfill gas wells. The pumps utilized on this project are capable of varying the pump rate from a low of approximately 1/2 gallon per minute to a maximum of approximately 3.3 gallons per minute. During the initial week of operation the pumps will be set at the maximum pump rate to remove the accumulated water in the wells and the surrounding waste mass. After approximately a week of operation the pump rate will be dialed back to approximately 1/2 to 1 gallon per minute as the recharge rate for solid waste is generally very slow. The intent is to keep the wells relatively clear of liquid to enhance the flow of methane gas to the collection and combustion system. Once the initial liquid is removed the anticipated flow rate to the pump station should be in the range of 3 – 6 gallons per minute. A knockout pot for collection condensate from the landfill gas collection lines also discharges into the package pump station. The pump in this tank is also a down-hole variable speed piston pump with the same capacity and operating characteristics as the aforementioned pumps except that it is operated with liquid level transducers to control when it runs.

The pump station, the knockout pot pump and the down-hole variable speed piston pumps operate off the same single electrical feed from Haywood EMC. The electrical power comes into the main disconnect located on a power control panel rack located in the vicinity of the pump station. From the main disconnect the power runs through a double-throw switch panel to allow the use of stand-by generator power should the need arise. From there the pump station, the down-hole piston pumps and the flare system feed through designated control panels. A unique feature of this system is that in the event of a system power failure at the site then all systems go down simultaneously and the flow to the pump station ceases except for the flow left in the pipes at the time the power ceased. When the power is restored, the pumping systems will restart automatically. Should the need arise, the entire system is equipped with a power connect feed for a standby generator. Operators are on site daily to monitor the operation of the flare system, the engine/generator system and the operation of the pump station.

The pump station is a 48" diameter unit that is 12'-6" in total vertical height with a capacity of approximately 94 gallons of liquid per vertical foot. Basically this package pump station has storage capacity in excess of approximately 640 gallons to 752 gallons that could be utilized in the case of an emergency or power outage.

McGill ASSOCIATES
Engineering • Planning • Finance
McGill Associates, P.A. P.O. Box 2259, Asheville, NC 28802
55 Broad Street, Asheville, NC 28801 828-252-0575 Fax 828-252-2518

PROJECT: Francis Farm Landfill, Haywood Cty.
PROJECT NO.: 09.00721
DESCRIPTION: Permit No. WQ0035486
CALCULATED BY: WHS CHECKED BY:
DATE: 1/30/12 SHEET NO. 1 OF 1

Packenger Pump Station - 48" Diameter - ≈94 gallons / vertical foot.

Controlling Elevation for the liquid level would be the elevation of the electrical coupling @ elevation 2693.0 (24"-30" below Top of pump station) - See copy of cut-sheet from pump station submittal.

Lowest approximate elevation of liquid retained in the pump station will be elevation 2685.0 (pump-off elevation) The highest normal level of liquid in the pump station should be approximately elevation 2686.2 when the lead pump should switch on.

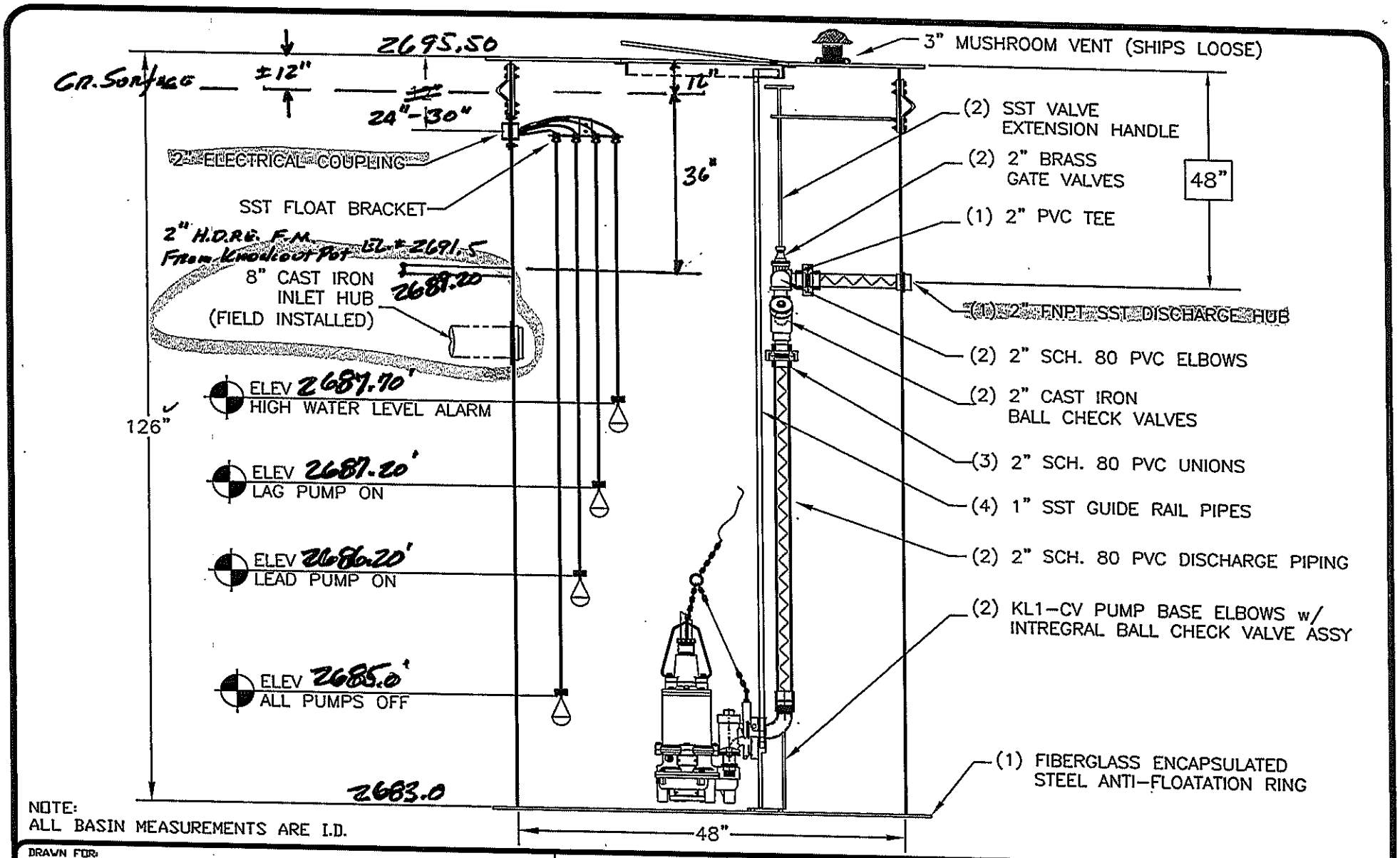
Storage available between the electrical coupling (elevation 2693.0) and the lead pump on elevation (elevation 2686.2) is 639.2 gallons.

Elev. Electrical Coupling: 2693.0
Elev. Lead pump on: 2686.2
6.8 v.f @ 94 gal./v.f. = *639.2 gal

Storage available between the electrical coupling (elev. 2693.0) and the pump off elevation (elev. 2685.0) is

Elev. Electrical Coupling: 2693.0
Elev. Pump Off: 2685.0
8.0 v.f @ 94 gal/v.f. = ≈ 752.0 gals

Therefore the volume of storage capacity could vary between approximately ≈640 gallons to ≈752 gallons depending on the level of the liquid at the time the power to the system went down.



NOTE:
ALL BASIN MEASUREMENTS ARE I.D.

DRAWN FOR: FRANCIS FARM LANDFILL – PHASE 2B	PO# ––– / QUOTE # –––	DISCONNECTS: KEEN KL1-CV / PUMPS: KEEN KG2-23	SHEET 1 OF 2 / Revision 0
JOB REFERENCE / Notes: PACKAGE LEACHATE GRINDER PUMP STATION	BASIN DESCRIPTION: 48" X 126" DUPLEX FIBERGLASS BASIN / COVER DESCRIPTION: 1/4" ALUMINUM DIAMOND-PLATED COVER	DRAWN BY: SMH / DATE: 6/06/2011 / CHECKED BY: SMH / DATE CHECKED: 7/22/2011	CAROLINA PUMPWORKS Engineered Pumping & Process Equipment phone: 828-692-4511 - fax: 828-692-4501 www.cpwllc.com

CPW
CAROLINA PUMPWORKS, LLC

172 Highlands Square Dr, Suite 313
Hendersonville, NC 28792
Cell: (803) 917-9798
Phone: (828) 692-4511
Fax: (828) 692-4501
E-mail: shale@cpwllc.com

July 23, 2011

To: Payne, McGinn & Cummins, Inc. **From:** Scott Hale

Attn: Rick Galway, P.E. **Re:** Package Submersible Leachate Pumping Station for Francis Farm Landfill – Phase 2B – Haywood County

PACKAGE SUBMERSIBLE LEACHATE PUMP STATION

2 ea Keen Pump Model KG2-23 Submersible Solids Handling Sewage Grinder Pump Of Heavy-Duty Cast Iron Construction, Direct Coupled To A Totally Encapsulated, Submersible Motor To Include the Following Items of Construction:

- 2-HP, 3450 RPM, 460-Volt, 3-Phase, Class F, High Torque Submersible Motor
- Double Mechanical Shaft Seals – Silicon Carbide Upper & Lower Seal Faces
- Motor Winding Over-Temperature Sensors
- Two-Probe Seal Fail Sensors Detects Moisture Intrusion Inside Motor Housing
- Stainless Steel Pump Lifting Bail Assembly
- 30-ft Dual Power & Control Cables

1 ea **48" Diameter X 126" Deep** Duplex Factory-Built Fiberglass Wet-Well System to Arrive Onsite with the Following Components Pre-Plumbed and Factory Installed:

- 2" NPT Cast Iron Base Elbows for Pump Lift-Out Guide Rail System
- Cast Iron Pump Sealing Flanges w/ Rail Guide Plates & Integral Ball Check Valve Assemblies
- 2" Sch. 80 PVC Discharge Piping, Elbows & Unions As Required
- 2" Brass Isolation Gate Valves w/ Stainless Steel Valve Extension Handles
- 2" FNPT Stainless Steel Discharge Hub – Located 48" Down From Top of Basin
- 1" Stainless Steel Guide Rails
- 3/16" Stainless Steel Lifting Chain Assemblies for Removing Pumps
- Stainless Steel Float Switch Mounting Bracket
- Aluminium Skid-Proof Cover w/ Hinged Access Door, Hold-Open Arm, & Lockable Latch
- 8" Cast Iron Inlet Hub *(inlet hub ships loose for field installation by contractor)*

1 ea Duplex 2-HP Pump Control Panel for **460-Volt, 3-Phase** Incoming Power To Include the Following:

- NEMA 4X Fiberglass Enclosure w/ Aluminium Dead Front Inner Door & Lockable Latch
- UL 508 Listed & Labeled
- Lightning Arrestor
- Power Distribution, Neutral & Grounding Blocks
- Phase & Voltage Monitor
- 460V/120V Control Power Transformer, 2kVA with Primary & Secondary Fusing
- Individual Pump Circuit Breakers
- Control Power Circuit Breaker
- IEC Rated Motor Starters w/ Adjustable Overloads
- Hand-Off-Auto Switches
- Pump Run Indicator Lights
- Elapsed Time Meters *(non-resettable type)*
- Duplex Float Switch Relay Logic *(pump off, lead pump, lag pump, & high water alarm)*
- Seal Failure & Motor Over-Temperature Alarms w/ Indicator Lights
- Flashing Alarm Light
- Audible Alarm Horn w/ Silence Pushbutton
- Auxiliary Contacts for Telephone Alarm Dialer

CONTINUED

CPW
CAROLINA PUMPWORKS, LLC

172 Highlands Square Dr, Suite 313
Hendersonville, NC 28792
Cell: (803) 917-9798
Phone: (828) 692-4511
Fax: (828) 692-4501
E-mail: shale@cpwllc.com

1 ea 4-Channel Automatic Telephone Alarm Dialer w/ 12-Volt Battery Back-Up To Be Mounted, Wired and Tested Inside Pump Control Panel. *(Telephone line and connection services provided by others)*

4 ea Liquid Level Float Switches, Internally Weighted & 30-ft. Control Cables

1 ea Flomotion Systems Isomag Model MS2500-T50-A6A4B - 2" Flanged Electromagnetic Flow Meter and Shall Include the Following Items of Construction:
- 304SS, PTFE Lined Flow Tube
- 150# ANSI Flanges
- Hastelloy C Flow and Grounding Electrodes

1 ea Flomotion Systems Isomag Model ML110-B0B1B1A0 Converter / Transmitter and Shall Include the Following Items of Construction:
- Two Line Alphanumeric Display
- Internal 3 Position Keypad
- Programmable 4-20mA & (2) Selectable Frequency, Scaled Pulse or Alarm Outputs
- Bi-Directional Flow Capability
- 90-265 VAC Power Input
- Corrosion Resistant Non-Metallic NEMA 4X Enclosure w/ Remote Sensor Mount

1 ea 100-ft. – Electrode and Coil Interconnect Cable

2 ea Sets of Recommended Spare Parts Provided for Each Submersible Grinder Pump

1 ea Day Start-Up Service, Equipment Testing & Operator Training – 1-Day, 1-Trip

1 ea Prepaid Freight to Jobsite – Equipment Off-Loading By Others

NOTES:

1. Our proposal only includes the components quoted herein.
2. Taxes are not included and any applicable taxes will be added to the final invoice.
3. The above pricing includes pre-paid freight to the jobsite via a commercial LTL freight carrier.
4. Equipment off-loading and/or installation services are provided by others.
5. Piping, valves, and/or any miscellaneous fittings external to the fiberglass basin provided by others.
6. Flow meter vault, access cover, piping, valves, fittings, wiring, and/or installation of meter by others.
7. Generator, transfer switch, generator receptacle, and/or generator plug are provided by others.
8. Main service disconnect, meter base, area lighting, and/or signage are provided by others.
9. Conduit, miscellaneous fittings, Kellum grips, and/or field wiring connections provided by others.
10. Flow meter vault, access cover, piping, valves, fittings, wiring, and/or installation by others.
11. Equipment delivered in **4 weeks** after receiving approved submittals.

All prices are F.O.B. factory, full freight allowed to jobsite where accessible by commercial carrier. Prices do not include any applicable taxes. Warranty and sales conditions are per manufacturers and Carolina Pumpworks standard terms and conditions. Payment terms are Net 30 days. A 1.5% per month finance charge will be applied to any past due invoices. Partial billing will be made on partial shipments. Payment terms are independent of and not contingent upon third party contracts or commitments, unless Carolina Pumpworks specifically agrees to terms in writing.

We thank you for your interest in our equipment and look forward to being of service to you in the near future.

Features and Benefits

1.Triple Sealed Cable Entrance
Stainless steel strain relief cord grip with compression grommet protects outer cord jacket. Epoxy filled inner cord cap with individually soldered wires provide anti-wicking moisture protection to the motor even if power cable is cut or damaged.

2. Modular Pump Design
Commonality of parts across the Keen product line minimizes the amount of parts required for servicing. Heavy duty ASTM A48, Class 30 cast iron components.

3. Strong Motor
Powerful high torque motor for reliable pump operation.
208 / 230 volt, 1-phase
208 / 230 / 460 volt, 3-phase
Pressed stator securely holds motor and efficiently transfers heat. Class F insulation with overload protection in oil filled chamber for cool operation and long motor life.

4. 3- Bearing Support
Motor / Pump shaft securely held with upper and lower ball bearing plus addition sleeve bearing in lower seal chamber. Long 50,000 hour B-10 bearing life.

5. Double Mechanical Seal Protection
Dual silicon carbide mechanical shaft seals provide twice the moisture protection for the motor. Dual seals are housed in a secondary oil filled seal chamber. Tougher silicon carbide seals better handles sand, grit and abrasive materials.

6. Moisture Detection
Seal leak probe signals alarm in control panel for scheduled maintenance.

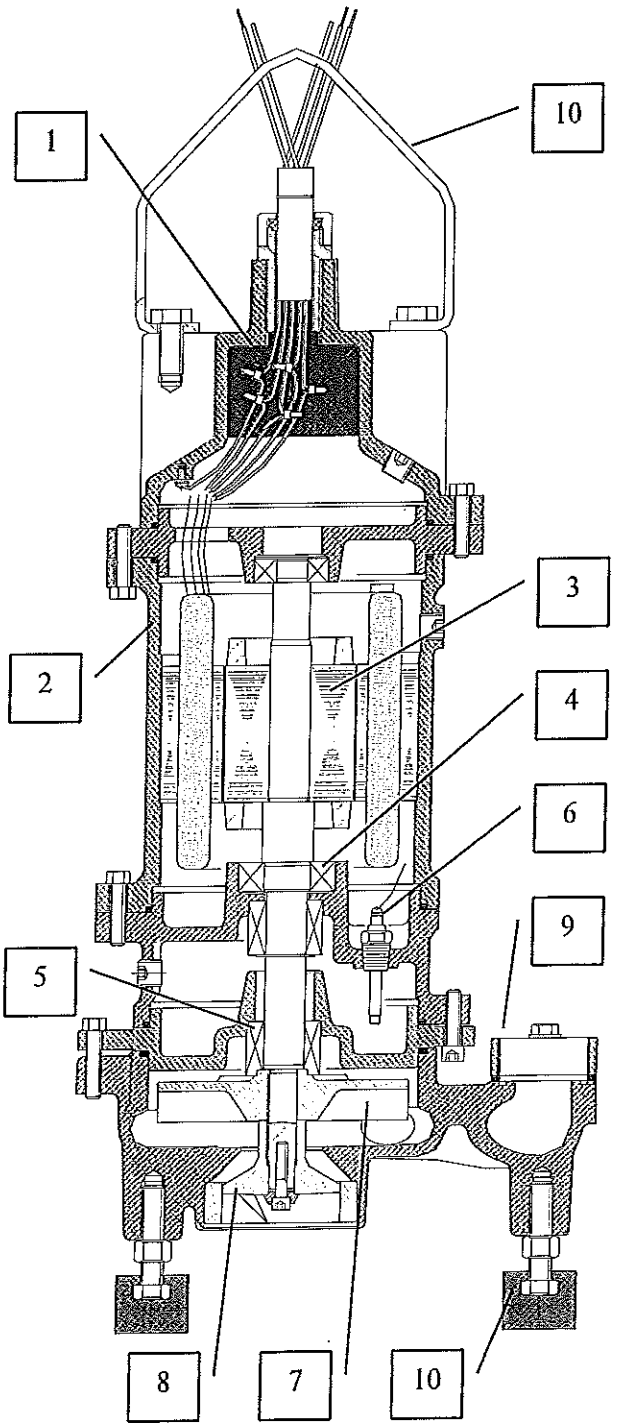
7. Non-Overloading Hydraulic Design
The recessed centrifugal impeller allows 100% performance curve operation from shut-off to maximum flow without damage to the pump or system. The recessed vortex impeller is out of the passageway of fluid flow, eliminating concerns of blockage or wear.

8. Proven Grinder Assembly
Hardened (Rockwell 56-60) stainless steel grinder assembly has 30+ years proven field experience. The reversible grinder ring and grinder impeller effectively reduces solids into a fine slurry, easily passable in a piping system without concerns of clogging. Highly efficient 16,600 cuts per second.

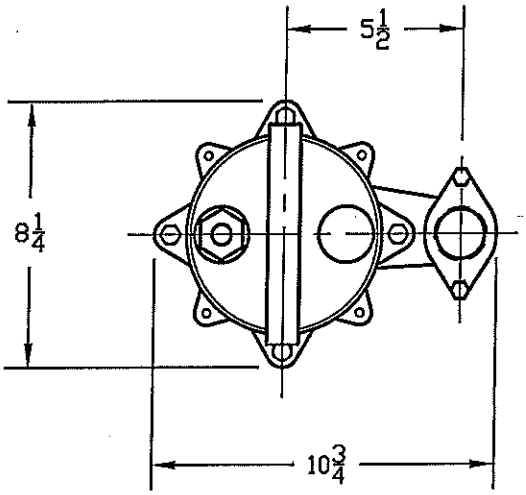
9. Easy Piping Connection
Removable 1-1/4" NPT connection flange for simple and easy connection to discharge piping.

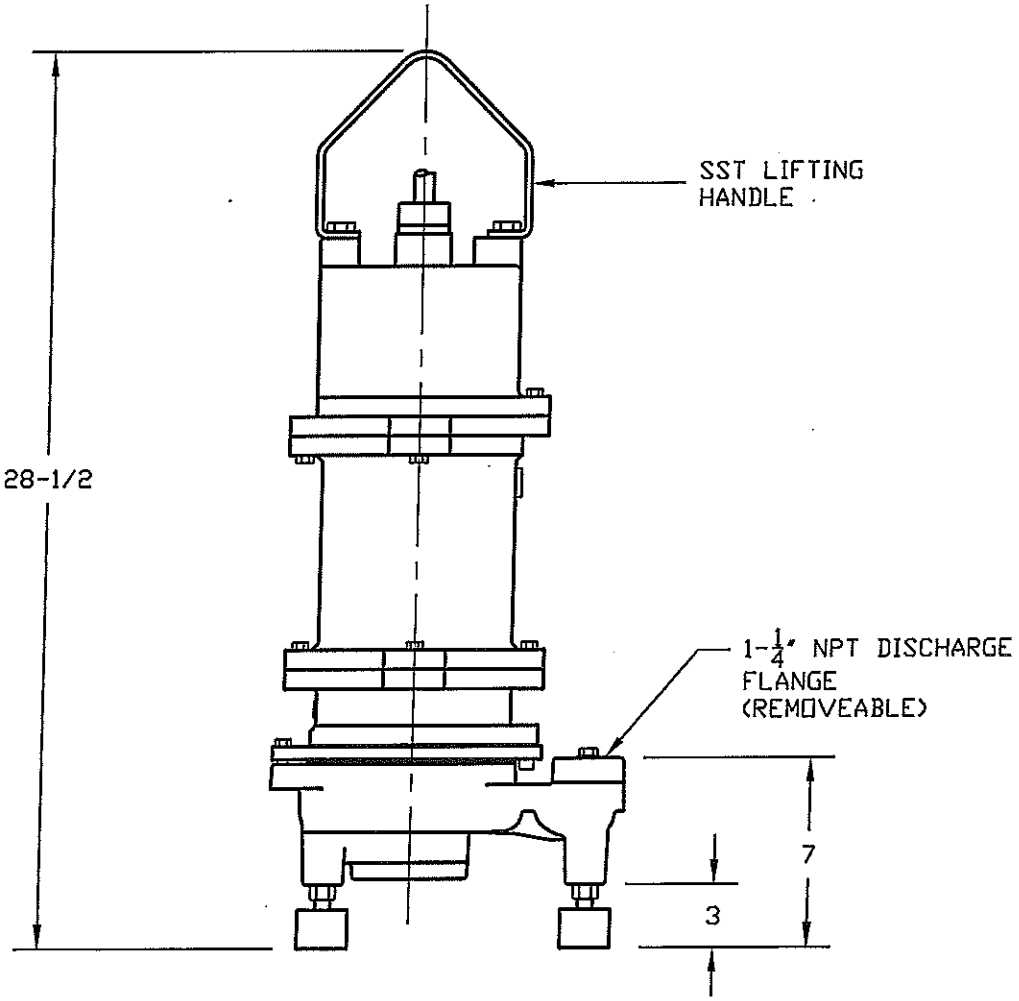
10. Accessories Included
Stainless steel lifting handle and anti-vibration rubber mounting feet are included with the pump.

2 HP Grinder Pump
Dual Seal
KG2-21 & 23



ISO 9001
CERTIFIED PUMP





KEEN PUMP COMPANY
KEEN PUMP CO.
471 EAST STATE ROUTE 250 E.
ASHLAND, OHIO 44805
PHONE: 419-207-9400
FAX: 419-207-8031

TITLE: KG2 2HP GRINDER PUMP OUTLINE			
SCALE: NTS		DWG. #: KN-16	REV.: -
DWG. BY: F. YUHASZ	DATE: 9/25/08		

Keen Pump

2 HP Grinder Pumps KG2-21 & 23

Performance Specifications

Pump Model – Pump shall be of the centrifugal type, KG2-21 & 23, with an integrally built-in grinder unit and submersible type motor. The grinder unit shall be capable of macerating all material in normal domestic and commercial sewage, including reasonable amounts of foreign objects such as sanitary napkins, disposable diapers, thin rubber, small wood, plastic and the like to a fine slurry that will easily pass through the pump and 1-1/4" NPT discharge.

Operating Conditions – The pump shall have a capacity of 30 GPM at a total head of 23 feet, and shall use a motor rated at 2 HP and 3450 RPM.

Pump Impeller – Ductile Iron threaded on a stainless steel shaft. The impeller shall be of the recessed vortex type to provide an unobstructed passage through the volute for the ground solids.

Grinder Construction – Both grinder impeller and shredding ring shall be of 440C stainless steel hardened to 56-60 Rockwell C. The grinder assembly shall consist of a grinder impeller and shredding ring mounted directly below the volute passage. The grinder impeller is threaded to a stainless steel shaft, locked with a screw and washer. The shredding ring shall be pressed into the cast iron volute for easy removal. All grinding of solids shall be from the action of the grinder impeller against the shredding ring. There shall be 16,600 cuts / second.

Seals – Type 21, dual mechanical seal construction mounted in tandem, shall protect the motor. Primary seal shall be silicon / carbide. Secondary seal shall be silicon / carbide. The seal face shall be lapped to a flatness of one light band. An electrode shall be mounted in the seal chamber to detect water entering the chamber through the lower seal. Water in the chamber shall cause a red light to turn on at the control box. This signal shall not stop the motor, but shall act as a warning only, indicating service is required.

Motor – The pump motor shall be of the submersible type, rated 2 HP, 3450 RPM. The motor shall be for 60 Hz, either 208,230, 460 volt, single or three phase operation. Single-phase motors shall be capacitor start, capacitor run type for high starting torque. Start & run capacitors, and electronic relay for operating the motor will be found in the control box. Major motor operating temperature must not exceed Class B ratings.

The stator winding shall be of the open type with Class F Insulation. Winding housing shall be filled with clean, high dielectric oil that lubricates bearings and seals, transferring heat from windings and rotor to the outer cast housing. Air-filled motors, which do not have the superior heat dissipating capabilities of oil-filled motors, shall not be considered equal.

The motor shall have two heavy-duty ball bearings and one sleeve bearing to support the pump shaft, taking radial and thrust loadings. Ball bearings shall be designed for a minimum 50,000 hours B-10 life. The stator shall be pressed into the motor housing. The common motor pump and grinder shaft shall be of 416 SST, threaded to take the pump and grinder impeller.

Single-phase motors shall have automatic reset overload protection attached to the top end of the motor windings to stop the motor if the motor winding temperature reaches 130 degrees C. The high temperature shut-off will cause the pump to cease operation, should a control failure cause the pump to run in a dry wet well. The overload shall automatically reset when the motor cools to a safe operating temperature. Three phase motors contain temperature sensors with (2) wires for attachment to the control panel.

Power Cord – The motor power cord shall be 12 Ga. SOW/SJOWA or SOOW. The cable jacket shall be sealed at the motor entrance by means of a rubber compression washer and compression nut. An epoxy filled cord cap shall seal the outer cable jacket and individual leads to prevent water from entering the motor housing. Individual conductor strands shall be soldered within.

PUMP SPECIFICATIONS

DISCHARGE..... 1-1/4" NPT, Vertical
LIQUID TEMPERATURE..... 120 degrees F (Continuous)
140 degrees F. (Intermittent)

MOTOR HOUSING..... Cast Iron, ASTM A-48, Class 30
CORD CAP..... Cast Iron, ASTM A-48, Class 30
VOLUTE..... Cast Iron, ASTM A-48, Class 30
SEAL PLATE.....Cast Iron, ASTM A-48, Class 30

IMPELLER..... Ductile Iron, ASTM A-48, Class 35B
12 vane, Vortex with Pump-out Vanes, Dynamically Balanced

SHREDDING RING..... Hardened 440C Stainless Steel
56-60 Rockwell C
GRINDER IMPELLER..... Hardened 440C Stainless Steel
56-60 Rockwell C

SHAFT..... 416 Stainless Steel

SHAFT SEAL..... Mechanical

Main (Motor)	Secondary(Pump)
Carbide – Rotating Face	Carbide – Rotating Face
Silicon– Stationary Face	Silicon – Stationary Face

Buna-N - Elastomer
300 Series Stainless Steel - Hardware

BEARING (UPPER)..... Single Row, Ball, Oil Lubricated
BEARING (LOWER)..... Single Row, Ball, Oil Lubricated

HARDWARE..... 300 Series Stainless Steel
O-RINGS..... Buna-N

CORD..... 12 AWG, Type SJOW or SOOW
30' Length Standard. Other Lengths Available.

CORD ENTRY..... Triple Sealed Design
Compression Grommet – Outer Jacket Seal
Epoxy Potted – Inner Conductor Seal
Butt Connector – Inner Wire Strand Wicking Blockage

MOTOR (SINGLE PHASE)..... 2 HP, 3450 RPM, 60 Hz
Dual voltage, 200 / 230 volts
Includes Overload Protection in the Motor.
Oil Filled, Class F
Capacitor Start / Capacitor Run

		Start Capacitor	Run Capacitor
KG2-115	K(H)G2-21C	..... 200 mfd, 125 VAC	70 mfd, 250 VAC
	K(H)G2-21	.... 150 mfd, 250 VAC	30 mfd, 370 VAC
	KHHG2(H)-21	.... 300 mfd, 250 VAC	30 mfd, 370 VAC

MOTOR (THREE PHASE)..... 2 HP, 3450 RPM, 60 Hz
Tri-voltage, 200 / 230 / 460 volts
On-Winding temperature sensor, requires temperature sensor circuitry in control panel
Oil Filled, Class F

OPTIONAL EQUIPMENT..... Seal Materials
Additional Cable Lengths
Impeller Trims

Pump Data Sheet - Keen Pump

Company: Carolina Pumpworks, LLC
Name: Scott M. Hale
Date: 7/23/2011

KEEN PUMP

Pump:

Size: KG2-21, KG2-23

Type: Grinder
Synch speed: 3600 rpm

Speed: 3450 rpm
Dia: 3.75 in

Curve:

Impeller:

Specific Speeds:

Ns: ---
Nss: ---

Dimensions:

Suction: ---
Discharge: 1.25 in

Pump Limits:

Temperature: ---
Pressure: ---
Sphere size: ---

Power: ---
Eye area: ---

Search Criteria:

Flow: 30 US gpm

Head: 23 ft

Fluid:

Water
Density: 62.25 lb/ft³
Viscosity: 1.105 cP

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: TEFC

Size: 2 hp
Speed: 3600
Frame: 145T

Sizing criteria: Max Power on Design Curve

---- Data Point ----

Flow:	30 US gpm
Head:	25.1 ft
Eff:	n/a
Power:	2 hp
NPSHr:	n/a

---- Design Curve ----

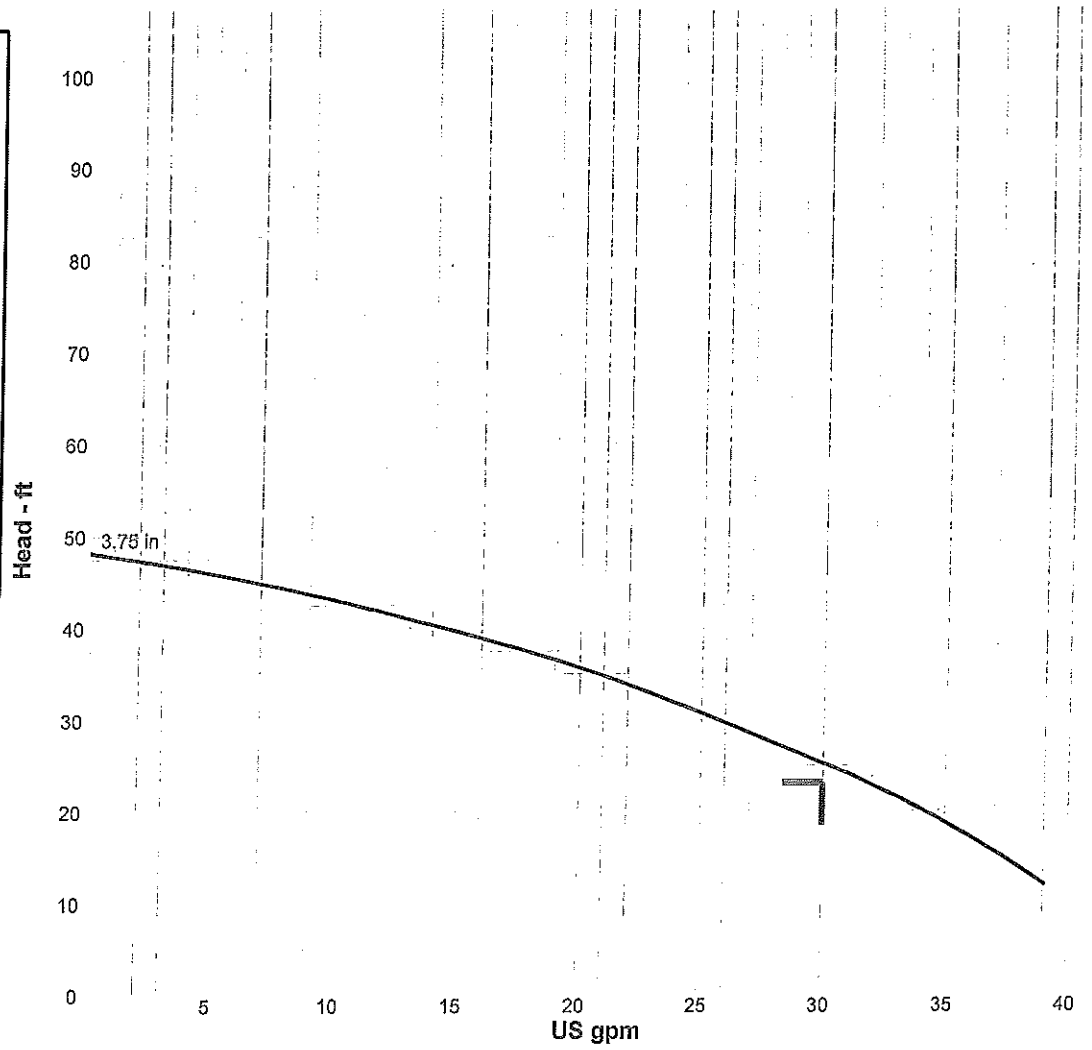
Shutoff head:	48.2 ft
Shutoff dP:	20.8 psi
Min flow:	---

BEP: --- %

NOL power:
2 hp @ 2.5 US gpm

-- Max Curve --

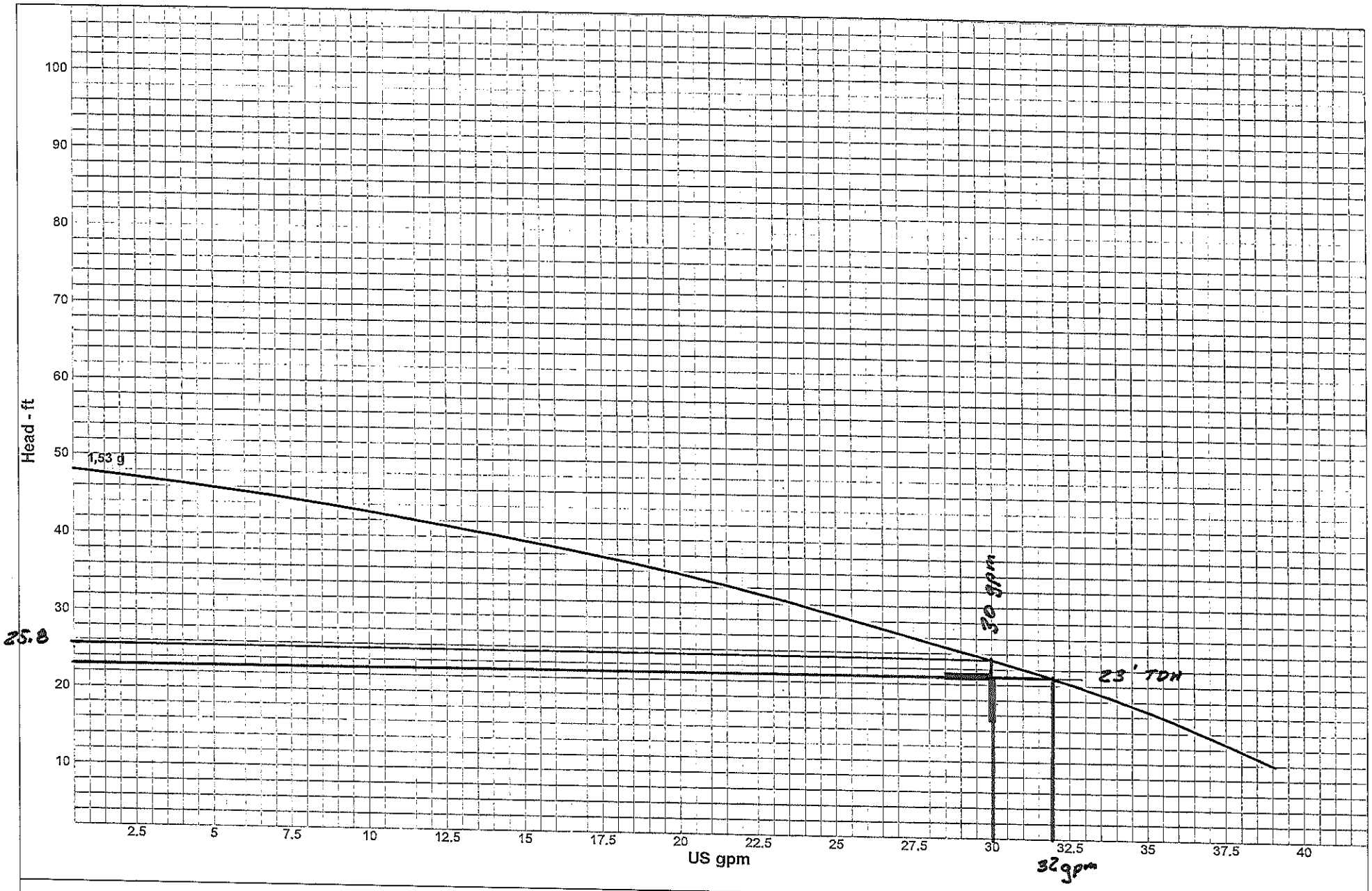
Max power:
2 hp @ 2.5 US gpm



Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
36	3450	17	---	2	---
30	3450	25.1	---	2	---
24	3450	31.6	---	2	---
18	3450	37.1	---	2	---
12	3450	41.7	---	2	---

Selected from catalog: Keen.60, Vers Nov 2009



Company: Carolina Pumpworks, LLC
Name: Scott M. Hale
7/23/2011

Keen Pump Company
Catalog: Keen.60, Vers Nov 2009
Grinder - 3600
Design Point: 30 US gpm, 23 ft

Size: KG2-21, KG2- 23
Speed: 3450 rpm
Dia: 3.75 in

KEEN PUMP

State of North Carolina
Department of Environment and Natural Resources
Division of Water Quality

Flow Tracking/Acceptance for Sewer Extension Permit Applications
(FTSE –10/07)

Project Applicant Name: Haywood County

Project Name for which flow is being requested: Francis Farm Landfill

More than one FTSE-10/07 may be required for a single project if the owner of the WWTP is not responsible for all pump stations along the route of the proposed wastewater flow.

I. Complete this section only if you are the owner of the wastewater treatment plant.

a. WWTP Facility Name: Town of Waynesville

b. WWTP Facility Permit #: NC 0025321

	All flows are in MGD
c. WWTP facility's permitted flow	6.0
d. Estimated obligated flow not yet tributary to the WWTP	0.008
e. WWTP facility's actual avg. flow	2.899
f. Total flow for this specific request	0.015
g. Total actual and obligated flows to the facility	2.922
h. Percent of permitted flow used	48.7%

II. Complete this section for each pump station you are responsible for along the route of this proposed wastewater flow.

List pump stations located between the project connection point and the WWTP

Pump Station Name	Approx. Capacity, MGD (Firm/Design)	Approx. Current Avg. Daily Flow, MGD

III. Certification Statement:

I, Frederick L. Baker, certify that, to the best of my knowledge, the addition of the volume of wastewater to be permitted in this project has been evaluated along the route to the receiving wastewater treatment facility and that the flow from this project is not anticipated to cause any capacity related sanitary sewer overflows or overburden any downstream pump station en route to the receiving treatment plant under normal circumstances. This analysis has been performed in accordance with local established policies and procedures using the best available data. This certification applies to those items listed above in Sections I and II for which I am the responsible party. Signature of this form indicates acceptance of this wastewater flow.

Frederick L. Baker Dir Pub Wks 6/22/10

Signing Official Signature *Date*

Appendix C

Landfill Gas Monitoring Plan
Francis Farm Landfill
Permit No. 44-03

LANDFILL GAS MONITORING PLAN

FRANCIS FARM LANDFILL
PERMIT NO. 44-03
HAYWOOD COUNTY, NORTH CAROLINA

JEFFREY R. BISHOP, PE

McGill ASSOCIATES
Engineering • Planning • Finance
Asheville, North Carolina

September 2010

10.00726

Landfill Gas Monitoring Plan
Francis Farm Landfill
Permit No. 44-03

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1.0 Introduction

2.0 Regulatory Compliance

3.0 Landfill Gas Monitoring Plan

3.1 Landfill Gas Compliance Monitoring Locations
3.2 Monitoring Frequency
3.3 Landfill Gas Analyzer
3.4 Field Monitoring Protocol
3.5 Methane Gas Response Plan

Appendices:

Appendix 1: Environmental Monitoring Plan Drawing (Figure 1)
Appendix 2: Landfill Gas Monitoring Probe Detail
Appendix 3: Landfill Gas Measurements – Field Worksheet
Appendix 4 LandTec GEM 2000 Operations Manual

1.0 Introduction

The Francis Farm Landfill, Permit No. 44-03, is located in Haywood County, North Carolina on Francis Farm Road, (S.R. 1802), Waynesville, North Carolina. The Francis Farm Landfill began operation in the early 1970's and was operated as Haywood County's primary MSW landfill through 1994. The facility was officially closed per a Closure Certification prepared by RCF, Inc. Hazelwood, North Carolina dated September 14, 1994 and submitted to the North Carolina Department of Environment and Natural Resources (NCDENR). The original Permit for Closure was issued on December 13, 1995. The facility encompasses approximately 33.1 acres as shown on the Environmental Monitoring Plan Drawing (Figure 1), included as Appendix 1. Within the Facility Boundary, in addition to the closed landfill, Haywood County Schools operates a maintenance facility. The Maintenance Facility includes a maintenance/bus garage building, equipment storage building, and maintenance storage building. The Maintenance Building consists of offices, carpentry shop and bus maintenance facility.

The Maintenance/ Bus Garage Building is equipped with a methane gas monitoring system and a gas ventilation system constructed below the concrete building slab. The methane gas monitoring system continuously monitors for methane gas at three (3) strategic locations within the building, including the base of the mezzanine stairs, the hallway of the office area, and the Carpentry Shop. The system is operated and maintained by the Haywood County School System staff. The system is calibrated once a month. The monitoring system sounds an alert horn if the methane gas readings are detected above 25 percent of the lower explosive limit of methane gas. The below-slab ventilation system was installed as part of the original construction of the building. Based on our discussions with staff, the system consists of a network of pipes tied to the gravel foundation of the building within the bus maintenance portion of the building, which is connected to an exhaust blower. The exhaust blower exhausts air to the outside of the building on the west side.

The Facility Boundary is bounded by private property utilized for residential and agricultural uses. The closest residential structure is located on the Stephens property, approximately 340 feet to the south of the facility property line.

2.0 Regulatory Compliance

The Francis Farm Landfill operates under the Permit for Closure with a most recent revision dated May 23, 2006. This Landfill Gas Monitoring Plan was developed to comply with the following Methane Gas Remediation Conditions section of the Permit for Closure. This section has been included below.

(8) The owner or operator shall maintain and operate the gas monitoring system to ensure that:
   (a) The concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components); and
   (b) The concentration of methane gas does not exceed 100% of the lower explosive limit for methane at the facility property boundary.

(9) If methane gas levels exceeding these limits are detected, the owner or operator must take all steps necessary to meet the standards established in condition 8. Methane gas remediation plans approved by the Division are described in the List of Approved Documents, Attachment 1, Part C of the Permit for Closure.

"Lower Explosive Limit" (LEL) is defined as the lowest percent by volume of a mixture of explosive gases which will propagate a flame in air at 25° C and atmospheric pressure.

3.0 Landfill Gas Monitoring Plan

The Landfill Gas Monitoring Plan has been developed to detect the migration of landfill gas to property line. The Francis Farm Landfill was not constructed with an impermeable base liner system and cap system. There may be a chance for landfill gas migration through the permeable *in situ* soils. The migration of landfill gas is induced by pressure gradients. The landfill gas will move from areas of high pressure to those of low pressure following the path of least resistance. The landfill gas generally migrates vertically until it reaches the landfill cap, where it may begin to flow horizontally. This occurs until it finds a pathway out through the permeable *in situ* soils. As the landfill gas migrates it will fill the void created by the monitoring point's gravel backfill whereupon a landfill gas detection device will detect and read the level of gas concentration.

3.1 Landfill Gas Compliance Monitoring Locations

The landfill gas monitoring probes have been strategically located around the perimeter of the Facility Boundary as shown on Figure 1. The locations were chosen based on the relationship of solid waste disposal areas to property lines and adjacent landfill structures. The existing gas monitoring system includes six (6) gas monitoring probes spaced along the northern, eastern, and southern reaches of the waste area. The probes consist of 1-inch PVC capped pipe enclosed by a metal enclosure with locking metal cap. The PVC pipe is equipped with a quick coupler for use with the landfill gas analyzer. The actual construction details for these original probes are not available.

In addition, the County monitors five (5) specific points within the three (3) existing on-site buildings. The five (5) points are identified with a small plastic sign at each location within the buildings. There are three (3) locations within the Maintenance/ Bus Garage Building, one location in the Equipment Storage Building, and one in the Maintenance Storage Building. These eleven monitoring locations define the existing compliance monitoring points for the landfill and are shown on the attached Figure 1, Environmental Monitoring Plan Drawing.

As part of a Landfill Gas Assessment Plan dated September 2010, Haywood County shall install six (6) new methane monitoring probes along the northern, southern and western reaches of the waste area. These proposed probes are also shown on Figure 1. A detail of the proposed landfill gas monitoring probes is shown in Appendix 2. The new probes are scheduled to be installed on or about November 15, 2010. Following the installation, these probes will be utilized for the Landfill Gas Assessment Plan and also included into the landfill gas compliance monitoring plan. In addition, one of the original methane probes, MM-8, will be reestablished at the time of installation of the new probes.

Table 1 lists the existing and proposed landfill gas compliance monitoring locations for the Francis Farm Landfill.

Table 1 –Landfill Gas Compliance Monitoring Locations

Compliance Point	Description
MM-1	Monitoring Probe along northern property line
MM-2	Monitoring Probe along northern property line
MM-3	Monitoring Probe along northern property line
MM-4	Monitoring Probe along northern property line
MM-5	Monitoring Probe along northern property line
MM-6	Monitoring Probe along eastern property line
MM-7	Monitoring Probe along eastern property line
MM-8	Monitoring Probe along eastern property line
MM-9	Monitoring Probe along southern property line
MM-10	Proposed Monitoring Probe along southern property line
MM-11	Proposed Monitoring Probe along western property line
MM-12	Proposed Monitoring Probe along western property line
MM-13	Proposed Monitoring Probe along western property line
SM-1a	Monitoring Point in Maintenance/ Bus Garage Building – Bus Garage (base of mezzanine stairs)
SM-1b	Monitoring Point in Maintenance/ Bus Garage Building – Office Area (main hallway)
SM-1c	Monitoring Point in Maintenance/ Bus Garage Building - Carpentry Shop
SM-2	Equipment Storage Building (doorway between garage and storage area)
SM-3	Maintenance Storage Building (middle storage bay at floor drain)

3.2 Monitoring Frequency

Haywood County will perform landfill gas monitoring on a quarterly basis (4 times per year) at all of the compliance monitoring locations listed in Table 1. All collected data will be documented on the Landfill Gas Measurement Field Worksheet, included as Appendix 3, and inserted into the permanent landfill operating record. The operating record is located at the office of the Solid Waste Director. Prior to the sampling event, the person performing sampling will review the complete Landfill Gas Monitoring Plan to become familiar with the locations of the compliance points and the requirements of the plan.

3.3 Landfill Gas Analyzer

Haywood County utilizes a LandTec Gem 2000 Gas Analyzer to perform the landfill gas sampling. The landfill gas analyzer equipment must be periodically calibrated by the manufacturer. The user shall verify that factory calibration has been completed in accordance with manufacturer's recommendations. In addition, the analyzer must be field calibrated prior to each sampling event. The field calibration procedure is included in the Operation Manual. A

copy of the Operation Manual is included in Appendix 4. Users shall become familiar with the operation and maintenance of the analyzer prior to use.

Prior to the sampling event, the following preliminary checks of the analyzer should be performed:

(1) Water trap has a clean and dry filter.

(2) Inlet port particulate filter is clean and dry.

(3) Battery is fully charged.

(4) Field Calibration is performed.

3.4 Field Monitoring Protocol

(1) Record date and weather information including weather conditions, temperature, and atmospheric pressure on Landfill Gas Measurement Field Worksheet.

(2) Field calibrate gas analyzer in accordance with manufacturer's procedure.

(3) Proceed to first sample point.

(4) Prior to connection to the probe, turn on analyzer and pump for minimum of 30 seconds to purge any remaining potential contaminates from the equipment.

(5) Unlock probe metal cap.

(6) Check probe or point for condition and suitability for monitoring. Record any problems with location on the Landfill Gas Measurement Field Worksheet.

(7) Connect sample tube from the inlet port of the analyzer to the probe or sample point. For on-site buildings, place sample tube near the designated sample point.

(8) Turn on analyzer air pump to take sample.

(9) For probes less than 20 feet deep, continue to sample until there is a steady reading of gases for a minimum of 30 seconds.

(10) Record the gas levels for % methane, % carbon dioxide, % oxygen, and time of sampling onto the Landfill Gas Measurement Field Worksheet.

(11) Turn-off air pump and disconnect sample tube from the probe.

(12) If gas readings exceed 25 percent of lower explosive limits in buildings or 100 percent of the lower explosive limit in the probes, resample the point. If readings still exceed the limits, notify the Haywood County Solid Waste Director as outlined below.

(13) Proceed to next sample point.

3.5 Methane Gas Response Plan

If methane gas levels exceeding the limits specified above are detected, the owner or operator will:

(1) Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure. The field technician should immediately notify the Haywood County Director of Solid Waste. The Solid Waste Director, or their designee, will immediately notify by telephone the Regulatory Specialist at the Solid Waste Section office in Asheville at 828-296-4500. The Director shall follow-up the telephone call with an electronic mail message detailing the event and the steps taken to protect human life.

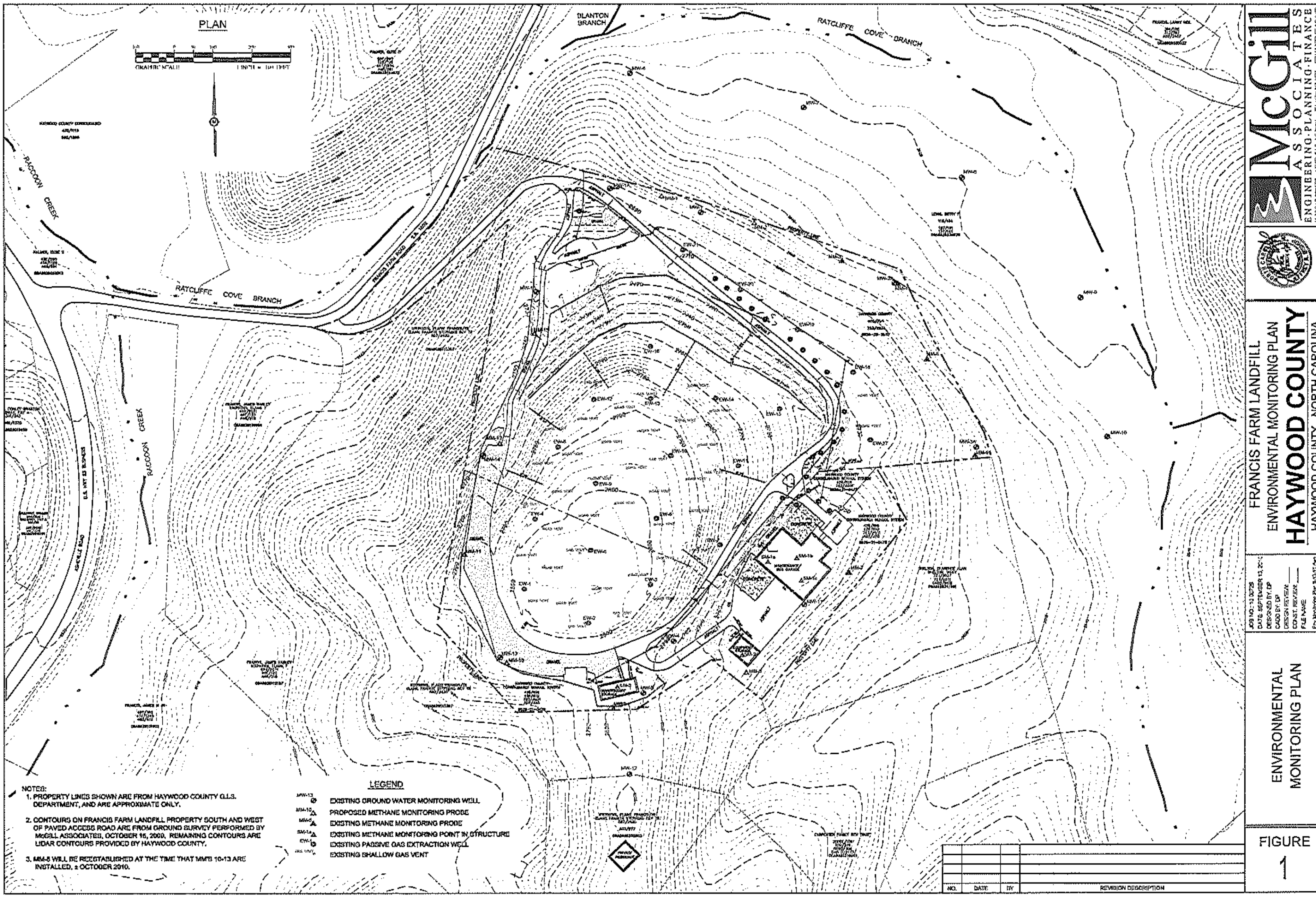
(2) Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and

(3) Within 60 days of detection, prepare and implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Division of Solid Waste Management that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

APPENDICES

APPENDIX 1

Environmental Monitoring Plan Drawing (Figure 1)

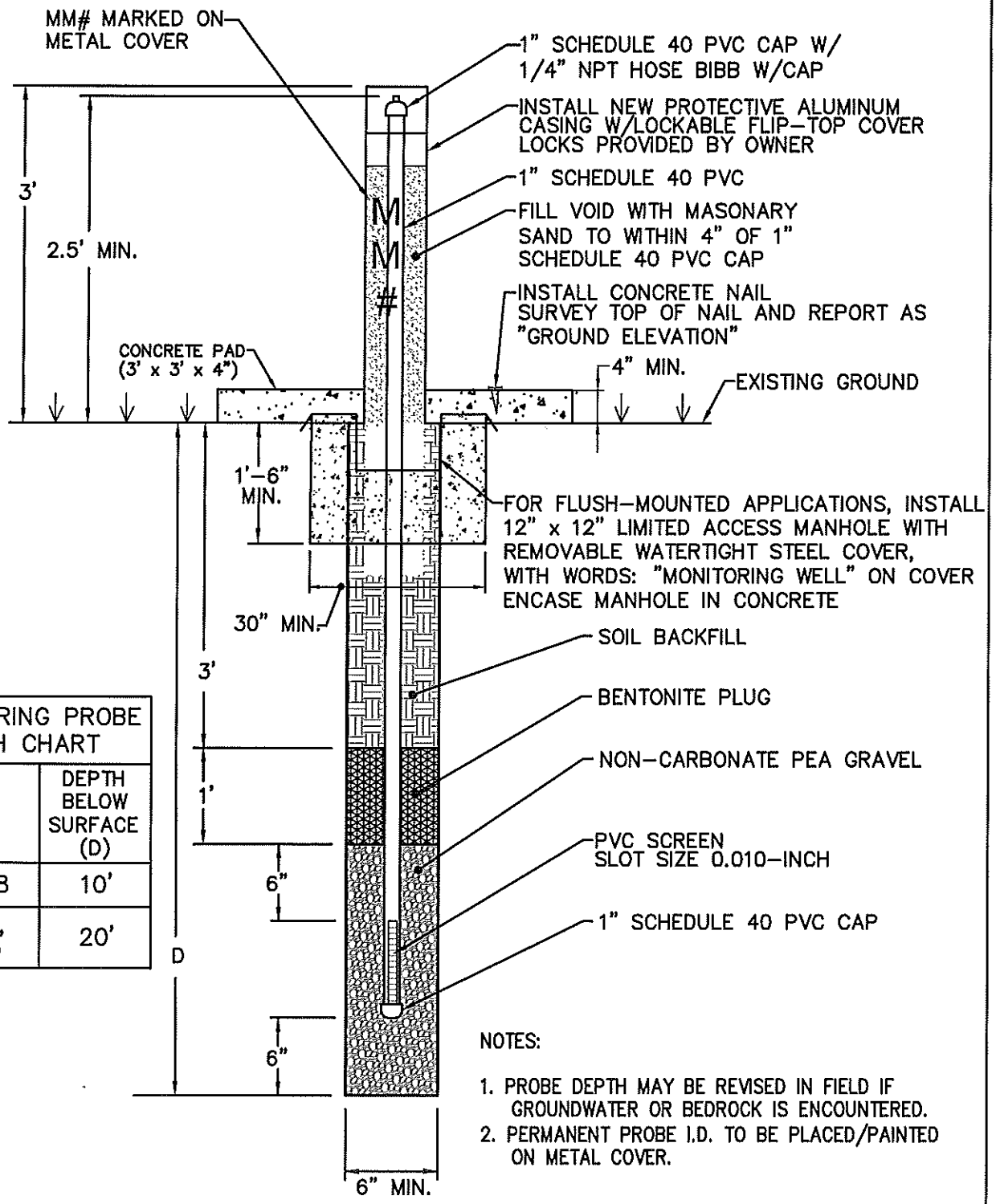


PLAN
GRAPHIC SCALE
RATCLIFFE COVE BRANCH
BLANTON BRANCH
RACCOON CREEK
FRANCIS FARM ROAD
PROPERTY LINE
NOTES:
1. PROPERTY LINES SHOWN ARE FROM HAYWOOD COUNTY G.I.S. DEPARTMENT, AND ARE APPROXIMATE ONLY.
2. CONTOURS ON FRANCIS FARM LANDFILL PROPERTY SOUTH AND WEST OF PAVED ACCESS ROAD ARE FROM GROUND SURVEY PERFORMED BY McGILL ASSOCIATES, OCTOBER 15, 2009. REMAINING CONTOURS ARE LIDAR CONTOURS PROVIDED BY HAYWOOD COUNTY.
3. MM-5 WILL BE REESTABLISHED AT THE TIME THAT MM'S 10-13 ARE INSTALLED, ± OCTOBER 2010.
LEGEND
EXISTING GROUND WATER MONITORING WELL
PROPOSED METHANE MONITORING PROBE
EXISTING METHANE MONITORING PROBE
EXISTING METHANE MONITORING POINT IN STRUCTURE
EXISTING PASSIVE GAS EXTRACTION WELL
EXISTING SHALLOW GAS VENT
NO. DATE BY REVISION DESCRIPTION
FRANCIS FARM LANDFILL
ENVIRONMENTAL MONITORING PLAN
HAYWOOD COUNTY
HAYWOOD COUNTY, NORTH CAROLINA
ENVIRONMENTAL MONITORING PLAN
FIGURE
1
McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE

APPENDIX 2

Landfill Gas Monitoring Probe Detail

NOTE: USE ABOVE GROUND PROTECTIVE METAL COVER UNLESS A FLUSH-MOUNTED APPLICATION IS REQUIRED, TO BE DETERMINED IN FIELD. BOTH COVERS SHOWN HERE.



MONITORING PROBE DEPTH CHART	
MM #	DEPTH BELOW SURFACE (D)
1, 2, 8	10'
10, 11, 12, 13	20'

NOTES:

1. PROBE DEPTH MAY BE REVISED IN FIELD IF GROUNDWATER OR BEDROCK IS ENCOUNTERED.
2. PERMANENT PROBE I.D. TO BE PLACED/PAINTED ON METAL COVER.

LANDFILL GAS MONITORING PROBE

NOT TO SCALE

APPENDIX 2

APPENDIX 3

Landfill Gas Measurements – Field Worksheet

Landfill Gas Measurements Field Worksheet
Francis Farm Landfill - Permit #44-03
Haywood County, North Carolina

Name of Person Taking Readings:_____ **Date:** _____

Weather Conditions: _____ **Ambient Temp:** _____

Atmospheric Pressure: _____

Gas Monitoring Equipment: Land-Tec GEM 2000 **Serial #:** GM05480

Factory Calibration Date:_____ **Field Calibration Date :** _____

Well or Probe ID	Stable Readings	Time	%LEL	$\%CH_4$	$\%CO_2$	$\%O_2$	Notes:
MM-1							
MM-2							
MM-3							
MM-4							
MM-5							
MM-6							
MM-7							
MM-8							
MM-9							
MM-10							
MM-11							
MM-12							
MM-13							
SM-1a							
SM-1b							
SM-1c							
SM-2							
SM-3							

Note: If methane gas readings exceed 25% of LEL in structures or 100% of LEL in probes contact Haywood County Solid Waste Director immediately

Field Observation Notes:

APPENDIX 4

Operation Manual
For
LandTec GEM 2000 Gas Analyzer

LANDTEC

GEM2000
GEM2000 Plus

GAS ANALYZER & EXTRACTION MONITOR

OPERATION MANUAL
For
Serial Numbers 10000 and up

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Web: www.landtecbrazil.com.br

LANDTEC Release Date: March 5, 2008

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2.3 BATTERY/CHARGING 3
2.4 INSTRUMENT CERTIFICATION 3
2.5 SAFETY INFORMATION 3
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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 GEM2000 and GEM2000 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 GEM2000 Plus also samples and analyzes Carbon Monoxide and Hydrogen Sulfide. The readings are displayed and can be stored in the instrument and downloaded to a personal computer for reporting, analyzing and archiving.

The GEM2000 / GEM2000 Plus instrument is shipped in a 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 the pressure relief valve is opened to equalize internal pressure. When shipping a GEM2000 / GEM2000 Plus back to LANDTEC for calibration or service, always ship it in the hard case to protect unit from damage.

Carefully unpack the contents of the GEM2000 / GEM2000 Plus, inspect and inventory them. The following items should be contained in your package:

- The GEM2000 / GEM2000 Plus instrument
- GEM2000 / GEM2000 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 tubing
- Spare external water trap filter element
- 100-240 volt battery charger
- Software on CD-ROM
- RS-232 serial cable for computer/instrument communications
- Temperature probe (optional)
- Hard carrying case

Complete the Registration/Warranty Card and return it to LANDTEC. The model and serial numbers are located on the back of the GEM2000 / GEM2000 Plus instrument.

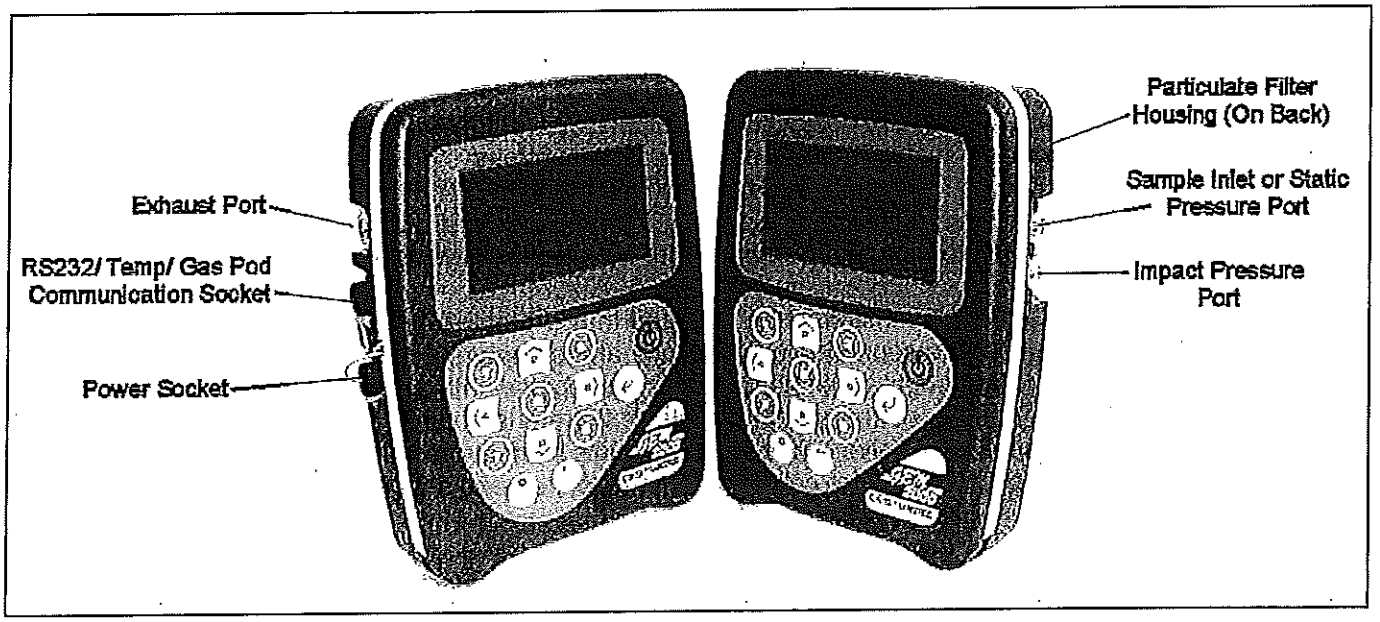
Immediately notify shipping company if the GEM2000 / GEM2000 Plus unit or accessories are damaged due to shipping. Contact LANDTEC immediately if any items are missing.

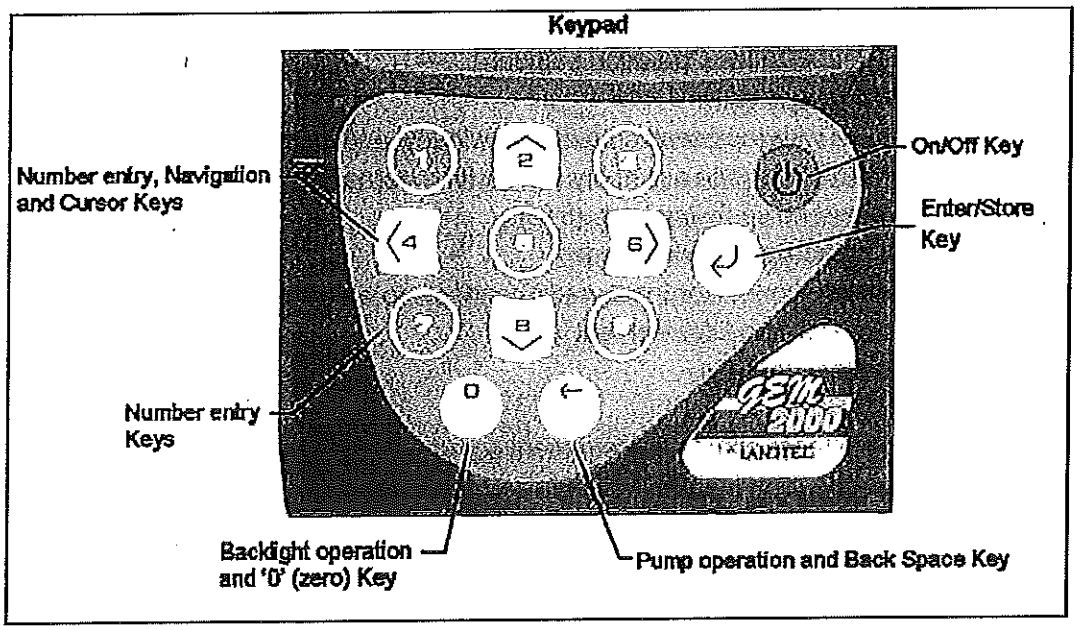
For questions regarding instrument operation and procedures, please contact LANDTEC at:

Customer Service or Technical Support	(800) 821-0496 Extension 6131
Factory Service	(800) 821-0496 Extension 6141

2 General Operational Features

2.1 Physical Characteristics of the GEM2000 / GEM2000 Plus





2.2 Storage

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

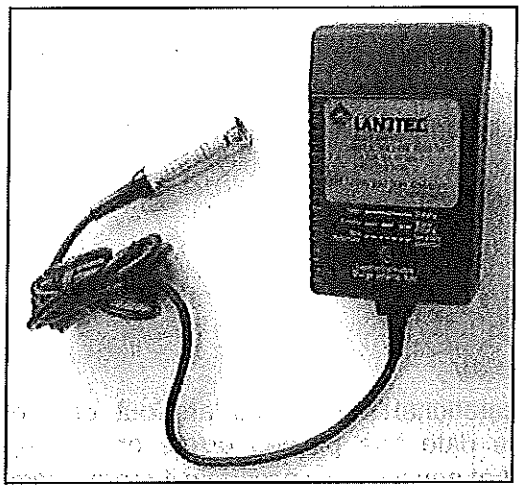
When not in use, instruments should be kept in a clean, dry and warm environment such as an office.

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.

2.3 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 GEM2000 / GEM2000 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 "Trickle Charge" the charging is completed and the unit can be disconnected from 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.

2.4 Instrument Certification

The GEM2000 / GEM2000 Plus is UL/Sira certified for use in hazardous locations. Specifically certified as to intrinsic safety for use in hazardous locations Class I, Zone 1, AEx ib d IIA T1 (Ta=32°F to +104°F).

For the certification to remain intact it is vital the instructions in this manual are followed closely and repairs of this equipment be carried out in accordance with the applicable code of practice by an approved repair facility. See section 9.2 for a list of authorized repair locations.

It is the responsibility of the operator to determine the protection concept and classification required for a particular application.

2.5 Safety Information

The GEM2000 / GEM2000 Plus is normally used for measuring gases from landfill sites. Inhaling these gases, or gases from other sites may be harmful to health and in some cases may be fatal. It is the responsibility of the user to ensure that he/she is adequately trained in the safety aspects of the gases being used and that appropriate procedures be followed. In particular, where hazardous gases are being used the gas exhausted from the analyzer must be piped to an area where it is safe to discharge the gas. Hazardous gas can also be expelled from the instrument when purging with clean air.

2.6 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. Whenever a key is pressed the unit will emit a short 'beep' as an acknowledgement. This function cannot be turned off.
When switching the instrument off, the On/Off button must be held down for approximately 2-3 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.

2.7 Warm-up Self Test

When switched on, the instrument will perform a predetermined self-test sequence taking approximately 30 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:

- Software version
- Serial Number. Calibration due date.
- Date format.
- Operating language.
- Communication Baud rate.

2.8 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, to exit from this screen press the "Enter/Store" key '↵'.

2.8.1 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_2 Cell out of calibration, CH_4 out of calibration, CO_2 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.

2.8.2 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_4 reading or channel out of specification, 02 - User cal data, CO_2 reading out of specification).

If any other Warnings or Errors are displayed, contact a LANDTEC Authorized Service Facility for further information.

2.9 Service Information Screen

Upon self-test completion, the GEM2000 / GEM2000 Plus will display service information including when the next manufacturers service is due, what type of service agreement the instrument is under (if applicable), and when the last factory gas check was performed. To exit from this screen press the "Enter/Store" key '↵'.

2.10 Technician ID Screen

The Technician ID screen is displayed after the Service Information screen. While it is not necessary to input a Technician ID it is possible to select a technician from a predetermined list (created in LSGAMS) or input up to four characters to identify the technician performing the readings. This ID will be appended to all readings that are taken until the instrument is turned off. To change the Technician ID simply turn the instrument off and back on again. The Technician ID can be input through a virtual key board shown on the instruments display. Letters or numbers can be selected by using the '∧' and '∨' key to scroll up/down and the '<' and '>' to scroll left and right. Pressing the "Enter/Store" key '↵' will select the highlighted character. Once the Technician ID is selected, or to bypass selecting any characters press the '①' button.

2.11 Gas Reading Screen

After inputting or bypassing the Technician ID, the instrument will go into the Gas Reading screen, also considered the normal operation screen. 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_4, CO_2, O_2 (in %)
- Two minor gases – CO & H_2S and indication of H2 (GEM2000 Plus only)
- Balance gas
- Last read time/date (if previous data is in memory)
- Technician ID
- External devices (displays pod type or temperature probe readings when attached)
- % LEL CH_4 (if selected through LSGAM)
- 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 IDs are available).
⑤Measure Flow	For GEM mode only.
⑦Previous Reading	Allows the previous reading of the selected ID to be viewed (if data is available).
↵ Store Reading	Stores the current displayed reading. (GA mode only)

2.11.1 Keypad Lock

After the instrument enters into the Gas Reading Screen, and from this point forward, the keypad can be locked by pressing and holding the backlight key for approximately 2 seconds. A message will display at the bottom of the display instructing you that to release the lock you will need to press and hold the backlight button.

2.12 Optional Gas Pods

Optional Gas Pods are available for use with the GEM2000 / GEM2000 Plus. These pods are available in seven different gases with eight 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. The Gas Pods are not classified as intrinsically safe they should not be attached or detached from the instrument in hazardous areas.

Gas Type	Range (PPM)	Resolution (PPM)
H_2S	0-50	0.1
	0-200	1.0
	0-5000	35
CO	0-1000	1.0
SO_2	0-20	0.1
	0-100	1.0
H_2	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 GEM2000, 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. If calibrated properly the accuracy of these Gas Pods are typically 5-10% Full Scale.

2.13 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.**

2.13.1 Cold Start

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.
(For Gas Calibration Error Messages, confirm that Factory Settings and User Calibration are 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 the communication software. It cannot be updated manually.

To carry out a cold start, turn the instrument on, before the instrument enters into the self-test screen press and continue to hold the '↵' key until a pass code entry screen is displayed. At this point the '↵' key may be released. Enter the passcode **12345** and press '↵' to confirm.

After the pass-code entry has been accepted, the instrument serial number will be displayed along with the hours in use, pump run time and service dates. There are four options from this screen;

1 - Cold Start
2 - Recover readings
3 - Print readings
0 - Exit

ONLY select option '**1**' if a Cold Start is to be carried out. Press key '**1**' to confirm this operation or press key '**0**' to continue with normal operation. If you select '**1**' to confirm the cold start a message will be displayed confirming the cold start operation and all memory will be cleared. The instrument will continue to the technician ID screen.

2.13.2 Recover Readings

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.

Recover readings is a low level memory function that should only be used as a last resort if all your readings were inadvertently deleted and you know how many readings you had. This function moves the memory buffer and can cause instrument corruption. Contact LANDTEC before attempting to recover readings.

2.13.3 Print Readings

This function is best performed using an appropriate RS232 cable (included with new instruments, also available from LANDTEC) and the LSGAM software. See section 3.12 Downloading Readings for more detail.

2.14 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.

3 The LANDTEC System Gas Analyzer Manager Software

3.1 Configuration Options

The GEM2000 and LANDTEC System Gas Analyzer Manager (LSGAM) software can be utilized in a number of ways:

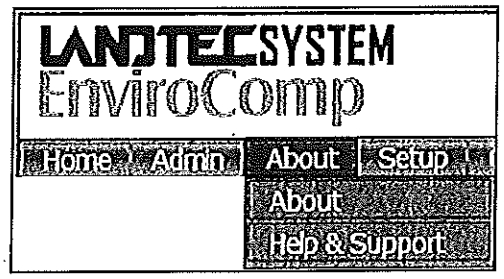
- Configured for operation with the LANDTEC System online service;
- Used offline as a local application storing information on the desktop/laptop computer;
- Used out of the box without software; (this does not allow the user to generate flow rate values or select comments with the instrument and also prevents downloading of readings to the computer. It also does not allow the user to correct the time and date or to clear the memory, unless cold started.)

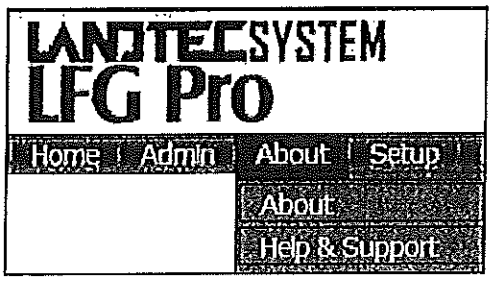
3.2 Online Users

The procedures included in the section are intended for those connected to the LANDTEC System online service. The LANDTEC System is an online collaboration tool to Collect, Validate, Analyze, and Communicate information based on field data obtained using LANDTEC instrumentation.

If you currently are a registered user on the LANDTEC System, please log in at https://www.landtecsystem.com/. If you are not currently using the LANDTEC System, you may register by contacting LANDTEC in the US: 800-821-0496 or International: +1-909-783-3636.

Online reference for using LANDTEC System Gas Analyzer Manager (LSGAM) with the LANDTEC System can be found under the About → Help & Support menu within the LANDTEC System.





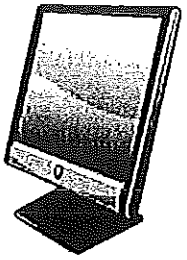
If you do not have login information please contact Technical Support at +1-909-783-3636 extension 6131.

3.3 Offline Users

The procedures included in the section describe use of the LANDTEC System Gas Analyzer Manager (LSGAM) Software while **NOT** connected to the LANDTEC System online service.

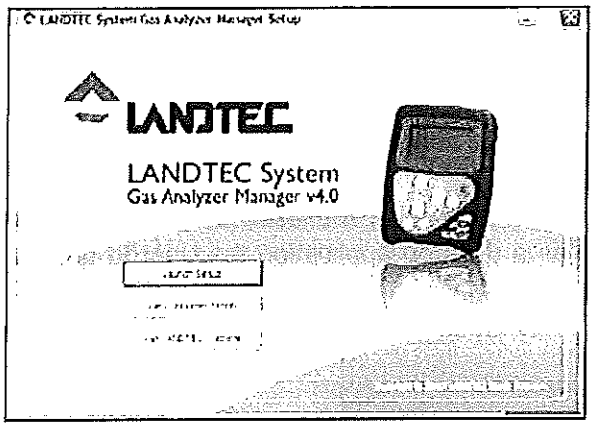
3.3.1 Installation with the CD

System Requirements:
Windows 98/NT/2000XP/Vista
Pentium III 500 MH or equal
64 (MB) RAM
120 (MB) Hard Drive Space Available
CDROM Drive

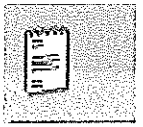


NOTE: The computer may need some administrative privileges to install the program.

Insert the CD into your CD ROM drive and wait for the setup to auto start. Click on the Launch Setup button and follow the onscreen instructions. Once the software is installed you will have a shortcut icon on your desktop which you will use to start the LSGAM instrument program.



The Java programming is an import part of this software and will be loaded with the CD install. The java icon, shown below, will be in the task tray at the bottom of your computer screen where your time is shown. There will also be a GAM log icon, shown below, that will be created on your desk top during installation.



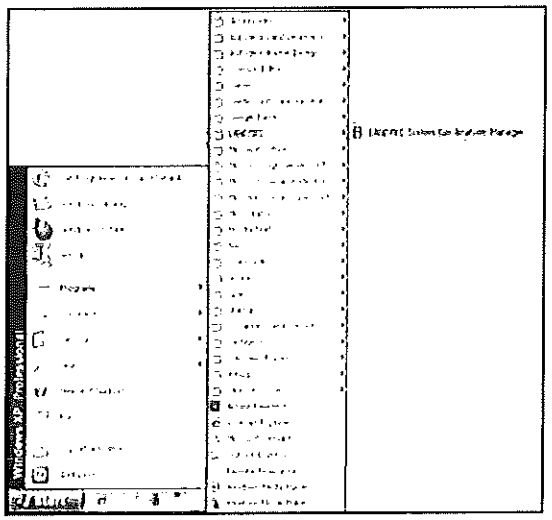
3.3.2 Start Up

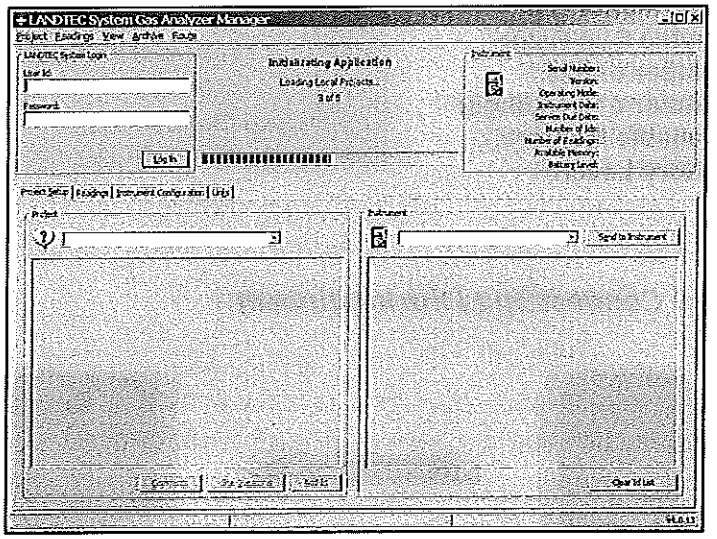
Starting LSGAM can be easily done by doing one of the following:

Double-Click on the Desktop icon.

OR - go to;

Start → All Programs → LANDTEC → LANDTEC System Gas Analyzer Manager



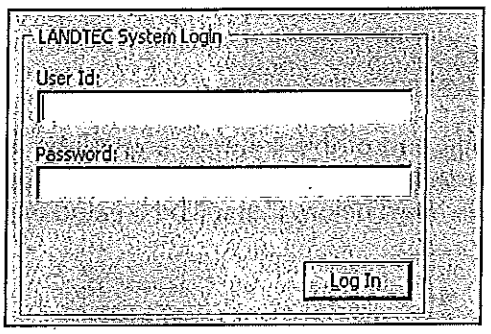


3.3.3 Navigation

The LANDTEC System Gas Analyzer Manager User Interface allows for easy access and navigation to various utilities to use the LANDTEC portable instrument on a day to day basis. The following is a general description of the user interface.

LANDTEC System Login

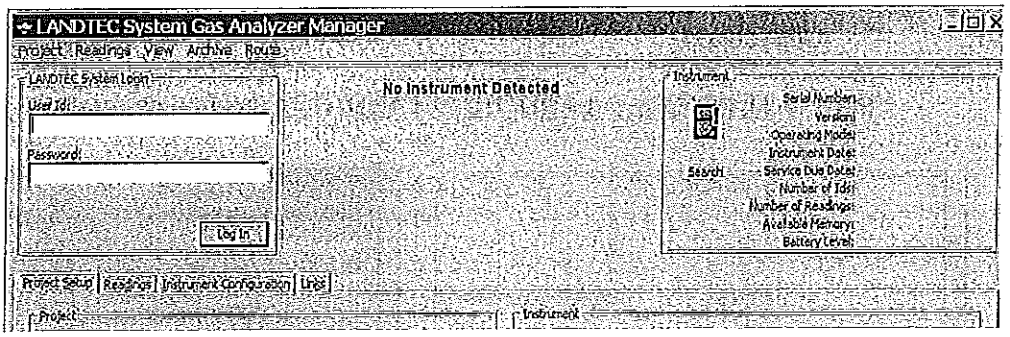
When LSGAM is used with the LANDTEC System online service, the username and password will be entered in the screen below, if you are using LSGSM as a desktop application the User Id and Password fields do not need to be filled in.



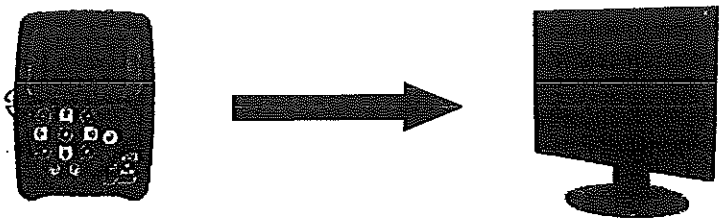
The Progress section indicates the status of the current process. For example, when starting up LSGAM, this will show you the activity of the software.

The Instrument section displays whether or not an instrument is connected. This also downloads the IDs, readings, and comments. If an instrument is found the following is shown:

Instrument Type:
Serial Number:
Version:
Operating Mode:
Instrument Date:
Service Due Date:
Number of IDs:
Number of Readings:
Available Memory:
Battery Level:

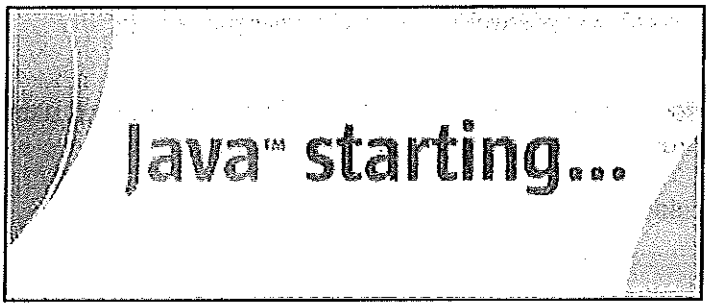


3.4 Connecting to the Instrument



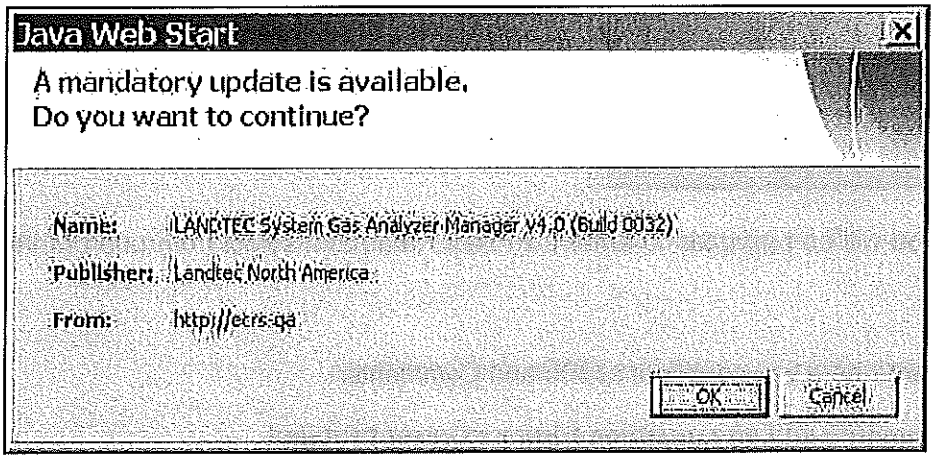
1. **Connect the GEM2000 with the RS-232 Download Cable to your Computer**
2. **Instrument must be powered ON and in the Gas Reading screen**
3. **Launch the LSGAM software by clicking on the icon on your desktop**

This is the first screen you will see when starting the program.



Once the software is installed on your computer with an internet connection this instrument communications program has Auto application updates. This enables you to always have the most current version of the instrument communications LSGAM.

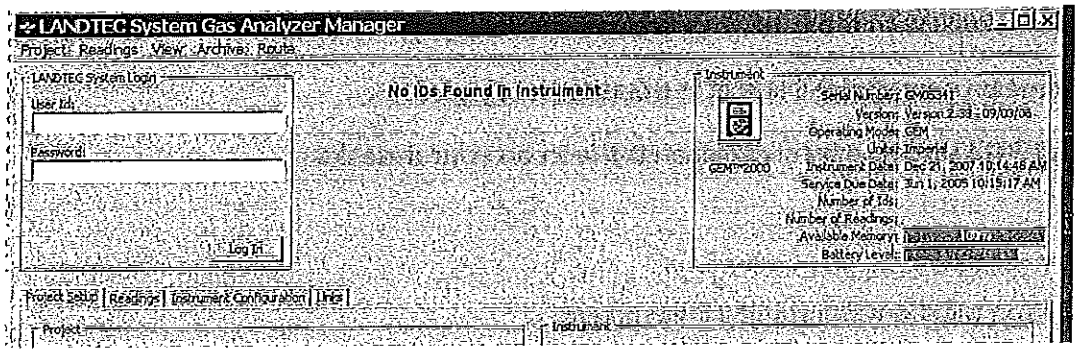
If an update to LSGAM is available, <u>you will see this notice when connected to the internet</u>.



Click on OK this will return you to the desktop and you will then need to click on the LSGAM shortcut again.

The GEM must be connected to computer and turned ON. It must also be in the Gas Reading screen. The LSGAM software will automatically download any information in the instrument including readings, comments and IDs.

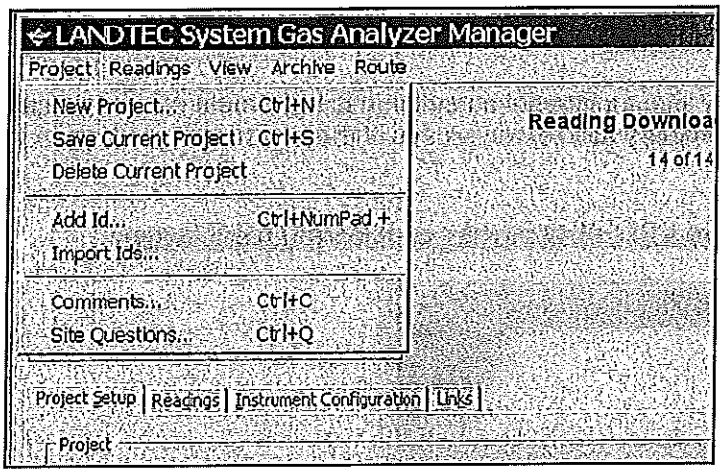
A new instrument containing no information will display only the instrument information: Serial Number, Version, Operating Mode, Instrument Date, Service Due Date, Number of IDs, Number of Readings, Available Memory, and Battery Level.



3.5 Create a Project / Select a Project

Projects are a collection of Device IDs and their associated reading history. A project can be created using LSGAM to contain a group of sequenced IDs and chronological history of instrument readings.

To create a Project, click on the Project menu and select New Project.



Upon selecting **New Project...** you will be prompted to enter a Project Name and select from one of three options.

Create a New Empty Project
This option creates an blank project where you configure all IDs and Comments.

Create a New Project with comments and site questions from a Current Project
Selecting this option allows the user to create a new project that will have the same Comments and Site Questions as an existing project.

Create a New Project from the data in a GEM2000
This option will create a New Project and automatically associate the IDs, Comments, and Site Questions that exist in the connected portable instrument.

3.6 Setup IDs

An ID represents a physical sampling point in the field. An ID can be allocated to field components such as extraction wellheads, gas transmission lines, or passive monitoring probes. LSGAM allows users to configure an ID for each sampling point in order to obtain accurate readings with LANDTEC portable

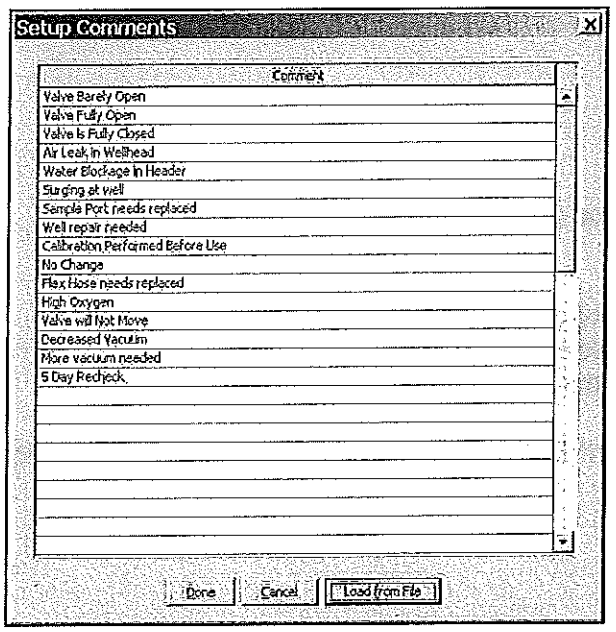
instrumentation

IDs are created, modified, and removed from the Project Setup tab in the software.

3.6.1 Creating Comments

Comments should be setup prior to creating new IDs. The user can define Comments that can be associated with a reading in the portable instrument.

If you selected Create a New Project when creating your project, you will need to click on the Create Comments button. Comments can be entered in this setup screen or loaded from a file and will be displayed in the user interface.



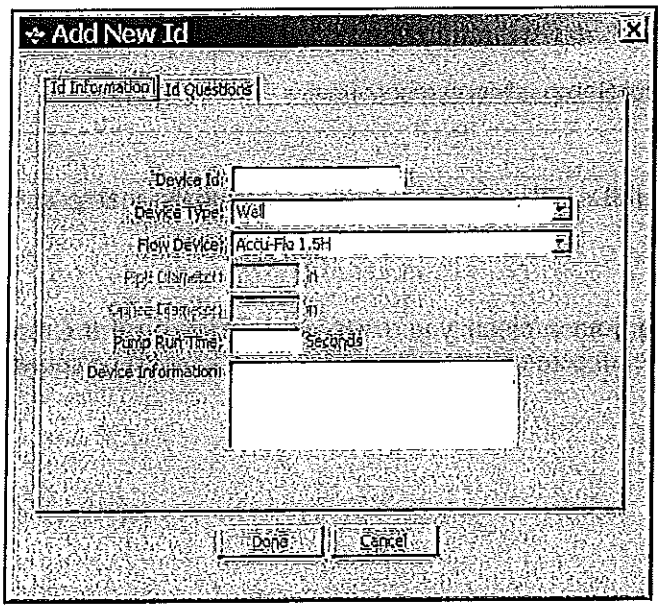
3.6.2 Creating IDs

There are several ways to input IDs to the Project. The following describes each process:

Creating new IDs with LSGAM

To create a new ID using the LANDTEC System Gas Analyzer Manager, Right Click on the left ID pane beneath your active project and select the Add New ID option.

The Add New ID form will be displayed. From the ID Information tab of this form, entry of the following is available:



Device ID: Must be eight (8) alphanumeric character spaces. (For example, LSGW0001)

Device Type:

- Well: An active gas extraction well which may require a flow rate reading.
- Sample Port: A sample point along a gas transmission line that may require a flow rate.
- Probe: A passive gas migration monitoring probe that does not require a flow rate.

The GEM2000 calculates flow rate values specific to each device type (listed above). The available flow devices programmed in GEM mode are listed below.

Flow Device:
Accu-Flo 1.5V
Accu-Flo 1.5H
Accu-Flo 2V
Accu-Flo 2H
Accu-Flo 3V
Accu-Flo 3H
Orifice Plate

- Pitot Tube
- User Input

Orifice Plate WellSide
Accuflo-1.5V-Include System Pressure
Accuflo-1.5H-Include System Pressure
Accuflo-2V-Include System Pressure
Accuflo-2H-Include System Pressure
Accuflo-3V-Include System Pressure
Accuflo-3H-Include System Pressure
Orifice Plate-System Side-Include System Pressure
Pitot Tube-Include System Pressure
User Input-Include System Pressure
Orifice Plate WellSide-Include System Pressure

Pipe Diameter: The pipe inside diameter (ID) is required.

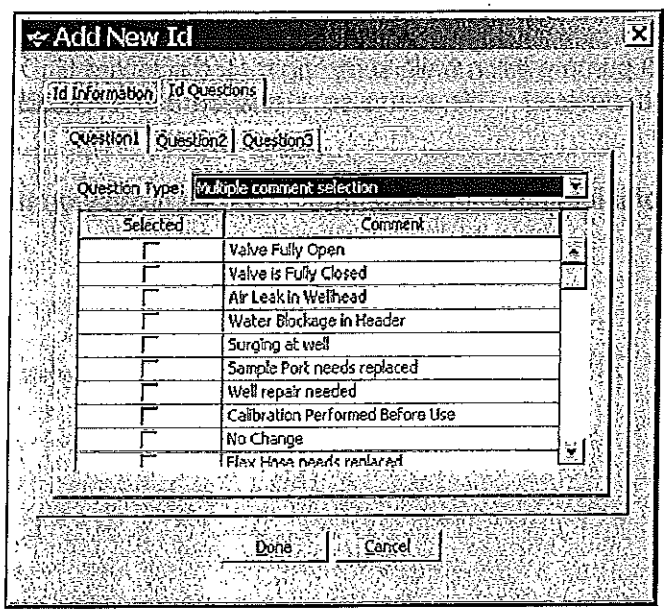
Orifice Diameter: The field for orifice bore diameter is available for all Orifice Plate flow devices.

Pump Run Time: Indicates the duration the GEM2000 pump will run while sampling for the selected ID. Allows the user to enter general information for the device. This can also displayed the GEM2000 instrument.

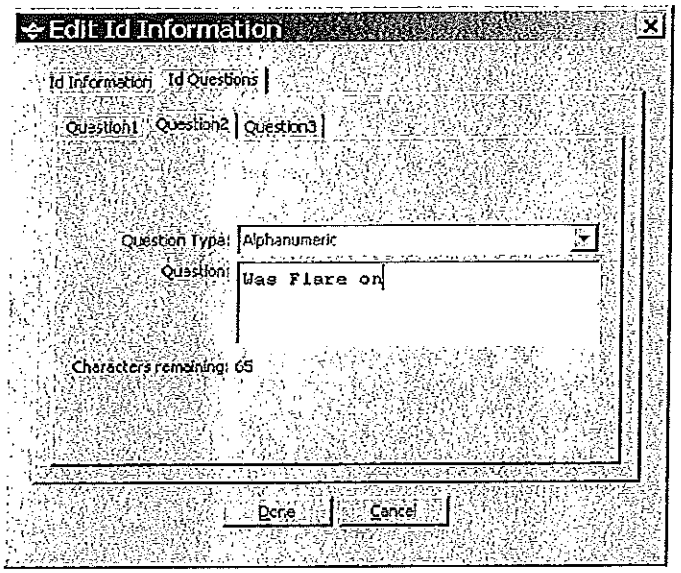
Device Information: Allows the user to enter general information for the device. This will display on the screen of the GEM 2000 instrument.

There are _ Question Types that can be selected:

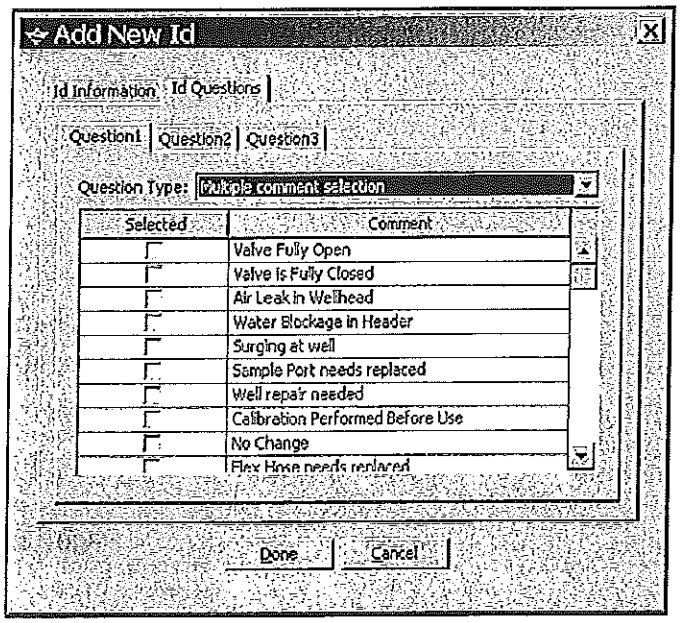
None
Alphanumeric
Numeric
Multiple comment selection
Single comment selection



Users may select up to 8 comments that will be available to the technician to select from when storing a reading with the GEM2000.

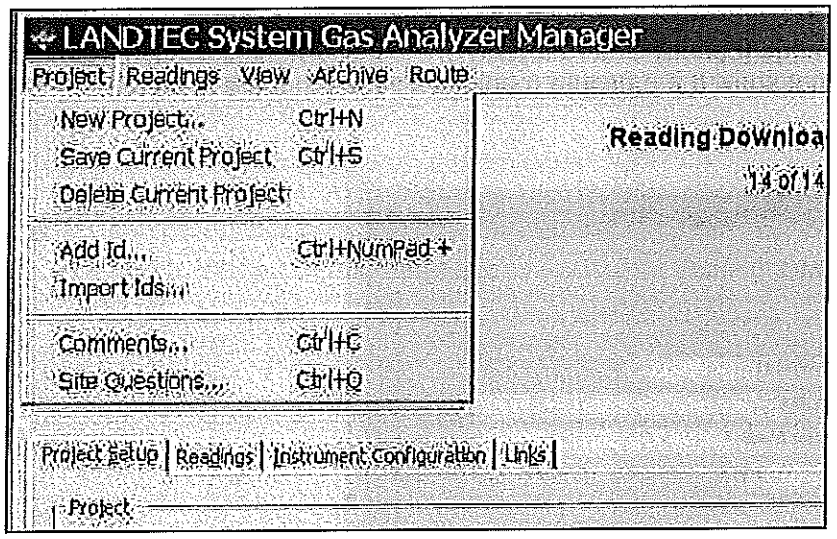


Alphanumeric questions prompt the user to enter a comment on the instrument consisting of letters and numbers.

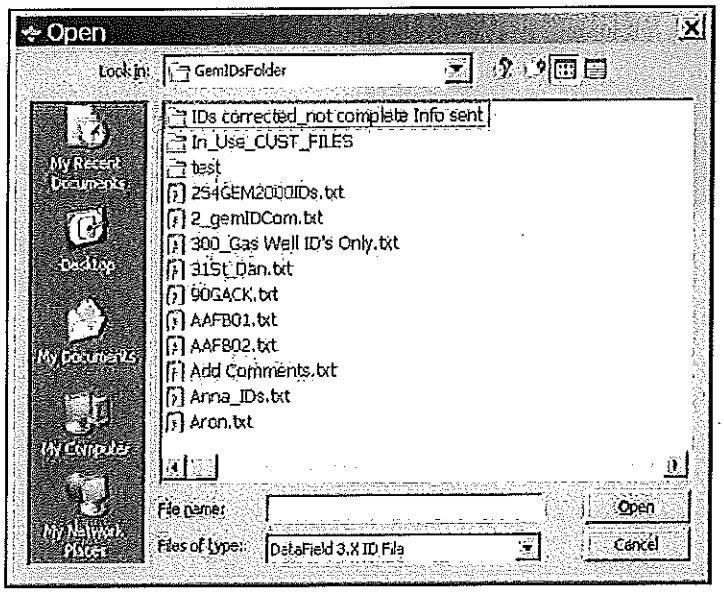


Numeric questions will prompt the user to enter a numeric answer on the instrument with a specified format.

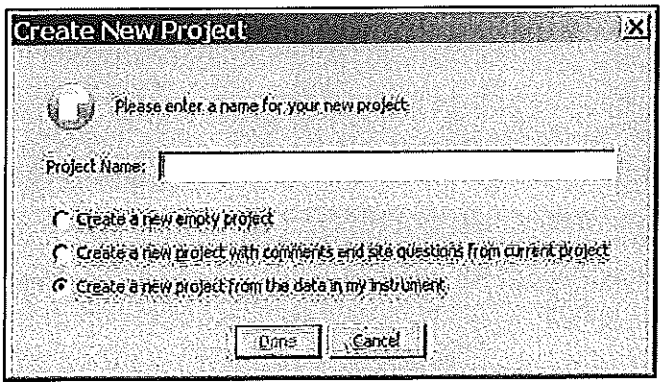
If you have existing ID files from DataField CS v3.2.x, these files can be imported by LSGAM. To begin this operation select the ***Import IDs...*** option from the ***Project*** menu.



Select an ID file generated by DataField CS v3.2.x.



3.6.1 IDS ALREADY IN THE INSTRUMENT:

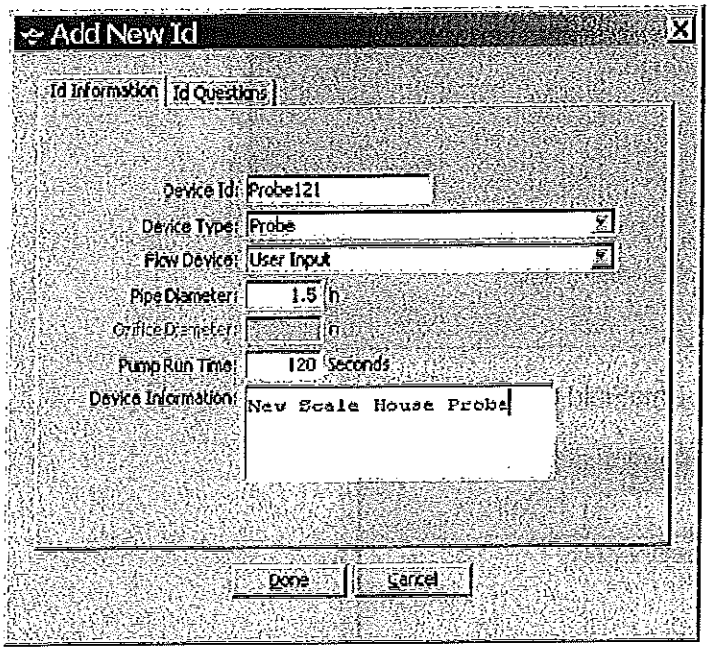


To create a Project based on the information in the GEM2000, select ***Create a new project from the data in my instrument.***

Creating a Device ID that does not measure flow Example- Probe or Sample Port

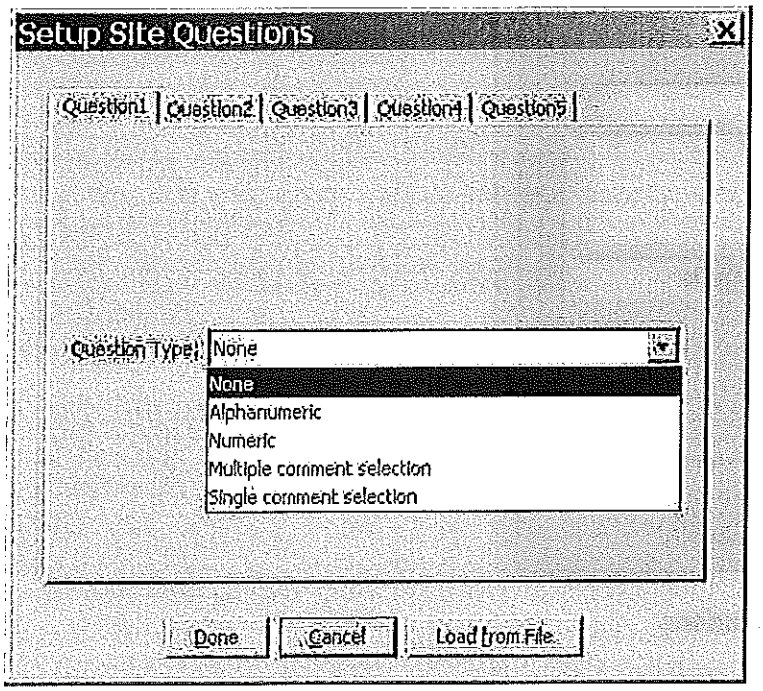
If there is no flow device you will choose User Input. When choosing the User Input option you will need to enter the appropriate pipe inside diameter and pump run time.

This ID is then generally sent to the GA mode [Landfill Gas Analyzer] of the instrument. Because this mode of the instrument does not read flow will not show the pressure readings screens that are in the GEM mode for vacuum and impact pressures.

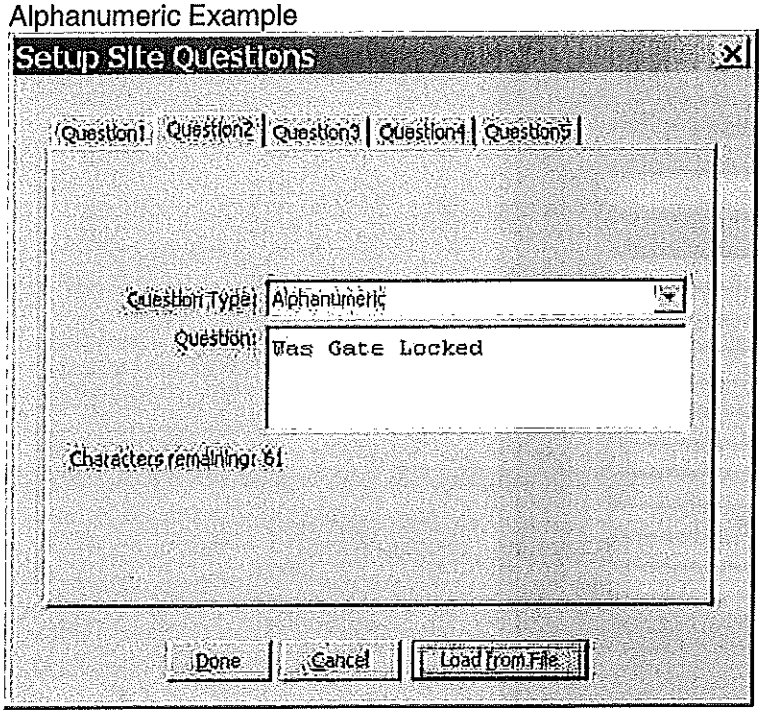


3.7 Creating your site questions

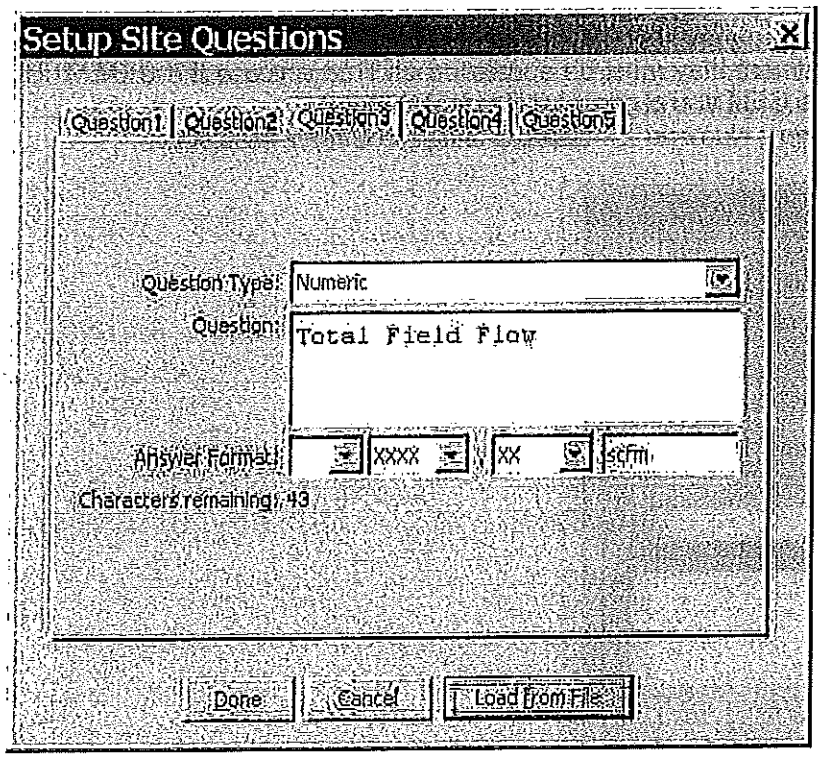
After sending site questions to your instrument they must be updated each time you use the GEM. This is done by going to the menu selection in the GEM and choosing [Update Site Data]
The options for questions are Alphanumeric – Numeric – Multiple or Single comment selection.



Alphanumeric Example

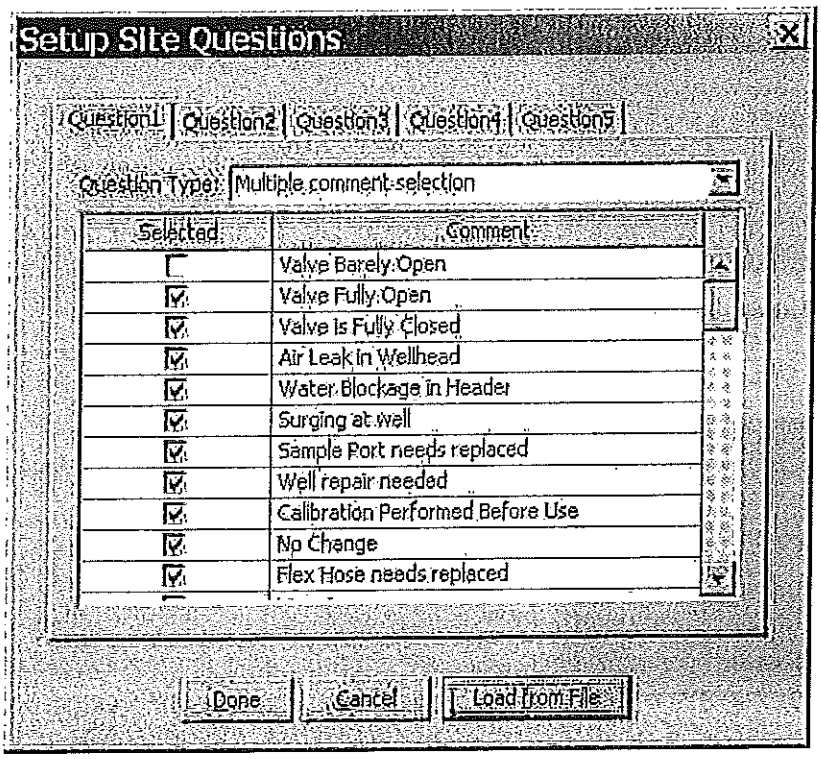


Example of Numeric Question

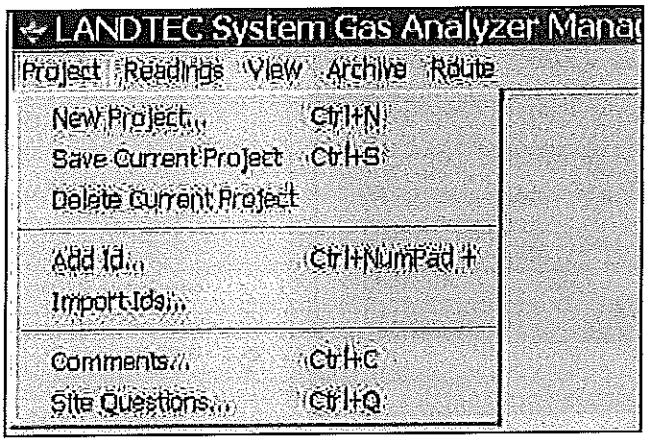


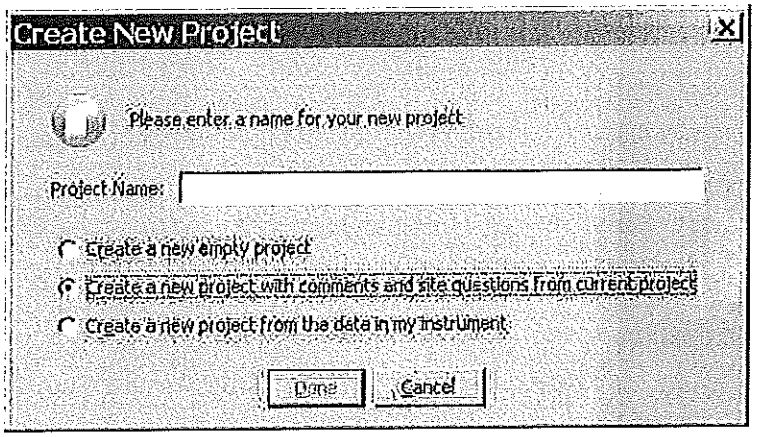
You may use Multiple or Single Comment selections

Using the Comments that were created for this project

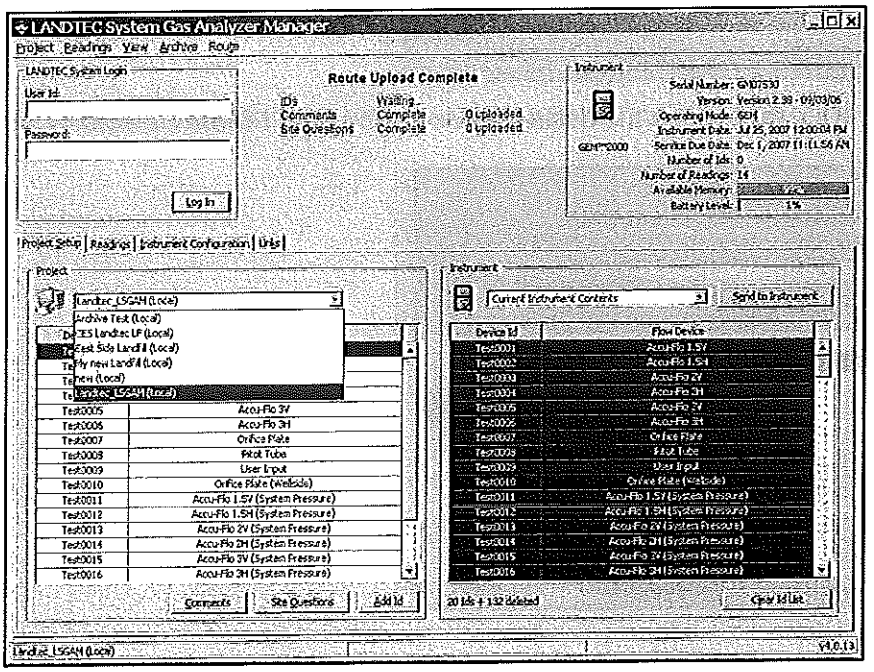


These Site Questions may be used again with another project by selecting the Create New Project and create new project with comments and **site questions** from current project.

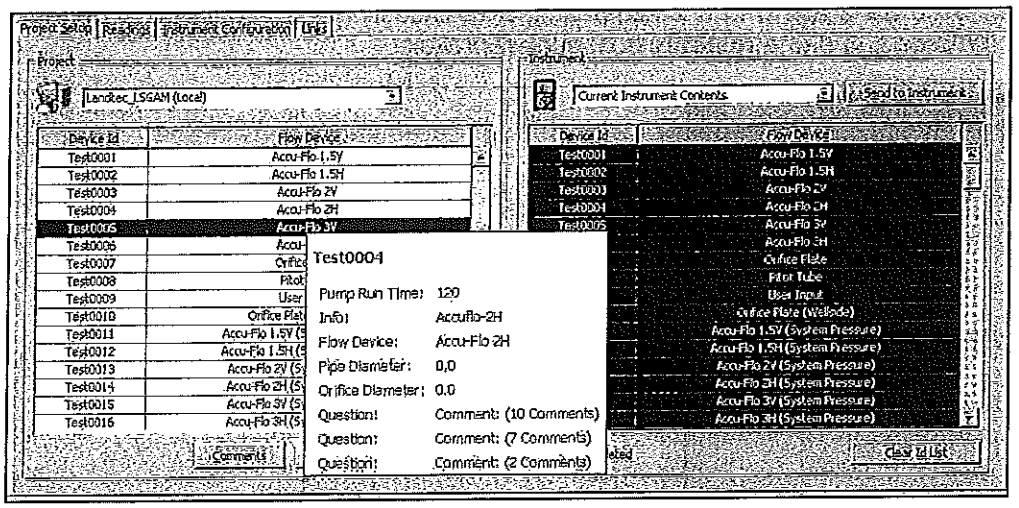




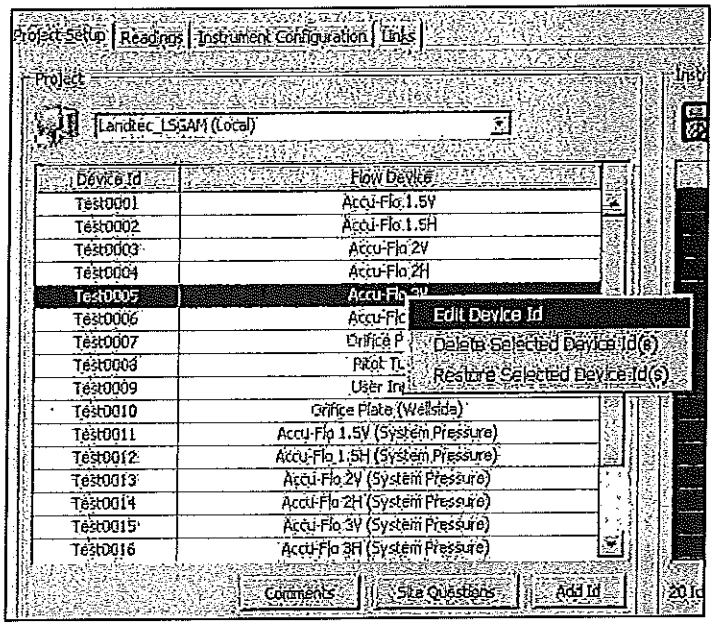
The project will be created and the IDs, Comments, and Site Questions that exist in the instrument will be applied to the new project.



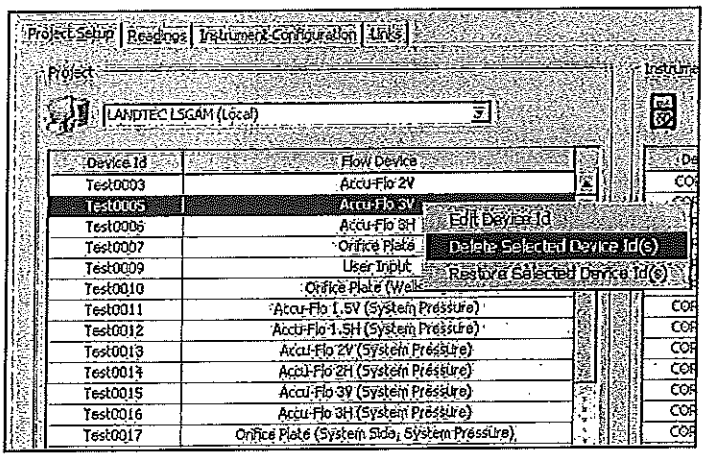
Placing the mouse cursor over a specific device ID will show detailed information about that ID.

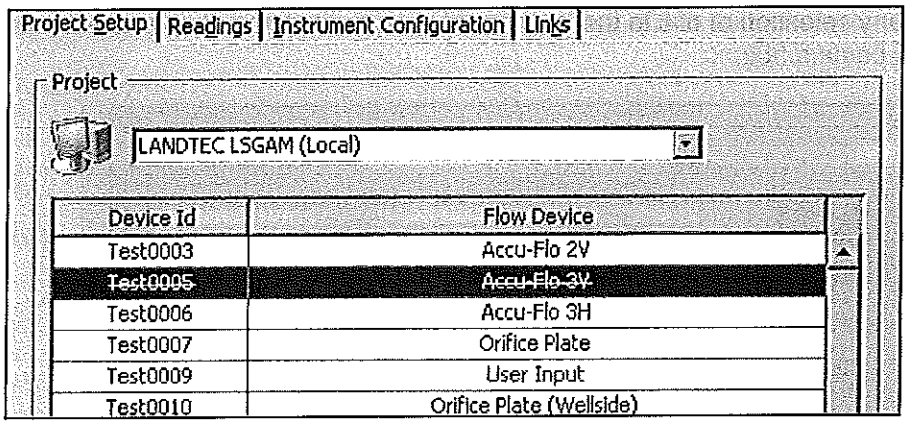


To edit a Device ID, right click on the desired device and select ***Edit Device ID.***



To delete an existing ID, right click on the desired device and select ***Delete Selected Device ID(s).***





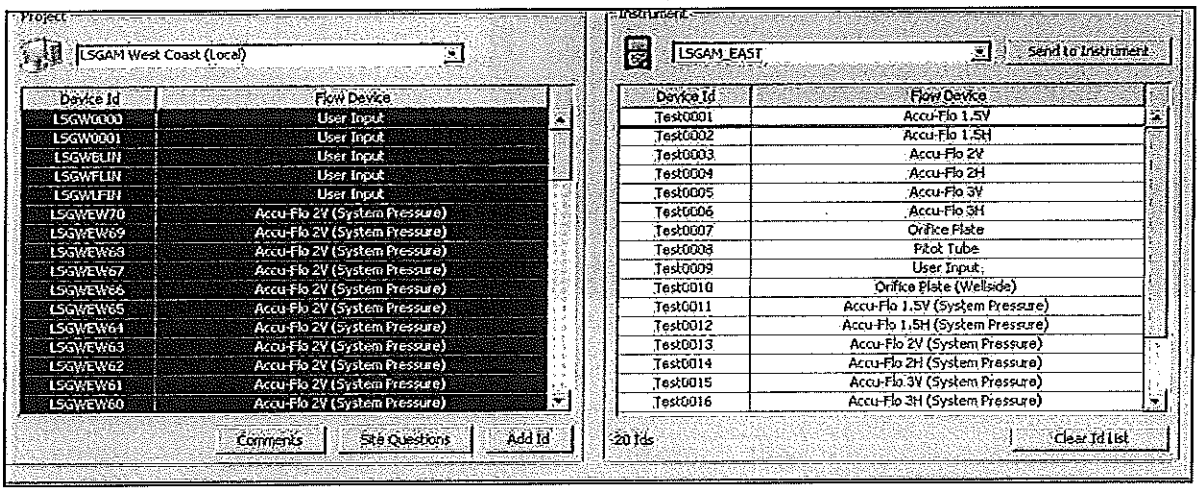
Deleted IDs are displayed with a line through the information on the screen. To restore a deleted ID, right click on the ID and click ***Restore Selected Device ID(s).***

3.8 Sending IDs to the instrument

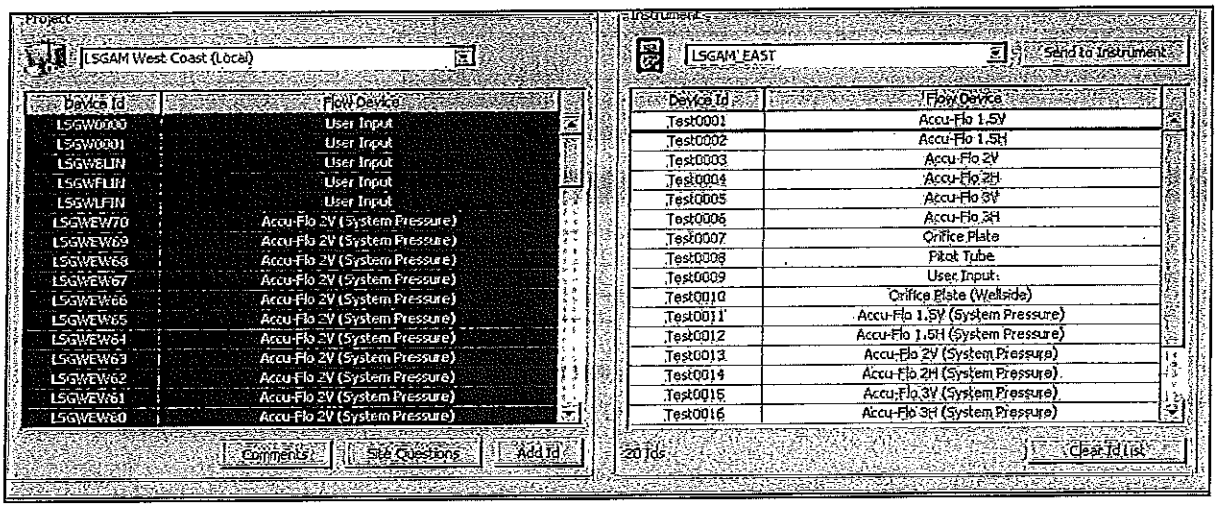
Once IDs have been created in the project, they must be uploaded to the instrument. To perform this operation, select the desired IDs from the left table under the Project name, left click and drag the IDs to the right table.

Place the mouse arrow at the edge of the first cell and hold down the left key. The arrow will change to .

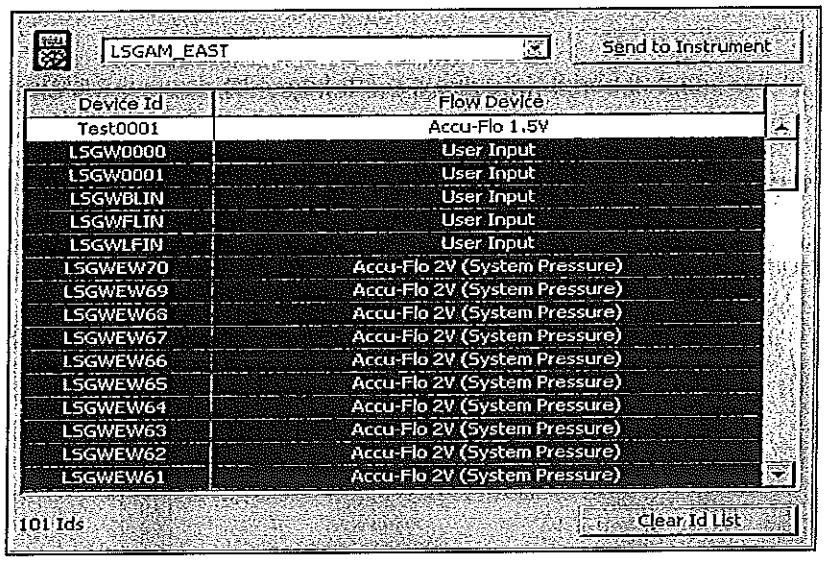
To highlight all, select control, then A on your key board. You can now drag the list to the Instrument side of the screen.



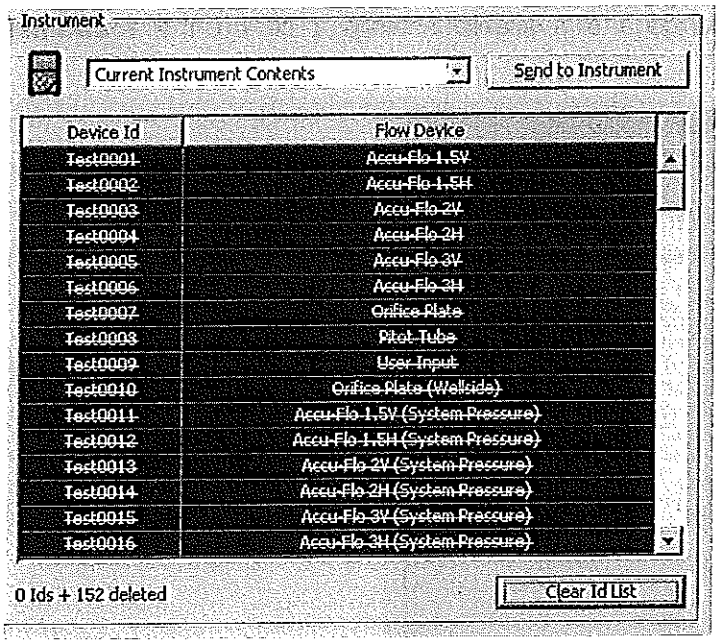
Once you have dragged the list or any selection of IDs to the instrument side, the line will change where you have the arrow and the circle will become a box.



Upon releasing the mouse key your IDs will be in the instrument list. Now select ***Send to Instrument*** button.

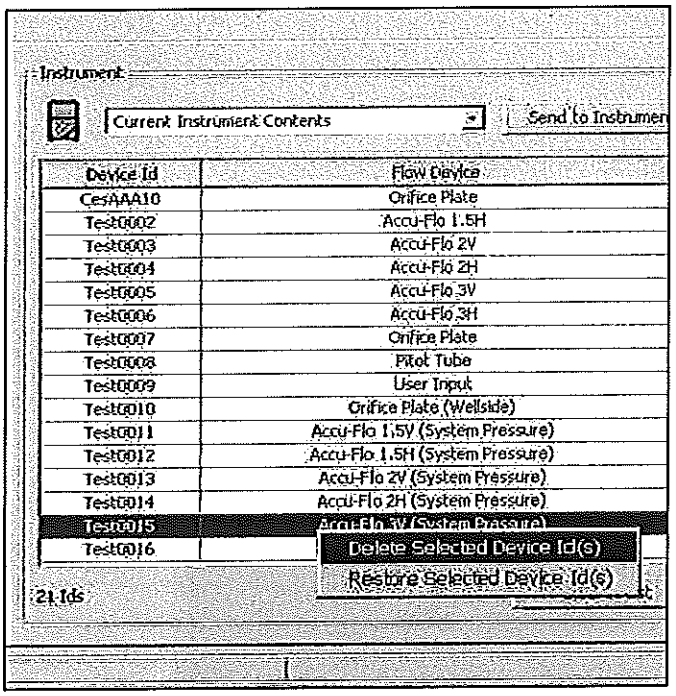


3.8.1 Clearing ID s from your instrument or Deleting a Project



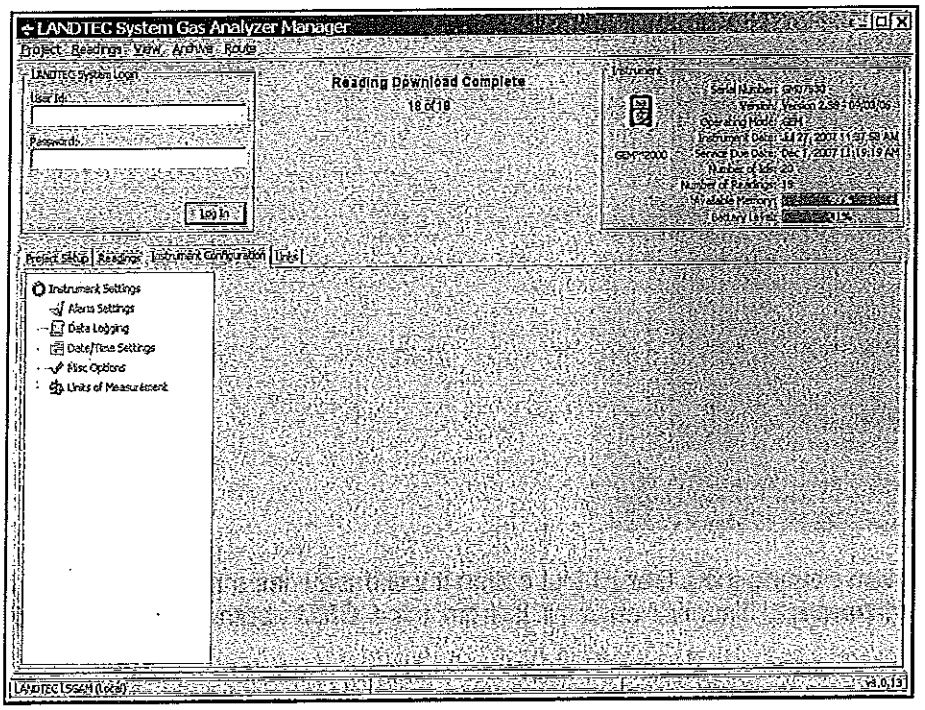
In current instrument contents when selecting the Clear ID List option it will draw lines through the IDS. You then need to select ***Send to Instrument.*** This will clear all IDs from the GEM in both the GEM and GA mode.

You may also delete one ID from a list by highlighting the ID RIGHT CLICK with your mouse and select the Delete Selected Device option. If you have selected the wrong ID and deleted then you may select the Restore option to return the ID to the list.



3.9 Instrument Settings

The LANDTEC System Gas Analyzer Manager software allows users to change many of the operational settings of the instrument. To view and change the available settings click on the ***Instrument Configuration*** tab.

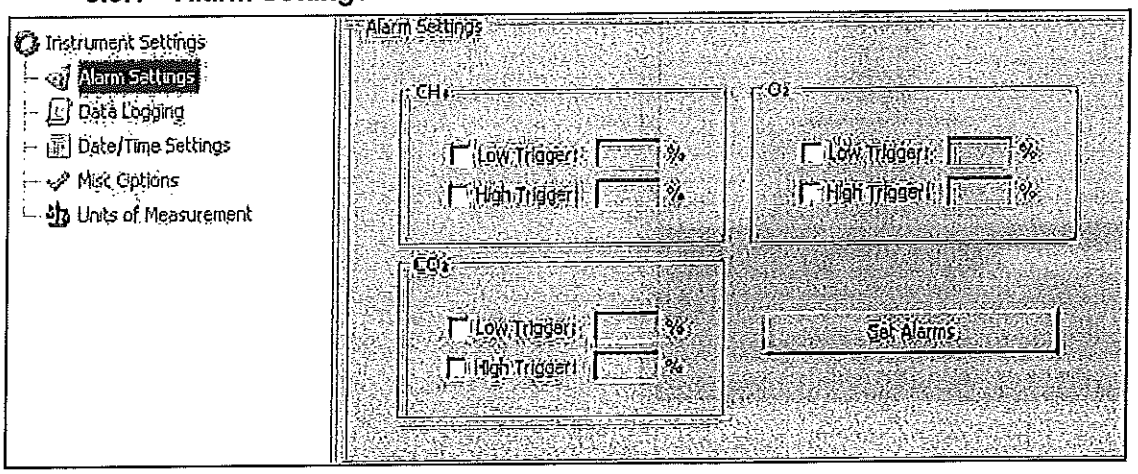


In the Instrument Configuration user interface, there is an Instrument Settings option tree. The Instrument Settings tree allows for easy navigation to the following categories:

Alarm Settings
Data Logging
Date/Time Settings
Misc Options
Units of Measurement

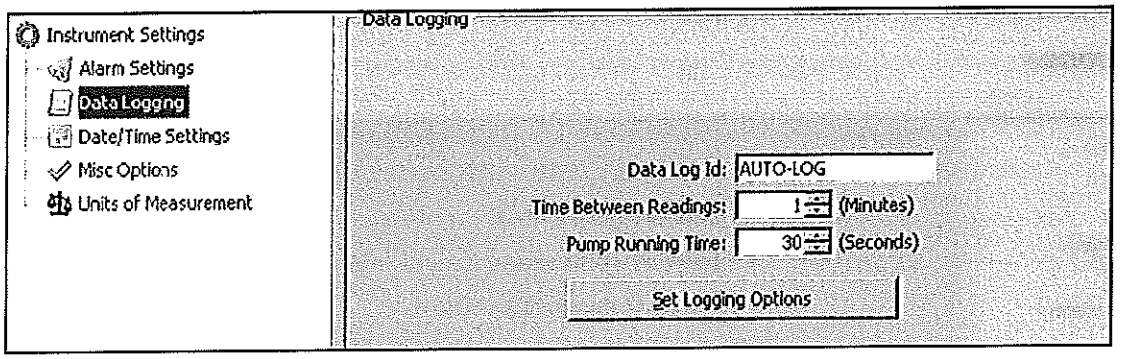
The following sections describe each option category.

3.9.1 Alarm Settings



The Alarm Settings options control the activation and deactivation of the audible alarms in the GEM2000 instrument. Audible alarms can be configured for CH_4, CO_2, or O_2 parameters. Each parameter can be configured with a Low Trigger and/or High Trigger for the alarm. To activate any specific alarm, click and place a checkmark in the desired box. This will activate the entry field to place the value. The values must be 0 – 100.

3.9.2 Data Logging

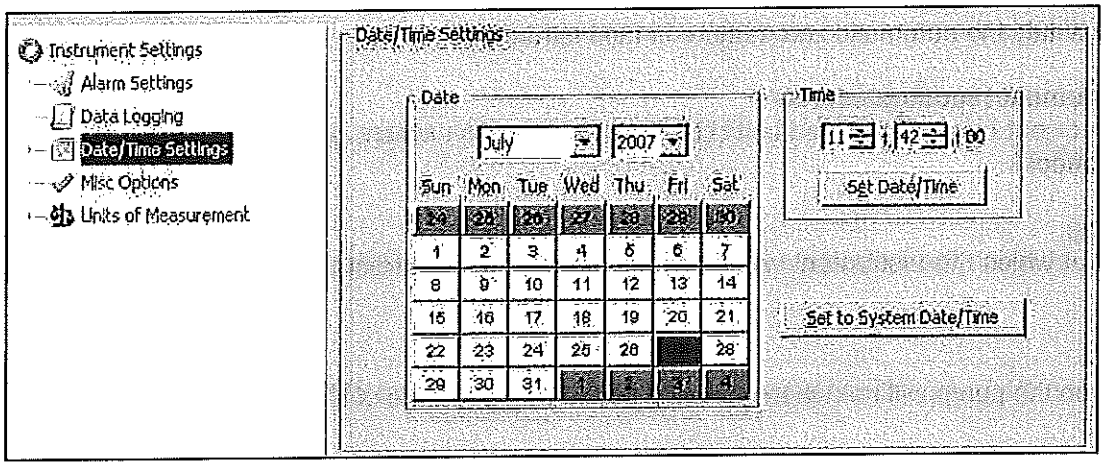


Data Log ID
The Data Logging option allows the user to specify an ID to be associated to readings taken with the Auto-logging feature of the instrument.

Time Between Readings
This value indicates the time from when the pump stops running until the pump begins sampling.

Pump Running Time
This value indicates the duration the pump will be run for sampling.

Date/Time Settings



The **Date/Time Settings** screen allows the user to set the date and time of the instrument.

Setting the Computer's Date and Time
To set the instrument's date and time to that of the computer, click on the Set to System Date/Time button. This will set the calendar and time fields to the current date and time of the computer. Then click the Set Date/Time button to apply to the instrument

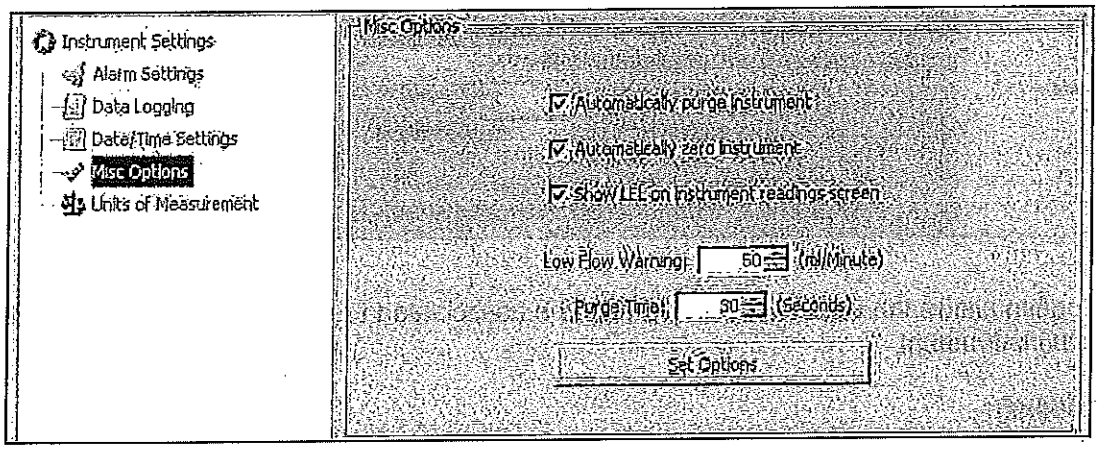
Date
Use the calendar options to select the desired date.

Time
Use the up and down controls to select the desired hour and minutes.

3.9.1 Set Date/Time in the instrument

Click the Set Date/Time button to apply the settings to the instrument

3.10 Misc Options



Under the miscellaneous options interface the user can change the following instrument settings:

Automatically purge instrument
Activates and deactivates the automatic purge feature in the instrument

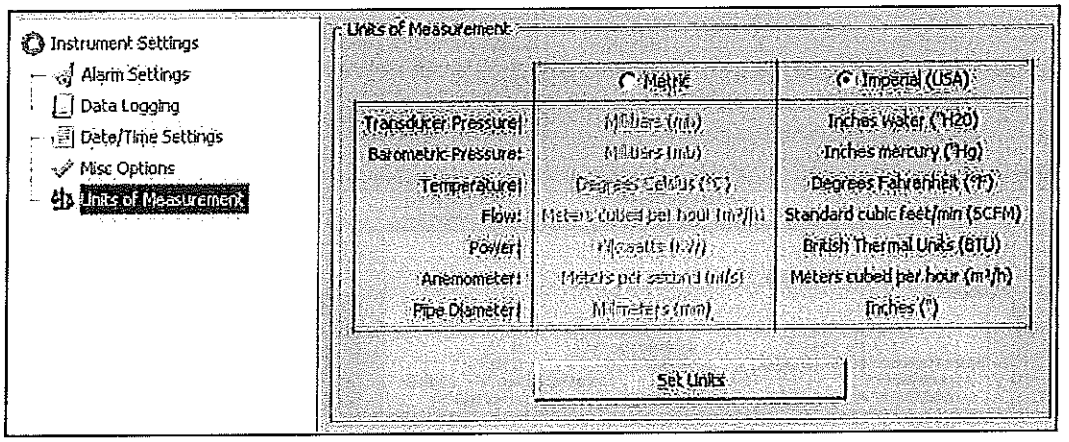
Automatically zero instrument
Activates and deactivates the automatic zero feature in the instrument

Show LEL on Instrument readings screen
Specifies whether or not Lower Explosive Limit (LEL) is displayed on screen, power instrument off and on for change to take effect.

Low Flow Warning
Specifies the point at which the instrument will indicate it is not able to extract the appropriate gas flow for analysis.

Purge Time
Specifies the duration the pump will run when activated by the purge feature of the instrument.

3.11 Units of Measurement



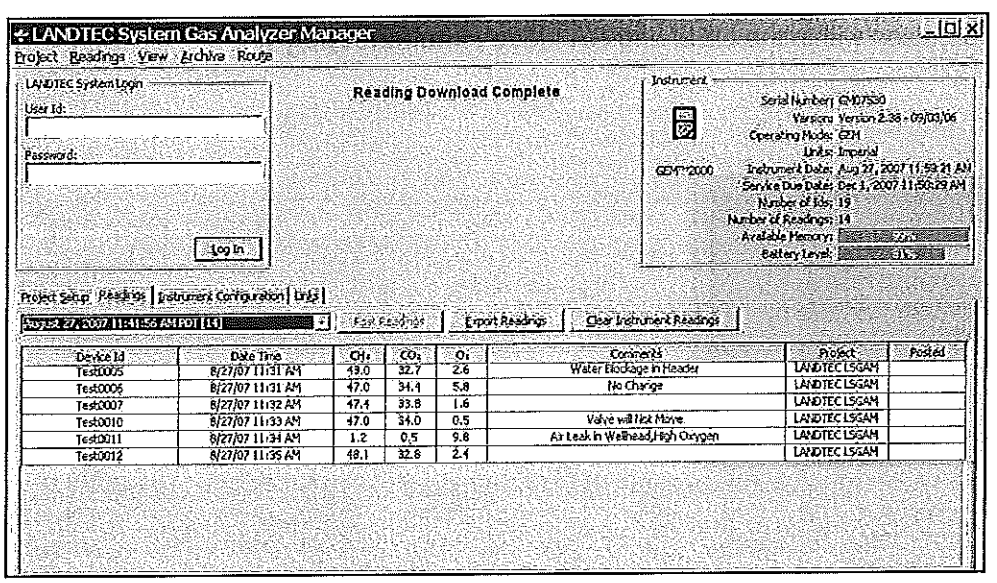
The Units of Measurement interface allows users to select whether to operate the instrument in metric or imperial units. The units for each parameter are displayed on the screen.

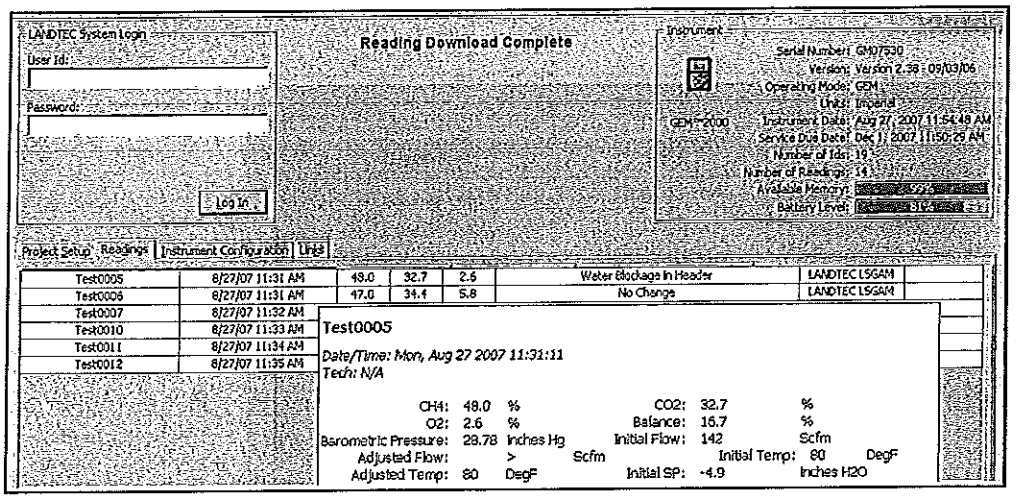
WARNING: *Units of Measure are as critical as the values of the readings stored. Be certain to verify the appropriate Units of Measure for your project prior to making a change to this option. Changing the Units of Measure will* ***NOT*** *convert any existing values stored in the instrument. To avoid confusion, download any stored readings prior the changing the Units of Measurement.*

3.12 Downloading Readings

After successfully creating projects, IDs, and setting appropriate instrument settings, the instrument is ready for field use. When used in the field, ***readings*** are collected and stored within the instrument's memory. The readings consist of the measured, input, and calculated parameters such as CH4, CO2, O2, Gas Temperature, Flow Rate, etc. These readings must be downloaded from the instrument to be reviewed on the computer and stored for review at a later time. This section of the Operation Manual reviews the process of downloading and storing readings from the instrument.

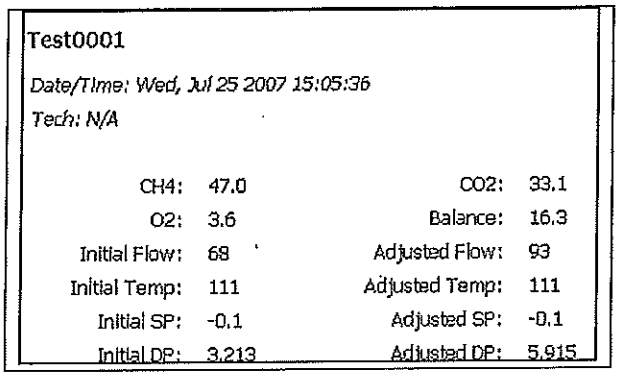
To view your downloaded readings from the instrument, select the Readings tab of the LANDTEC System Gas Analyzer Manager software.



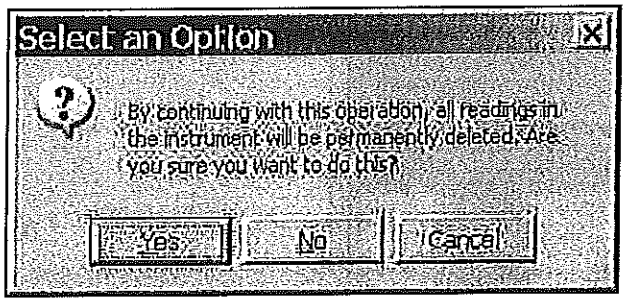


When the instrument is initially detected by the LSGAM software, the readings are automatically downloaded from the instrument, placed in the Readings tab table, and stored in your project previously set up on your computer.

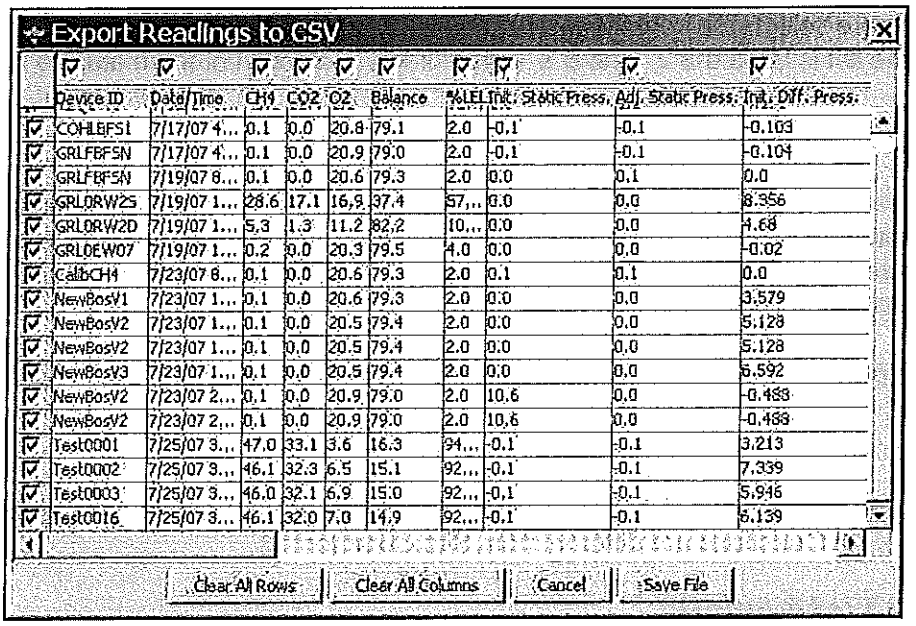
Placing your mouse over a reading will display additional parameters of the reading.



To clear the readings from your instrument, after the readings are downloaded successfully, click the ***Clear Instrument Readings*** button. A prompt will verify the permanent deletion of the readings from the instrument. This will clear information within the GEM and GA Mode **simultaneously**.



To export readings to a file, click the ***Export Readings*** button. This will open the ***Export Readings to CSV*** screen. This interface provides several options described below.

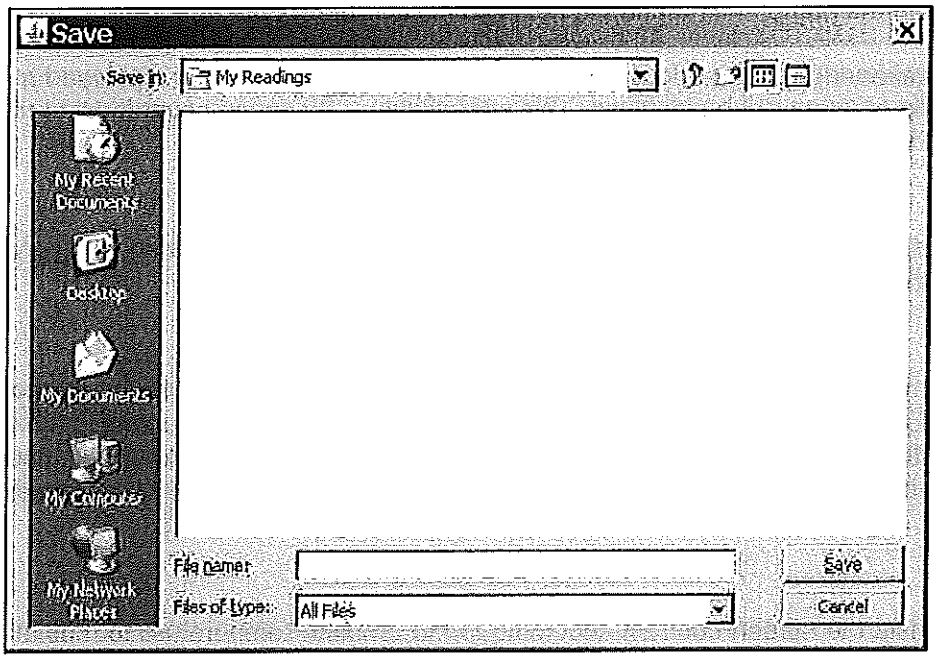


Export Readings to CSV

Device ID	Date/Time	CH4	CO2	O2	Balance	%LEL	Int. Static Press.	Adj. Static Press.	Int. Diff. Press.
COHLBFS1	7/17/07 4...	0.1	0.0	20.8	79.1	2.0	-0.1	-0.1	-0.103
GRLFBFSN	7/17/07 4...	0.1	0.0	20.9	79.0	2.0	-0.1	-0.1	-0.104
GRLFBFSN	7/19/07 8...	0.1	0.0	20.6	79.3	2.0	0.0	0.1	0.0
GRL0RW2S	7/19/07 1...	28.6	17.1	16.9	37.4	57,...	0.0	0.0	8.356
GRL0RW2D	7/19/07 1...	5.3	1.3	11.2	82.2	10,...	0.0	0.0	4.68
GRL0EW07	7/19/07 1...	0.2	0.0	20.3	79.5	4.0	0.0	0.0	-0.02
CalibCH4	7/23/07 8...	0.1	0.0	20.6	79.3	2.0	0.1	0.1	0.0
NewBosV1	7/23/07 1...	0.1	0.0	20.6	79.3	2.0	0.0	0.0	3.579
NewBosV2	7/23/07 1...	0.1	0.0	20.5	79.4	2.0	0.0	0.0	5.128
NewBosV2	7/23/07 1...	0.1	0.0	20.5	79.4	2.0	0.0	0.0	5.128
NewBosV3	7/23/07 1...	0.1	0.0	20.5	79.4	2.0	0.0	0.0	6.592
NewBosV2	7/23/07 2...	0.1	0.0	20.9	79.0	2.0	10.6	0.0	-0.488
NewBosV2	7/23/07 2,..	0.1	0.0	20.9	79.0	2.0	10.6	0.0	-0.488
Test0001	7/25/07 3...	47.0	33.1	3.6	16.3	94...	-0.1	-0.1	3.213
Test0002	7/25/07 3...	46.1	32.3	6.5	15.1	92,..	-0.1	-0.1	7.339
Test0003	7/25/07 3...	46.0	32.1	6.9	15.0	92,..	-0.1	-0.1	5.946
Test0016	7/25/07 3...	46.1	32.0	7.0	14.9	92...	-0.1	-0.1	6.139

Clear All Rows | Clear All Columns | Cancel | Save File

To add or remove a single reading from export, click on a checkbox in the leftmost column.
To add or remove a specific parameter from export, click on the corresponding checkbox across the top.
To clear all rows click the ***Clear All Rows*** button at the bottom of the screen.
To clear all column selections, click on the ***Clear All Columns*** button at the bottom of the screen.
To exit the operation without saving, click the ***Cancel*** button.
To specify a filename and save the selection to a file, click the ***Save File*** button. Clicking this button will open a Save window.



Specify a filename and location then click the Save button. The selected readings will be saved in comma separated value (.CSV) format. The .CSV file may now be opened in another application.

4 General Operations Menu

The following features and functions are selectable from the main menu via key '① **Menu**' from the read gas levels screen. Navigation through the list is via the 2 '∧' and 8 '∨' cursor keys. Selection of the feature is by pressing the '↵' key.

4.1 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. When zeroing transducers it is important to allow them to stabilize first so an accurate zero is achieved. If ① is pressed the instrument will return to the gas reading screen without zeroing.

NOTE: Zeroing Transducers may take a few extra minutes in the field, but is a recommended step to ensure the best possible accuracy.

4.2 Update Site Data

Allows the user to answer questions (pre-defined in LSGAM 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 3.7 of this manual.

4.3 Data Logging (GA mode only)

Enables the user to leave the Instrument unattended to take samples at pre-determined intervals. The reading interval and pump run time may be edited prior to commencing the logging cycle. The ID code may ONLY be set in LSGAM 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 automatically 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 LANDTEC logo will be displayed for a few seconds and the Gas Reading screen will be displayed. This will initiate a 30 second countdown to the next sample being taken unless the operator stops the logging function.

4.4 Operating Language

The operating language of the instrument can be set to English, German, Spanish, French, Italian or Brazilian Portuguese through this option.

4.5 View Data

The view data allows the user to see the readings that are in the GEM2000 / GEM2000 Plus memory. Often the amount of data stored is more than can be displayed adequately on one screen so pressing the ⑤ key will allow the user to see additional screens with stored data. The 2 '∧' and 8 '∨' cursor keys will move forward or backwards through the instruments memory. Pressing the ① key will exit to the Gas Reading screen.

4.6 Adjust Contrast

The GEM2000 automatically adjusts the screen contrast according to the ambient temperature to maintain normal viewing.

The contrast can be manually adjusted by using the 4 '<' and 6 '>' cursor keys. The manual contrast setting is stored when the '↵' key is pressed.

4.7 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 certified gas or 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. It is important to confirm the concentration of the calibration gas(es) used and enter the value(s) properly.

4.7.1 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_4, and O_2, 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.

4.7.2 Span Channels

Spanning Channels should be carried out prior to use or when the ambient operating temperature changes greater than +/- 20 degrees Fahrenheit. 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_4, CO_2, O_2, (CO & H_2S 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**'.

4.7.3 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_4, CO_2, O_2 (CO & H_2S for the Plus) or Gas Pod (if fitted) and pressure transducers.

4.7.4 Last Field Cal

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

4.8 Mode of Operation

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

4.9 Information Screen

The information screen will automatically display the following information:

Software Version- Date
Serial Number-GM00000
Date Format- USA
Language- American
Communication- 1920014

4.10 Exit Menu

The Exit Menu simply exits the main menu screen and returns to the gas reading screen.

5 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), are typically 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 GEM2000 / GEM2000 Plus instrument may be configured as a Gas Analyzer (GA mode) for sampling probes. To access this function from the gas read screen press '①' 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.

5.1 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 LSGAM 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_4, CO_2, and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) readings have been 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. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

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

5.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data and Technician Login should be updated (if programmed). This is accessed via the General Menu '①' then **'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 using LSGAM, see Section 3.7. If Site Questions were uploaded to the instrument, they should be answered at this time. The answers are stored and appended to each reading stored thereafter, until the Site Data is updated for another site.

5.3 Taking Readings – With ID

For this function to be used it is essential that the relevant ID be previously uploaded to the Instrument using LSGAM, see Chapter 3. An ID **cannot** be created by the Instrument alone.

1. When the Read Gas Levels screen is displayed, option **'③ 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 available; such as a description of the probe location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (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 '①**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 tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' into place. Then connect the sample tube to the probe sample port. **Do not connect the sample tube 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 tubing from the probe and start again at 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_4, CO_2, O_2 (, CO and H_2S for the Plus)).
- LEL CH_4.
- 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.

5.4 Taking Readings – Without ID

Gas Readings can be taken without an ID in the instrument by following the instructions below. To create and uploaded IDs to the instrument using LSGAM, see Chapter 3. An ID **cannot** be created by the Instrument alone.

1. From the Gas Reading Screen first select '③ **Next ID**' then press '⑤ **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 '- - - - - - - -'.

2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (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.
3. At this point, connect the sample tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' in to place.
4. Now connect the sample tube to the probe sample port. **Do not connect the sample tube 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. 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.
6. Upon storing the reading, a virtual keyboard will be displayed for any alphanumeric comments to be entered.
7. Disconnect the sample tubing 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.

5.5 Temperature Probe Reading

The GEM2000 / GEM2000 Plus has the facility to automatically display and record the probe temperature via an optional Temperature Probe (TP-2000). When the 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 GEM2000 UL certification and is therefore certified for use under the same conditions as the instrument.

5.6 Cross-Gas Effects

5.6.1 Methane, Carbon Dioxide and Oxygen

The Methane reading is filtered to an infrared absorption frequency of 3.41μm (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 4.29μm (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_2, CO, H_2S, SO_2 or H_2, 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.

5.6.2 H_2S, CO and other Optional Gas Pods

The Gas Pods used to measure H_2S 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_2S	SO_2	H_2	CH_4	CO_2
CO	100	<3	0	<40	0	0
H_2S	<0.5	100	~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.

5.6.3 GEM2000 Plus Internal Electrochemical Cells for Measuring H_2S and CO

The GEM2000 Plus employs two internal electrochemical cells to measure Hydrogen Sulfide (H_2S) and Carbon Monoxide (CO). Electrochemical cells which measure CO are typically susceptible to cross gas interference by Hydrogen (H_2) and Hydrogen Sulfide (H_2S). Two components that may be present in the Landfill Gas sample. This means that if H_2 and/or H_2S are/is present in the Landfill Gas sample a normal CO electrochemical cell would give an artificially high reading.

The GEM2000 Plus uses a 'hydrogen compensated' CO cell to counteract the interference by H_2. This is why the instrument displays an H_2 channel. H_2 is not directly measured, although a rough value, which is shown as LO, MED or HI, can be interpreted. If the H_2 value is displayed as LO or MED the H_2 compensation will mitigate the H_2 effect on the CO reading, however if the H_2 value is shown as high it is possible that there is more H_2 present than the compensation is capable of adjusting for. If that is the case the CO value may be artificially high due to cross gas interference by the H_2. Additionally, if a HI level of H_2 is encountered then a longer than normal purge time will typically be necessary to clear all the H_2 from the electrochemical cell. It is recommended that after encountering a HI level of H_2 the instrument be purged with clean air until the H_2 channel displays LO. This could take as long as five or ten minutes (if the H_2 channel was over ranged) but is necessary to ensure the subsequent readings are accurate.

The CO cell used in the GEM2000 Plus also utilizes an internal H_2S filter to eliminate H_2S cross gas interference. However, the filter does have a finite capacity. If the filter's capacity is exceeded then the CO cell will be susceptible to cross gas interference by any H_2S that is present in the gas sample. It is quite easy to determine if the capacity of the filter has been exceeded. After all the sample gas has been purged from the instrument, with clean air, and the CO reading is zero, run a certified gas that contains H_2S but not CO (the H_2S calibration gas) through the instrument. If the CO reading remains zero while the H_2S reading increases to the certified value then the internal H_2S filter has remaining capacity. If the CO reading increases with the H_2S reading then the internal filter's capacity has been exceeded and the cell will need to be replaced.

The GEM2000 Plus was designed to read a maximum H_2S concentration of 200ppm and a maximum CO reading of 2000ppm. If the gas sample contains more than the maximum concentration the instrument will be over ranged and display >>> as the reading. If the instrument is over ranged the readings typically stay artificially high for several minutes and will not go back to zero with a normal purge. While over ranging the instrument is not recommended and will slightly shorten the life span of the electrochemical cells the resulting high readings are not permanent. If one of the channels is over ranged it is recommended to purge the instrument, with clean air, until the reading returns to zero. This may take as long as five or ten minutes. The cell may need to be recalibrated but normally the extra long purge is all that is necessary.

6 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 GEM2000 / GEM2000 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 '①' 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.

6.1 Preliminary Checks

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

- All necessary ID codes and readings have been uploaded via LSGAM 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_4, CO_2 and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) 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. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

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

6.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data and technician login should be updated (if programmed). This is accessed via the General Menu '①'. 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 LSGAM 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.

6.3 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 LSGAM 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 '③ **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 tubes, as a clean air purge will automatically remove the

previous sample from the instrument. Purge time may be set via LSGAM (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 '①**EXIT**' key.

3. Connect the sample tubes (with water trap filter) to the wellhead ensuring the gas sample tube and impact pressure tubes are properly oriented. Insert the temperature probe if used.
4. Press the '⑥' 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 and any time by pressing the '⑥' key. The pump run time is set in LSGAM software. Allow the gas readings to stabilize and press '⑤**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 tubes and allow the pressure to stabilize. Once the pressure has stabilized press '↵ **Zero Transducers**'. Press '①' to continue. **Note**; if Accu-Flo wellheads are used this zero function may be performed prior to connecting the sample tubes to the well head by selecting '① **MENU**' and highlighting '**ZERO TRANSDUCERS**'. This eliminates the need to disconnect and re-connect the sample tubes 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 '③ **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_4, CO_2, O_2 (CO & H_2S 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.

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_4.

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_2 and gas temperature and later as increased Oxygen from well over-pull. In time, the Methane will also decline. This is the result of a portion of the landfill, usually at the

surface, being driven aerobic. In this portion of the landfill, the Methane-producing bacteria will have been destroyed (due to the presence of Oxygen). With the Methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this area, and may lead to the operator opening the well or increasing flow.

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_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily Nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2000 or magnehelic) or other device(anemometer/velometer)
- Velocity head (P or PT) (from GEM2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2000, or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well's LFG and Methane flow and sum total
- Observations/comments

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

7.6 Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2000 or magnehelic)
- Velocity head (P or Pt) (from GEM2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2000, 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 then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
- Type of fill
- Size and shape of refuse mass
- Depth of fill
- Compaction
- Leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and Methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

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. The particulate filter or water trap filter needs replacing.
Readings taken are not what was expected	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. Field calibrate Oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software. 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. Contact Factory Service.
Oxygen readings drift	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 Service & Maintenance

9.1 Factory Service

LANDTEC is the ONLY authorized service center for the GEM™2000 / GEM™2000 Plus instruments. Factory service includes but is not limited to the following;

General operations
The main functions of the gas analyzers operation are checked to ensure that they are within specification.

Barometric pressure reading
The barometric pressure reading is checked to ensure it is within specification. This is carried out by way of comparing the atmospheric reading against a known standard. If necessary, reprogramming is quoted.

Static and differential pressure readings
The static and differential pressure transducers are checked to ensure they are within specifications. This is carried out by comparing instrument readings to a known standard, applying a known pressure and noting both readings. If necessary, reprogramming will be quoted.

Pump functionality (flow and vacuum)
All flow and vacuum functions of the internal pump are checked to ensure the operation is within specification.

Water ingress/blockage
The internal filters are checked for cleanliness and moisture ingress to ensure they are not contaminated.

Flow fail setting
The flow fail function is checked to ensure proper operation within the specified limits.

Gas pod and Temperature probe connectivity reading
The connectivity of the gas analyzer is checked to ensure correct operation and reading performance with accessories.

Computer controlled gas check
Inward and outward gas checks are carried out by way of connecting the gas analyzer to a custom built computer controlled 'gas checking rig' and proprietary software. At the inward stage, two sets of readings are taken - one using the customer's calibration settings and a second set using factory calibration settings. During this process a range of gases are used that span the reading range of the gas analyzer.

Structural and aesthetics check
The instrument is checked for cracks, scratches and broken or missing pieces.

9.2 Factory Service Facilities

LANDTEC North America
850 S. Via Lata, Suite 112
Colton, CA 92324
USA
Tel: 800-821-0496 or +1-909-783-3636
Web: www.ces-landtec.com

LANDTEC Europe
Formerly Geotechnical Instruments
Sovereign House Queensway
Leamington Spa, Warwickshire CV31 3JR,
England
Tel: +44(0)1926 338111
Web: www.geotech.co.uk

LANDTEC South America
LANDTEC Produtos e Servicos Ambientais Ltda.
Rua Pedroso de Carmargo, 237 - Chácara
Santo Antonio - SP/SP CEP 0417-010
Brazil
Phone: +55(11) 5181-6591
Web: www.landtecbrazil.com.br

9.3 User Maintenance

This instrument is designed to be low maintenance and rugged however field calibrations are recommended prior to use or when the ambient operating temperature of the instrument changes more than +/- 20 degrees Fahrenheit. See section 4.7 for further information on field calibrations. Additionally it may be necessary to change the user accessible filters and o-rings from time to time.

There are two user accessible filters, the particulate filter is located in the back of the instrument, see section 2 for location, and the water trap filter which is part of the included hose kit. There are four user changeable o-rings, one on the particulate filter cover, one on the outside of the water trap filter housing, one on the inside of the water trap filter housing, and ones on the ends of the male quick connect fittings included on the hose kits.

10 Technical Specifications

10.1 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.

10.2 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_2, CH_4 and O_2 Min/Max levels via LSGAM CS software.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

10.3 Power supply

Battery type	Rechargeable Nickel Metal Hydride battery pack containing six 4AH cells. **Not user replaceable.** 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.

10.4 Gas Ranges

Detection principle	CO_2 and CH_4 by dual wavelength infrared cell with reference channel. O_2 (and CO & H_2S in Plus) by internal electrochemical cell.
Oxygen cell lifetime	Approximately 18 months in air.
Typical Accuracy 0 - Full Scale	**Gas** — **0-5% volume** — **5-15% volume** — **15%-FS** **CH_4** — ±0.3% — ±1% — ±3% (100%) **CO_2** — ±0.3% — ±1% — ±3% (60%) **O_2** — ±1% — ±1% — ±1% (21%) **CO & H_2S in Plus Instruments** ±10%FS from 0-Full Scale
Response time, T90	CH_4 ≤20 seconds CO_2 ≤20 seconds O_2 ≤20 seconds

Range	CH_4 0-70% to specification, 0-100% reading. CO_2 0-40% to specification, 0-100% reading. O_2 0-25% CO (in Plus Instruments) 0-2000ppm H_2S (in Plus Instruments) 0-500ppm

10.5 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_20.

10.6 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.

10.7 Optional Gas Pods

Typical Accuracy (Subject to User calibration).	**Gas**	**0-Full Scale**
	CO	±10% FS
	H_2S	±10% FS
	SO_2	±10% FS
	H_2	±10% FS
	HCN	±10% FS
Response time, T90	CO	≤60 seconds
	H_2S	≤60 seconds
	SO_2	≤60 seconds
	H_2	≤60 seconds
	HCN	≤60 seconds
Range	CO	0-500ppm
	H_2S	0-50 or 0-200ppm
	SO_2	0-20 or 0-100ppm
	H_2	0-1000ppm
	HCN	0-100ppm

Appendix D

NCDENR Division of Air Quality
Permit Applicability Determination
Applicability Determination Application No. 1756

NCDENR

North Carolina Department of Environment and Natural Resources
Division of Air Quality

Beverly Eaves Perdue
Governor

Sheila C. Holman
Director

Dee Freeman
Secretary

July 14, 2011

Mr. Stephen King
Director, Haywood County Solid Waste Department
Francis Farm Landfill
278 Recycle Drive
Clyde, NC 28721

SUBJECT: Air Permit Applicability Determination
Applicability Determination Application No. 1756
Francis Farm Landfill
Waynesville, Haywood County

Dear Mr. King:

The Division of Air Quality received your completed application on July 1, 2011 requesting that this Office determine whether an Air Quality Permit is necessary for the proposed methane gas combustion system at the Francis Farm Landfill, Haywood County, North Carolina. The approximately 89 scfm landfill gas combustion system will include a generator (approximately 75 kW / 35 scfm) and a flare.

The July 1, 2011 letter indicates that actual air emissions of criteria air pollutants from the project, including nitrogen oxides and carbon monoxide, will each be less than 5 tons per year. NC Regulation 15A NCAC 2Q .0102(c)(2)(E)(ii) exempts facilities from air quality permitting as follows:

> *any facility whose actual emissions of particulate, sulfur dioxide, nitrogen oxides, volatile organic compounds, and carbon monoxide before air pollution control devices, i.e., uncontrolled emissions, are each less than five tons per year, whose potential emissions of all hazardous air pollutants are below their lesser quantity cutoff emission rate, and none of whose sources would violate an applicable emissions standard;*

Therefore, this Office has determined that an Air Quality Permit is not required for the proposed methane gas combustion system. It should be noted that this exemption from the permitting requirement does not exempt the Haywood County Solid Waste Department from complying with any applicable regulations.

Furthermore, should you decide to modify the process such that the result is an increase of emissions of air pollutants including toxic air pollutants, an Air Quality Permit may be required and the Haywood County Solid Waste Department should submit a permit application to this Office prior to such actions.

It should also be noted that future Regulations including Federal Maximum Achievable Control Technology (MACT) for hazardous air pollutant (HAP) may be promulgated and adopted by the Division which apply to this type of facility. If so the Haywood County Solid Waste Department may be required to apply for an Air Quality Permit for this equipment at that date.

The gas-fired engine may be subject to the following federal rules and the Haywood County Solid Waste Department should ensure compliance if applicable: 40 CFR 60 Subpart JJJJ *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines* and 40 CFR 63 Subpart ZZZZ *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines.*

This exemption from the permitting requirement is based upon your statement that equipment will be operated under the threshold levels as outlined in the Regulation. Please be advised that the operation of any air pollution emission sources which results in emissions in excess of the threshold levels without an Air Quality Permit is a violation of 15A NCAC 2Q.0101, "Required Air Quality Permits." If this facility is required to obtain an Air Quality Permit for this equipment in the future because of increased emissions, each day of operation of the emission sources without an Air Quality Permit represents a separate violation. Such violations may be subject to enforcement action, including a civil penalty of up to $25,000 per violation and/or injunctive relief, pursuant to NCGS 143-215.114A.

If you have any questions, with reference to the above matter, please do not hesitate to contact Brendan Davey at (828) 296-4500.

Sincerely,

Paul K. Muller

Paul K. Muller, P.E.
Regional Air Quality Supervisor

PKM:bgd

cc: Asheville Regional Office
William Sperry (McGill Associates)

Appendix E

Flare Station / Engine-Generator Data Sheet
Francis Farm Landfill

FLARE STATION / ENGINE-GENERATOR DATA SHEET
FRANCIS FARM LANDFILL

TECHNICIAN: _____ DATE: _____ TIME: _____

WEATHER CONDITIONS: _____

AMBIENT TEMPERATURE: _____ (Deg F) ATMOSPHERIC PRESSURE: _____ (in-Hg)

FLARE: ON / OFF (Circle One) **OPERATING MODE:** ENGINE MODE FLARE MODE (Circle One)

FLARE STACK TEMPERATURE: _____ (deg F) PILOT TEMPERATURE: _____ (deg F)

KNOCKOUT POT: LIQUID LEVEL: _____ (inches in site glass)

VACUUM LOSS AROUND DEMISTER: _____ (in-w.c.)

COMMENTS: _____

BLOWER: VACUUM - INLET SIDE: _____ (in-w.c.) Hz: _____

LFG PRESSURE - OUTLET SIDE: _____ (in-w.c.) Amps: _____

%: _____

FLOW RATE: MAIN LINE FLOW RATE: _____ (scfm) Metered

ACCUMULATED TOTAL FLOW: _____ (scf) Main Line

FLOW RATE TO ENGINE: _____ (scfm) Metered

VALVE POSITION - ENGINE: _____

FLOW RATE TO FLARE: _____ (scfm) (Main line flow - flow to engine)

VALVE POSITION - FLARE: _____

LANDFILL GAS COMPOSITION: GAS TEMPERATURE: _____ (Deg F)

CH4: _____ (% by Vol.)

CO2: _____ (% by Vol.)

O2: _____ (% by Vol.)

ALARMS: (Circle One)

FLARE IGNITION FAULT: ON OFF CONDENSATE TANK HIGH LEVEL: ON OFF

FLARE TEMP LOW: ON OFF LFG LOW FLOW: ON OFF

METHANE SAMPLE PURGE FAIL: ON OFF FLAME SENSOR ALARM: ON OFF

FLAME ARRESTOR SENSOR: _____ EST. PROPANE TANK LEVEL: 1/4 1/2 3/4 F

GENERAL COMMENTS AND ACTION TAKEN: _____

_____

_____

FLARE STATION / ENGINE-GENERATOR DATA SHEET
FRANCIS FARM LANDFILL

TECHNICIAN: _____ DATE: _____ TIME: _____

WEATHER CONDITIONS: _____

ENGINE:

RUNNING / STOPPED STATUS: _____

COOLANT TEMPERATURE: _____

OIL PRESSURE: _____ OIL CHANGED: _____

AIR FILTER: _____ FILTER CHANGED: _____

ALTERNATOR: _____

RUN TIME/HOUR METER READING: _____

EMERGENCY SHUT-DOWN ALARM: _____

_____

GENERATOR:

RUNNING / STOPPED STATUS: _____

AC VOLT METER: _____

AC AMP METER: _____

AC FREQUENCY METER: _____

ACCUMULATED KWH: _____

AIR FILTER: _____ FILTER CHANGED: _____

GENERATOR TROUBLE ALARM: _____

_____

GENERATOR FAILURE ALARM: _____

_____

GENERAL CONDITION OF ENGINE-GENERATOR, COMMENTS AND ACTION TAKEN: _____

_____

_____

Appendix F

Wellfield Data Sheet
Francis Farm Landfill

WELLFIELD DATA SHEET
FRANCIS FARM LANDFILL

TECHNICIAN: _____ DATE: _____

WEATHER CONDITIONS: _____

AMBIENT TEMPERATURE: _____ (Deg F) FLARE INLET: LFG TEMPERATURE: _____ (Deg F) CH4: _____ % by Vol

ATMOSPHERIC PRESSURE: _____ (in-Hg) LINE PRESSURE: _____ (in H2O) O2: _____ % by Vol

WELL ID NO.	TIME OF READING	GAS COMPOSITION				WELLHEAD GAS TEMP. (deg F)	STATIC PRESS, Ps (in H2O)	IMPACT PRESS, Pi (in H2O)	VELOCITY HEAD PRESS, Pt (in H2O)	WELLHEAD GAS FLOW (scfm)	WELLHEAD VALVE POSITION (Initial)	WELLHEAD VALVE POSITION (Adjusted)	NOTES
		CH4 (% Vol)	O2 (% Vol)	CO2 (% Vol)	N2 (% Vol)								
EW-1													
EW-2													
EW-3													
EW-4													
EW-5													
EW-6													
EW-7													
EW-8													
EW-9													
EW-10													
EW-11													
EW-12													
EW-13													
EW-14													
EW-15													
EW-16													
EW-17													
EW-18													
EW-19													
EW-20													
EW-21													
VAL-1													
VAL-2													
VAL-3													
VAL-4													
VAL-5													
VAL-6													
									TOTAL GAS FLOW				

GENERAL COMMENTS: _____

Appendix G

Operation Manual
LANDTEC GEM
Gas Analyzer & Extraction Monitor
Revision C2
November 30, 2010

LANDTEC

GEM™2NAV Plus
GEM™2NAV
GEM™2000 Plus
GEM™2000

GAS ANALYZER & EXTRACTION MONITORS

OPERATION MANUAL
for
Serial Numbers 10000 and up

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This manual is subject to revision without prior notice. Please periodically check our website for a newer revision.

Revision	Date	Approved by	Translated from	Comment
A	Oct-2009		N/A	*This document uses Arial, Wingdings, Wingdings 2, Wingdings 3, GI2k fonts. Printing of this document to PDF should only be done if these fonts are present. "Whitespace" has been removed from many of the graphical images and the images are otherwise "cropped" to reduce the total number of pages. These alterations of the actual screen images do not detract from the technical content presented*1st Release of this manual
B	Nov-2009	MC & SM	N/A	Minor Corrections / Final Proofing
B1	Nov-2009	SM	N/A	Minor corrections to images
C1	16-Feb-2010	SM	N/A	Explanation of single media format & software installation.
C1a,b	1-Mar-2010	SM	N/A	Environmental Chamber Clarified. H_2S & CO specs modified
C2	Nov - 2010	MC	N/A	Clarified instruments are not total hydrocarbon analyzers, cross gas interference and solutions for typical interferences.

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1 Introduction

LANDTEC is the premier manufacturer of products, instruments and software for landfill gas extraction and 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 GEM2000, GEM2000 Plus, GEM2NAV and GEM2NAV Plus instruments designed by LANDTEC, are specifically for use on landfills to monitor landfill gas (LFG) extraction systems, flares and migration control systems. These instruments sample and analyze the Methane, Carbon Dioxide and Oxygen content of LFG. The GEM instruments are not total hydrocarbon analyzers. The Plus versions (GEM2000 Plus and GEM2NAV Plus) also sample and analyze Carbon Monoxide and Hydrogen Sulfide. The NAV versions (GEM2NAV and GEM2NAV Plus) include an integral GPS (Global Positioning System). The readings are displayed and stored in the instrument and can be downloaded to a personal computer for reporting, analyzing and archiving. Since there are variations to the features of the instruments, this single manual is designed to cover all instrument versions. Throughout this manual, the term GEM2xxx is intended to refer to ANY of the GEM instruments with a serial number above 10,000. Features specific to one particular instrument will be designated within this manual to be specific for the particular instrument.

The GEM instruments are shipped in a 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 the pressure relief valve is opened to equalize internal pressure. When shipping an instrument to LANDTEC for calibration or service, always ship it in the hard case to protect unit from damage. It is a good idea to also call and generate a Service or Repair Authorization (RA) prior to sending the instrument. This ensures proper routing of your instrument once it arrives at LANDTEC. The RA also will detail a list of reasons as to why the instrument is being returned for service. If an RA does not exist when the instrument arrives it can delay service of your instrument.

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

- The GEM2000, GEM2000 Plus, GEM2NAV or GEM2NAV Plus instrument (Plus instruments have a Silver Keyboard and the numbers 1, 3, 5, 7, and 9 will be white on a blue background with a red highlight.)
- 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" polyurethane pressure sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue & clear tubing
- Spare O-rings for the male connectors
- Spare external water trap filter element
- 100-240 volt battery charger
- Software on CD-ROM
- USB communications cable
- Temperature probe (optional)
- Hard carrying case

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

Immediately notify shipping company if the instrument or accessories are damaged due to shipping. Please keep all packaging material and take pictures to document the damage. Next, contact LANDTEC immediately so that a claim can be established with the shipping company.

For questions regarding instrument operation and procedures, please contact LANDTEC at the regional office of your choice. General Operational Features

1.1 Physical Characteristics of the GEM2xxx instruments

1	Exhaust Port
2	Temperature / Gas Pod / Communications Socket (Connector "A")
3	Power Socket (Connector "B")
4	Particulate Filter Housing (on back of instrument)
5	Sample Inlet, Static or System Pressure Port
6	Impact Pressure Port

①	① key
②	② key, up arrow, '∧' cursor key, scroll up
③	③ key
④	④ key, left arrow, '<' cursor key, scroll left
⑤	⑤ key
⑥	⑥ key, right arrow, '>' cursor key, scroll right
⑦	⑦ key
⑧	⑧ key, down arrow, '∨' cursor key, scroll down
⑨	⑨ key
⓪	⓪ key, (zero) key, Backlight operation, Keyboard Lock (press and hold for 2 second to activate keyboard lock, press again to deactivate the lock)
	Pump Operation, Pump On/Off, Backspace Key (press and hold for 1 second to backspace)
↵	Enter/Store key
⑩	Red Power Button, On-Off (Press and Hold for 2-3 seconds for normal On-Off function, Press and Hold for 15 seconds to forcibly turn off the instrument)

1.2 Storage

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

After use or before storing the instrument it should be purged with clean nitrogen or air. Purging with nitrogen may prolong the oxygen sensor's life. When not in use, instruments and accessories should be kept clean, dry and warm inside of their hard case.

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.

1.3 Battery/Charging

The Battery Charger IS NOT covered by the unit UL certification. Warning - To reduce the risk of ignition of a flammable or explosive atmosphere, charge batteries only in an area known to be non-hazardous" or equivalent.

The battery used in the GEM2xxx instrument is an encapsulated six cell, Nickel Metal Hydride pack. This type of battery is not as 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 "Trickle Charge" the charging is completed and the unit should be disconnected from 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.

1.4 Instrument Certification

The GEM2xxx is UL/Sira certified for use in hazardous locations. Specifically certified as to intrinsic safety for use in hazardous locations Class I, Zone 1, AEx ib d IIA T1 (Ta=32°F to +104°F).

When the GEM2xxx instrument is in the hazardous area it shall only be externally attached via connector A to devices that are marked with the UL File Number E203142

For the certification to remain intact it is vital that the instructions in this manual are followed closely and repair of this equipment be carried out in accordance with the applicable code of practice by an approved repair facility. See section 7.2 for a list of authorized repair locations.

It is the responsibility of the operator to determine the protection concept and classification required for a particular application.

1.5 Safety Information

The GEM2xxx instruments are normally used for measuring gases from landfill sites. Inhalation of any gas may be harmful to health and in some cases may be fatal. It is the responsibility of the user to ensure that they are adequately trained in the safety aspects of the gases being used and that appropriate procedures be followed. In particular, where hazardous gases are being monitored or used the gas exhausted from the analyzer must be piped to an area where it is safe to discharge the gas. Hazardous gas can also be expelled from the instrument when purging with clean air.

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

When switching the instrument off, the On/Off button must be held down for approximately 2-3 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.

1.7 Warm-up Self Test

When switched on, the instrument will briefly display the LANDTEC logo and perform a predetermined self-test sequence taking approximately 30 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:

- Software version
- Serial Number
- Calibration due date
- Date format
- Operating language
- Communication Baud rate

Depending upon your version of GEM2xxx instrument you may see additional items listed from the self-test as well.

1.8 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, to exit from this screen press the "Enter/Store" key '↵'.

1.8.1 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_2 Cell out of calibration, CH_4 out of calibration, CO_2 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.

1.8.2 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_4 reading or channel out of specification, 02 - User cal data, CO_2 reading out of specification).

If any other Warnings or Errors are displayed, contact a LANDTEC Authorized Service Facility for further information.

1.9 Service Information Screen

Upon self-test completion, the instrument will display service information including when the next manufacturers service is due, what type of service agreement the instrument is under (if applicable), and when the last factory gas check was performed. To exit from this screen press the "Enter/Store" key '↵'.

1.10 Technician ID Screen

The Technician ID screen is displayed after the Service Information screen. It is not necessary to input a Technician ID but it is suggested to do so for record purposes. Up to four characters can be entered to identify the technician performing the readings. This technician ID will be appended to all readings that are taken until the instrument is turned off. To change the Technician ID simply turn the instrument off and back on again. The Technician ID can be input through a virtual key board shown on the instruments display. Letters or numbers can be selected by using the '∧' and '∨' keys to scroll up/down and the '<' and '>' to scroll left and right. Pressing the "Enter/Store" key '↵' will select the highlighted character. Once the Technician ID is selected, or to bypass selecting any characters press the '①' button.

1.11 Gas Reading Screen

After inputting or bypassing the Technician ID, the instrument will go into the Gas Reading screen, also considered the normal operation screen. 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_4, CO_2, O_2 (in %)
- Two minor gases – CO & H_2S and indication of H_2 (GEM2xxx Plus instruments only)
- Balance gas
- Last read time/date (if previous data is in memory)
- Technician ID
- External devices (displays pod type or temperature probe readings when attached)
- % LEL CH_4 (if selected through LSGAM)
- 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 / GPS Screen /	Allows the next ID to be selected (if IDs are available). (GPS Screen is for GEM2NAV Models when ID's are not used)
⑤ Measure Flow	For GEM mode only.
⑦ Previous Reading	Allows the previous reading of the selected ID to be viewed (if data is available).
↵ Store Reading	Stores the current displayed reading. (GA mode only)

1.11.1 Keypad Lock

After the instrument enters into the Gas Reading Screen, and from this point forward, the keypad can be locked by pressing and holding the backlight key for approximately 2 seconds. A message will display at the bottom of the display instructing you that to release the lock you will need to press and hold the backlight button.

1.12 Optional Gas Pods

Optional Gas Pods are available for use with the instruments. These pods are available for a variety different gases. For certain gases, more than one PPM range may be available; consult with a sale representative for the Gas Pod that would best meet your specific needs. Connection to the instrument is made via the communications socket 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. The Gas Pods are not classified as intrinsically safe they should not be attached or detached from the instrument in hazardous areas.

Gas Type	Range (PPM)	Resolution (PPM)
H_2S	0-50	0.1
	0-200	1.0
	0-5000	35
CO	0-1000	1.0
SO_2	0-20	0.1
	0-100	1.0
H_2	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 a Gas Pod, indicates the presence of the pod's 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. If calibrated properly, the accuracy of these Gas Pods are typically 5-10% Full Scale. Certain gases used to calibrate gas pods may be dangerous or fatal to your health. Be familiar with material safety data sheets (MSDS) prior to using any gas.

1.13 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 charged.

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

When using the instrument please cover the communications and charging sockets with their "dust plugs". Although unlikely, sudden shocks, high levels of electromagnetic interference or static discharge may cause memory corruption or loss. Additionally the use of cell phones or other high powered devices near the instrument may cause radio frequency interference and may cause memory corruption or loss. If this occurs, the instrument may need to be Cold Started and the calibration reset to factory settings before further use. **NOTE: Cold Starting will erase all data in the instrument including resetting the following to default values:**

- Time and Date
- Language Settings
- Screen Contrast Setting
- Mode of Operation
- Field Calibration

1.13.1 Cold Start

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.
(For Gas Calibration Error Messages, confirm that Factory Settings and User Calibration are 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, reset the internal time/date to the default settings, and load device IDs into the instrument. Please note that the time/date and device IDs may only be updated through the communication software. They cannot be updated manually.

To carry out a cold start, turn the instrument on, before the instrument enters into the self-test screen press and continue to hold the '↵' key until a pass code entry screen is displayed. At this point the '↵' key may be released. Enter the pass-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 in use, pump run time and service dates. There are four options from this screen;

1 - Cold Start
2 - Recover readings
3 - Print readings
0 - Exit

ONLY select option '**1**' if a Cold Start is to be carried out. Press key '**1**' to confirm this operation or press key '**0**' to continue with normal operation. If you select '**1**' to confirm the cold start a message will be displayed confirming the cold start operation and all memory will be cleared. The instrument will continue to the technician ID screen.

1.13.2 Recover Readings

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.
Recover readings is a low level memory function that should only be used as a last resort if all your readings were inadvertently deleted and you know how many readings you had. This function moves the memory buffer and can cause instrument corruption. Contact LANDTEC before attempting to recover readings. After using this function, it is recommended that you download data from the GEM and then perform a cold start to ensure all memory is cleared and returned to an initialized state.

1.13.3 Print Readings

This function is performed as a technical support diagnostic tool and can assist LANDTEC personnel in troubleshooting certain types of problems.

1.14 Radio Frequency (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.

2 The LANDTEC System Gas Analyzer Manager (LSGAM) Software

Beginning with GEM2xxx serial number 10000 and above, LSGAM is the only software that will communicate with the instrument.

2.1 Configuration Options

The GEM2xxx and LANDTEC System Gas Analyzer Manager (LSGAM) software can be utilized in a number of ways:

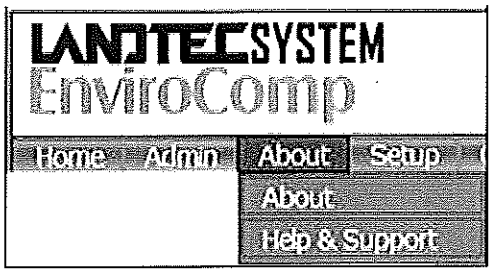
- Configured for operation with the LANDTEC System online service
- Used offline as a local application storing information on the desktop/laptop computer
- Use of the GEM2xxx out of the box without software; (this does not allow the user to generate flow rate values, select comments or select IDs with the instrument. This also prevents downloading of readings to the computer. It also does not allow the user to correct the time and date or to clear the memory, unless cold started.)

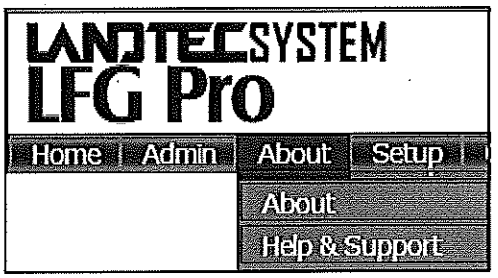
2.2 LANDTEC System Online Users

The procedures included in this section are intended for those who connect to the LANDTEC System online service. The LANDTEC System is an online collaboration tool to Collect, Validate, Analyze, and Communicate information based on field data obtained using LANDTEC instrumentation.

If you are a currently registered user on the LANDTEC System, please log in at http://www.landtecsystem.com/. If you are not currently using the LANDTEC System, you may register by contacting LANDTEC in the US: (800) 821-0496 or International: +1 (909) 783-3636.

Online reference for using LANDTEC System Gas Analyzer Manager (LSGAM) with the LANDTEC System can be found under the About → Help & Support menu within the LANDTEC System.



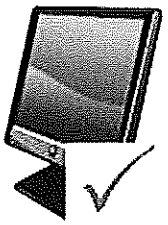


If you do not have login information please contact LANDTEC System Technical Support at +1 (909) 783-3636 extension 6131. Alternately, you may contact your local LANDTEC office for information on connecting to the LANDTEC System online service.

2.3 Offline Users

The procedures included in the section describe use of the LANDTEC System Gas Analyzer Manager (LSGAM) Software while **NOT** connected to the LANDTEC System online service.

2.3.1 Installation with the CD



System Requirements

- Windows XP, Vista, 7
- Pentium 750MHz or faster
- 128MB RAM
- 200MB Hard Drive Space Available
- CD-ROM Drive
- Available USB port

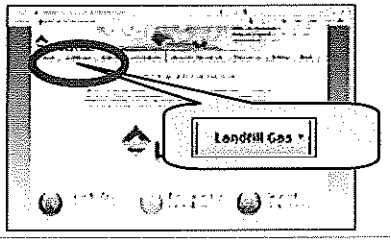
NOTE: The computer may need some administrative privileges to install the program. Program may run on other versions of Windows but LANDTEC has not tested the program on older versions of windows or with lesser processor and memory requirements.

As part of LANDTEC's continual improvement process, LANDTEC has consolidated its product information and instrument communications software into one menu structure. On your memory stick or CD you will find technical information, instrument communication software, USB cable drivers, videos and instrument manuals.

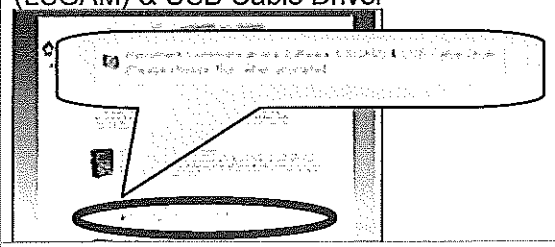
To install the USB Cable Drivers and LSGAM (instrument communication software) from this media format, you will need to place your CD or memory stick into your computer. If you have a CD it should automatically start. If you have a memory stick, you may have to browse to it in your computer and then click on the ***ClickHereToStart.htm*** icon.

Once the media opens, you will need to choose your appropriate application area from one of the application categories. This example is for a **GEM2NAV** instrument being used on a ***Landfill Gas*** application. After the page opens you'll click on the link titled ***Instrument Communications Software (LSGAM) & USB Cable Driver.***

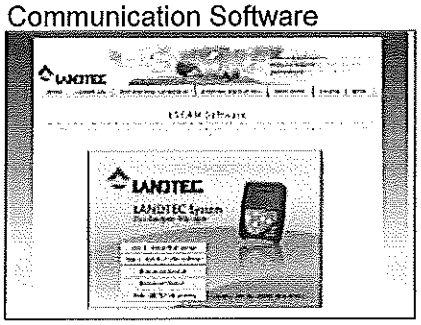
Step A
—Click on LANDFILL GAS



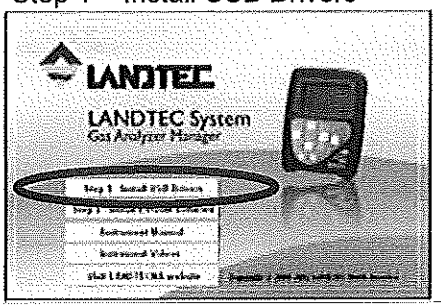
Step B
—Click on Instrument Communications Software (LSGAM) & USB Cable Driver



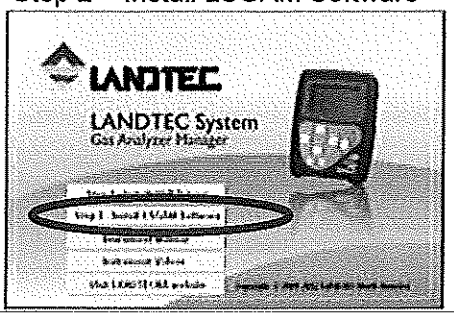
Step C
—Install Components of the Instrument Communication Software



Step D
—Choose
"Step 1 – Install USB Drivers"

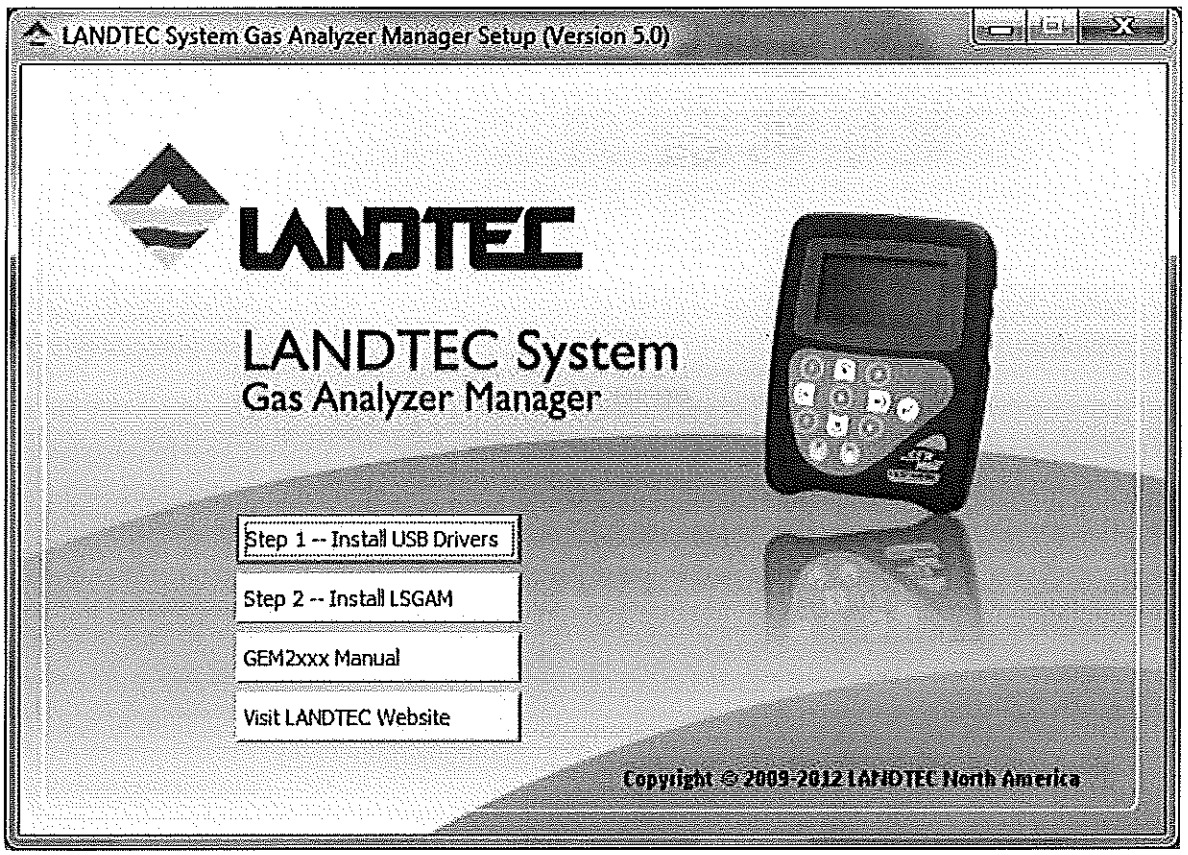


Step E
—Choose
"Step 2 – Install LSGAM Software"



The software will automatically update if an internet connection is available when the software starts. This software has been tested with Windows XP. Partial testing on Windows Vista and Windows 7 is complete and the software is performing as expected.

Should you have any difficulties, please don't hesitate to contact us. Our Software support group can be reached at (909) 783-3636 x6131 or support@landtecna.com



The instrument communicates to the computer by means of a USB. This USB cable requires drivers to be installed prior to use on the computer. From the CD (or USB memory stick) choose the first option "Step 1— Install USB Drivers"

The Java programming is an import part of this software and will be loaded with the CD install. If you have internet access, it is recommended to update your java to the latest version by going to http://www.sun.com

then click the Java Icon under the "downloads" section. Once at the Java downloads you'll see links to download the latest version of Java for your computer. The java icon, shown below, will be in the task tray at the bottom of your computer screen where your time is shown. There will also be a GAM log icon, shown below, that will be created on your desk top during installation.

2.3.2 Startup

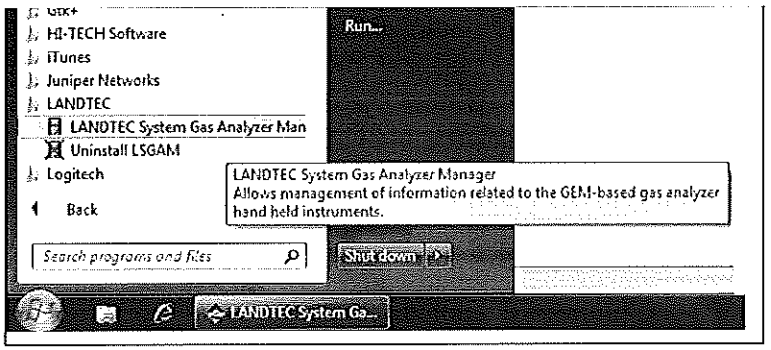
Up Once the USB cable drivers are installed and you've checked for the latest Java Runtime from the www.sun.com website, click on "Step 2 — Install LSGAM". LSGAM will install placing an Icon on your desktop and a new Start Menu Group named LANDTEC.

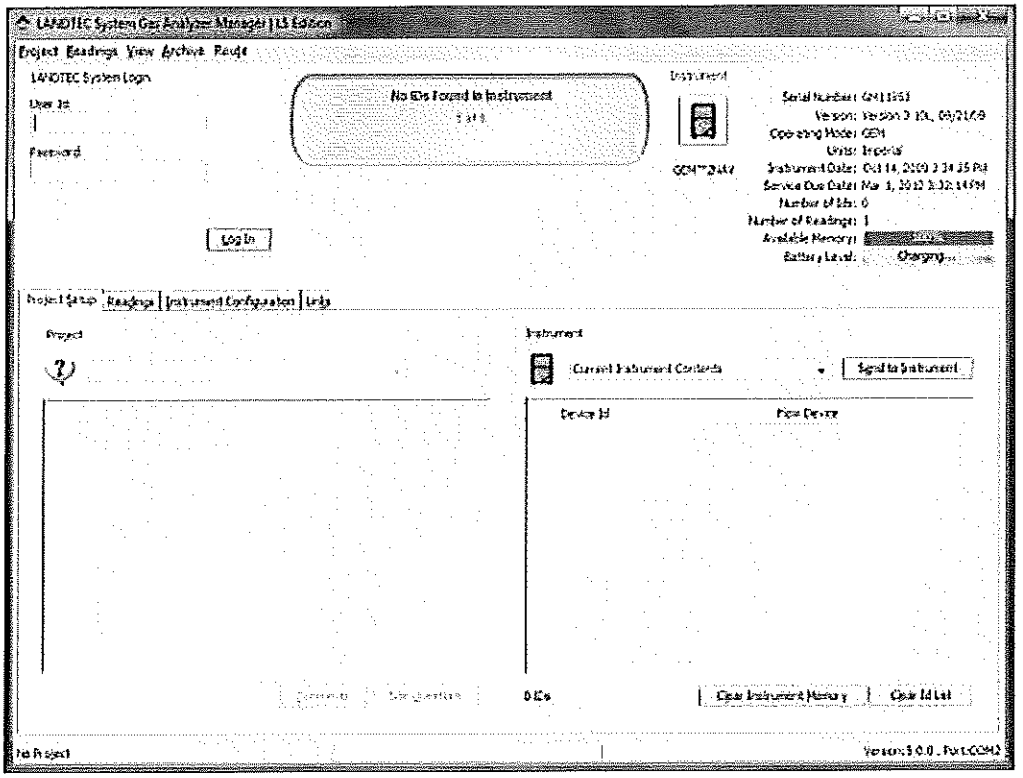
Starting LSGAM can be easily done by doing one of the following:

Double-Click on the Desktop icon.

OR - go to;

Start → All Programs → LANDTEC → LANDTEC System Gas Analyzer Manager



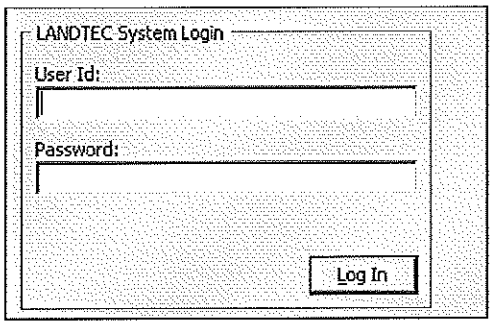


2.3.3 Navigation

The LANDTEC System Gas Analyzer Manager User Interface allows for easy access and navigation to various utilities to use the LANDTEC portable instrument on a day to day basis. The following is a general description of the user interface.

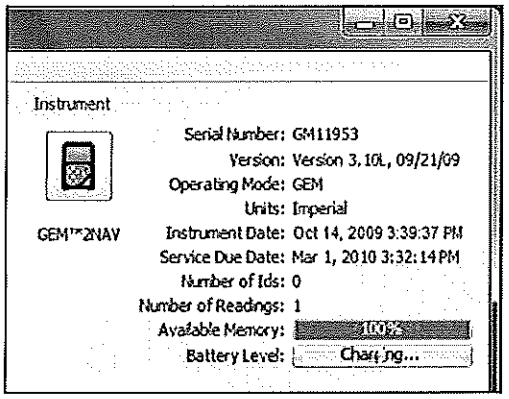
LANDTEC System Login

When LSGAM is used with the LANDTEC System online service, the username and password will be entered in the screen below, if you are using LSGSM as a desktop application the User Id and Password fields do not need to be filled in.

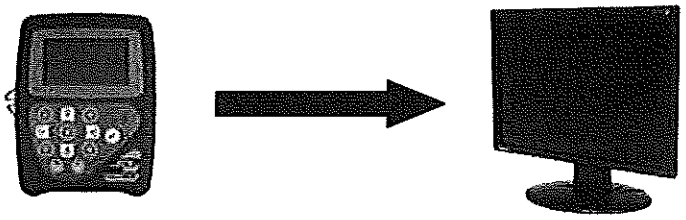


The Progress section indicates the status of the current process. For example, when starting up LSGAM, this will show you the activity of the software.

The Instrument section displays whether or not an instrument is connected. This also downloads the IDs, readings, and comments. If an instrument is found the following details are shown about the instrument:

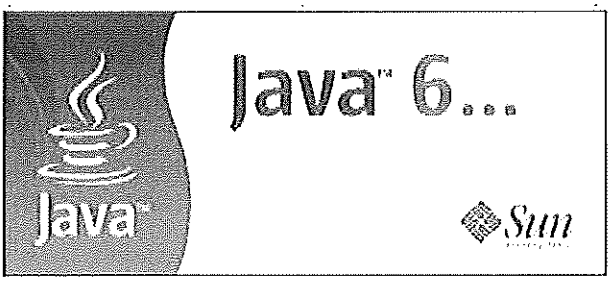


2.4 Connecting to the Instrument



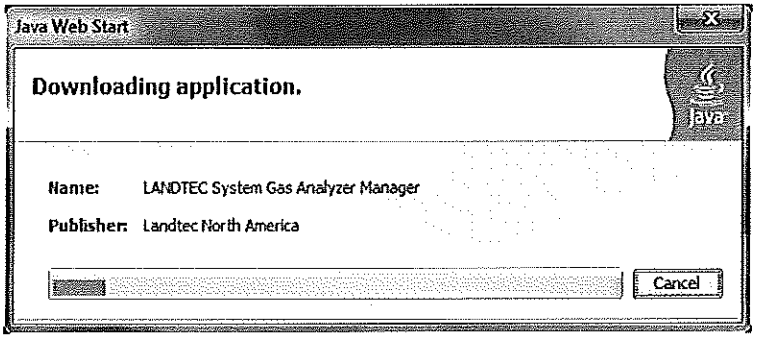
1. Connect the GEM2xxx with the USB or RS-232 Download Cable to your Computer
2. Instrument must be powered ON and in the Gas Reading screen
3. Launch the LSGAM software by clicking on the icon on your desktop

This is the first screen you will see when starting the program.



Once the software is installed on your computer with an internet connection this instrument communications program has Auto application updates. This enables you to always have the most current version of the instrument communications LSGAM.

If an update to LSGAM is available, <u>you will see this notice when connected to the internet</u>.

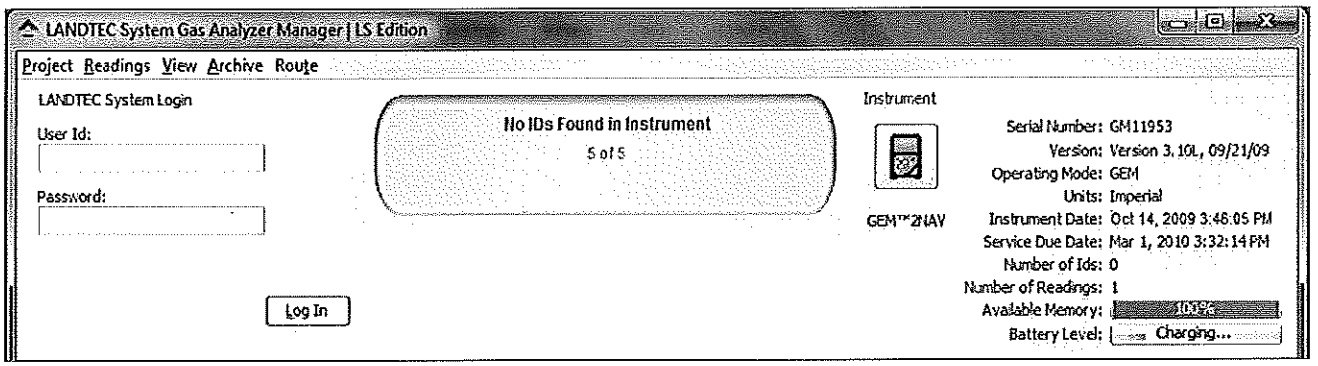


Click on OK this will return you to the desktop and you will then need to click on the LSGAM shortcut again.

The GEM2xxx must be connected to computer and turned ON. It must also be in the Gas Reading screen. The LSGAM software will automatically download any information in the instrument including readings, comments and IDs.

Note: Connection of instrument to computer should not be perfomed in a hazardous area.

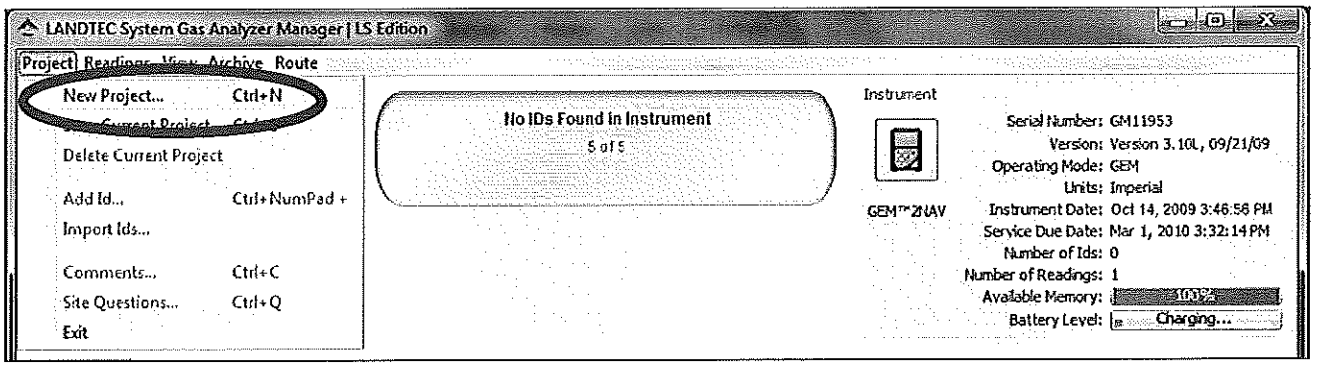
A new instrument containing no information will display only the instrument information: Serial Number, Version, Operating Mode, Instrument Date, Service Due Date, Number of IDs, Number of Readings, Available Memory, and Battery Level.



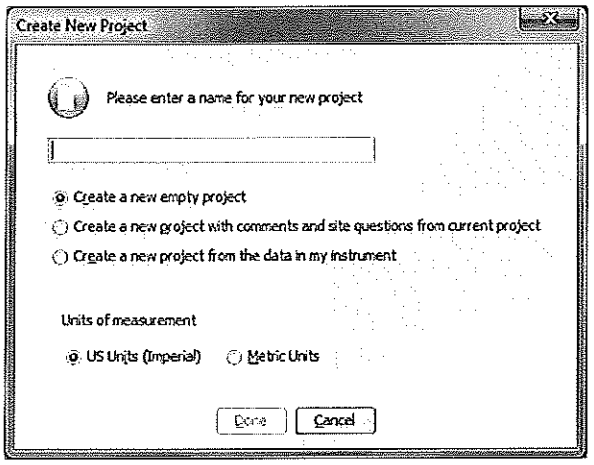
2.5 *Create a Project / Select a Project*

Projects are a collection of Device IDs and their associated reading history. A project can be created using LSGAM to contain a group of sequenced IDs and chronological history of instrument readings.

To create a Project, click on the Project menu and select New Project.



Upon selecting **New Project...** you will be prompted to enter a Project Name and select from one of three options.



Create a New Empty Project
This option creates a blank project where you configure all IDs and Comments.

Create a New Project with comments and site questions from a Current Project
Selecting this option allows the user to create a new project that will have the same Comments and Site Questions as an existing project.

Create a New Project from the data in a GEM2xxx instrument
This option will create a New Project and automatically associate the IDs, Comments, and Site Questions that exist in the connected portable instrument.

2.6 ID Setup

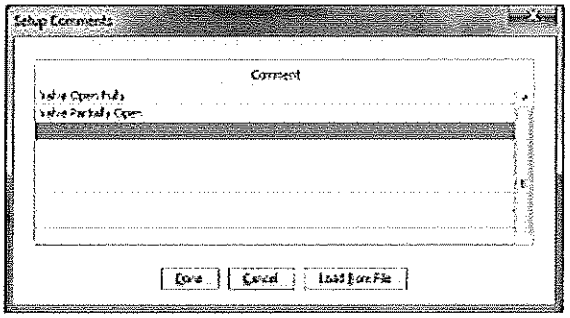
An ID represents a physical sampling point in the field. An ID can be allocated to field components such as extraction wellheads, gas transmission lines, or passive monitoring probes. LSGAM allows users to configure an ID for each sampling point in order to obtain accurate readings with LANDTEC portable instrumentation

IDs are created, modified, and removed from the Project Setup tab in the software.

2.6.1 Creating Comments

Comments should be setup prior to creating new IDs. The user can define Comments that can be associated with a reading in the portable instrument.

If you selected Create a New Project, when creating your project, you will need to click on the Create Comments button. Comments can be entered in this setup screen or loaded from a file and will be displayed in the user interface.



Typical Comments Might Include
Valve Fully Open
Valve Partially Open
Valve Closed
Air Leak in Wellhead
Water Blockage in Header
Surging at well
Sample Port Needs Replacement
More Vacuum Needed
5 Day Recheck

2.6.2 Creating IDs

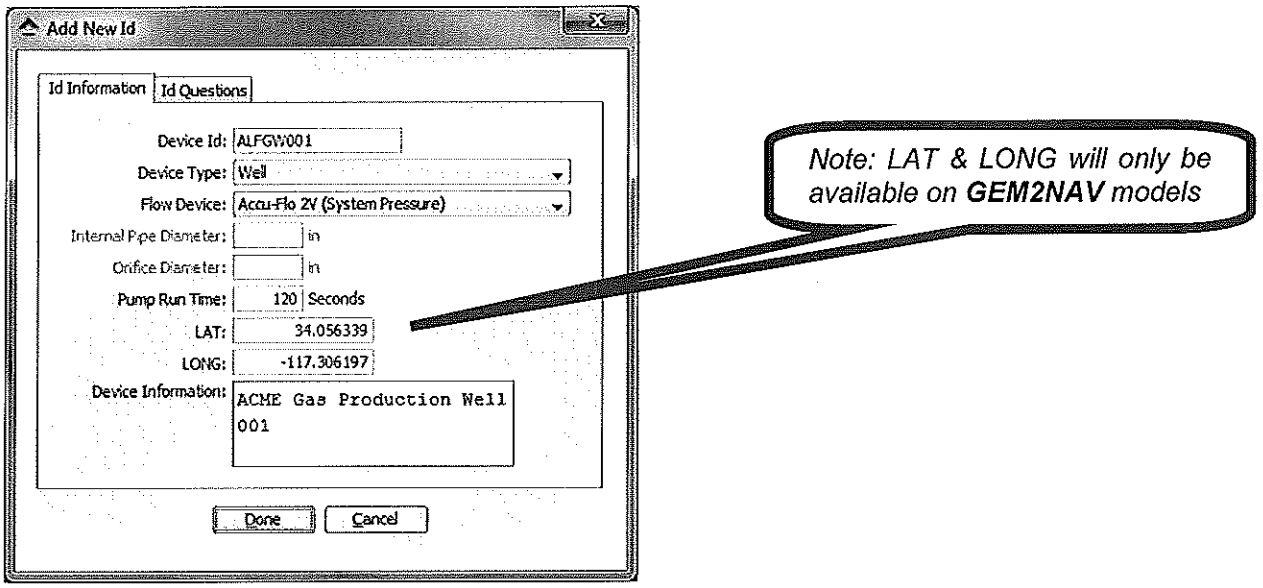
There are several ways to input IDs to the Project. The following describes each process:

Creating new IDs with LSGAM

To create a new ID using the LANDTEC System Gas Analyzer Manager, Right Click on the left ID pane beneath your active project and select the Add New ID option.

The Add New ID form will be displayed. From the ID Information tab of this form, entry of the following is

available:



ID INFORMATION

Device ID: Must be eight (8) alphanumeric character spaces. (For example, ALFGW001)

Device Type:

- Well: An active gas extraction well connected to a piping network which may require a flow rate reading.
- Sample Port: A sample point along a gas transmission line that may require a flow rate.
- Probe: A passive gas migration monitoring probe that does not require a flow rate.

The GEM2xxx calculates flow rate values specific to each device type (listed above). The available flow devices programmed in GEM mode are listed below.

Flow Devices:

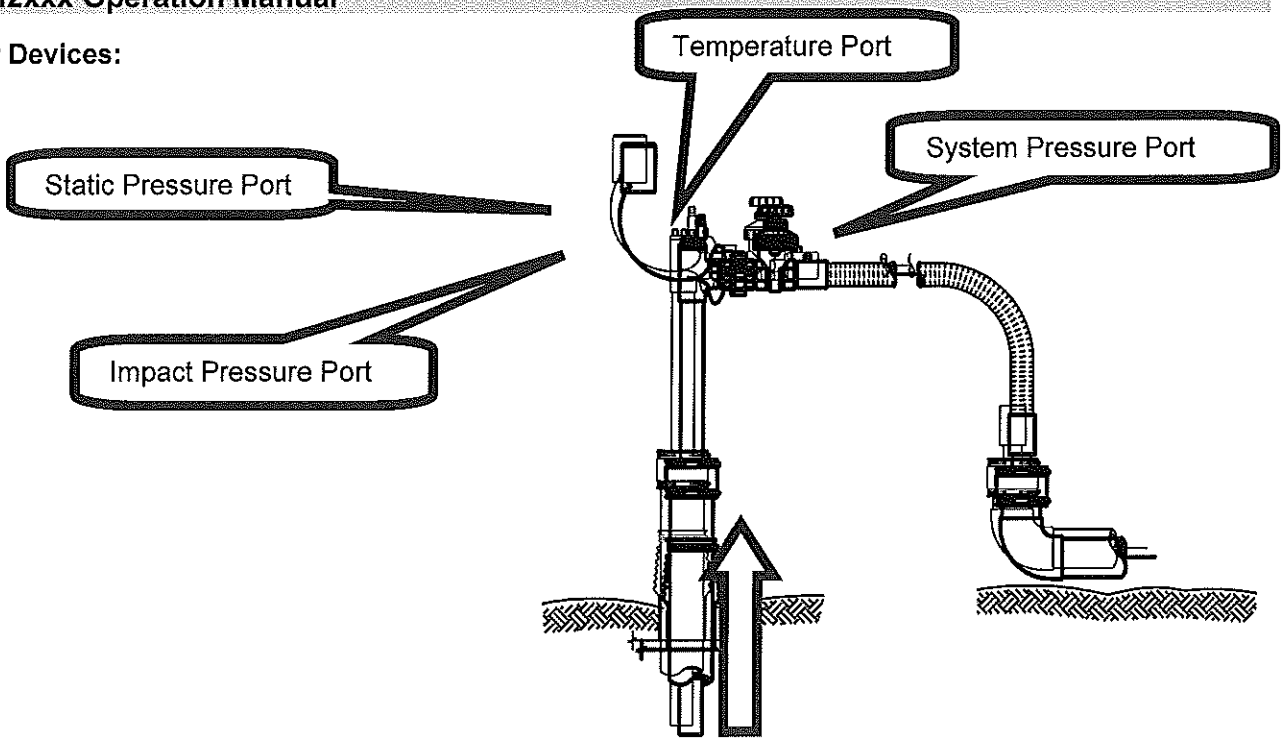


Figure 1 - ACCU-FLO Vertical Wellhead

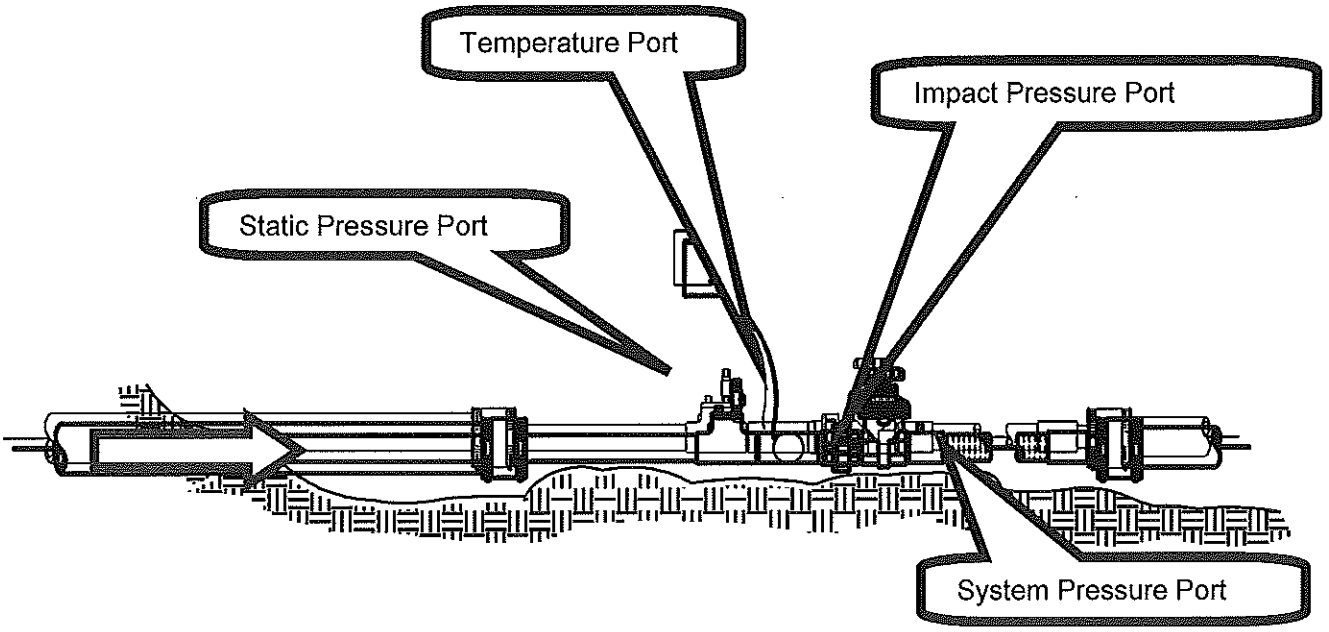


Figure 2 - ACCU-FLO Horizontal Wellhead

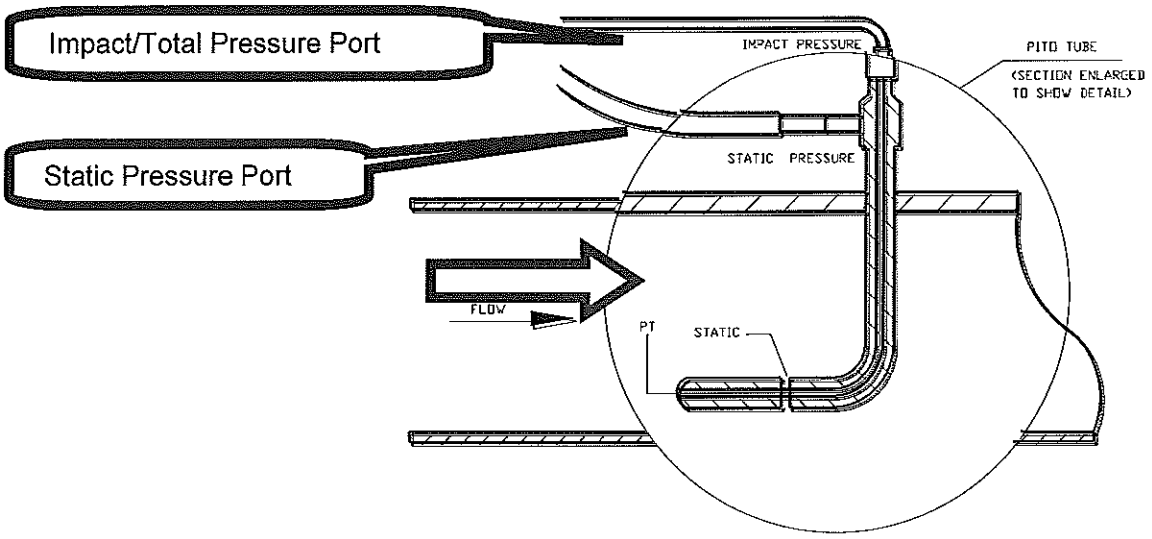


Figure 3 - Pitot Tube

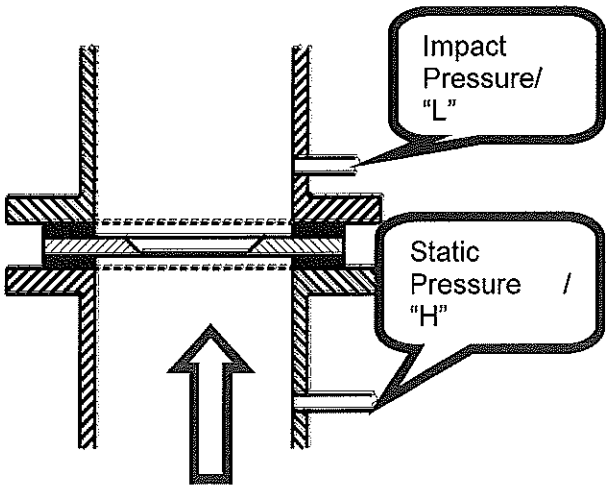
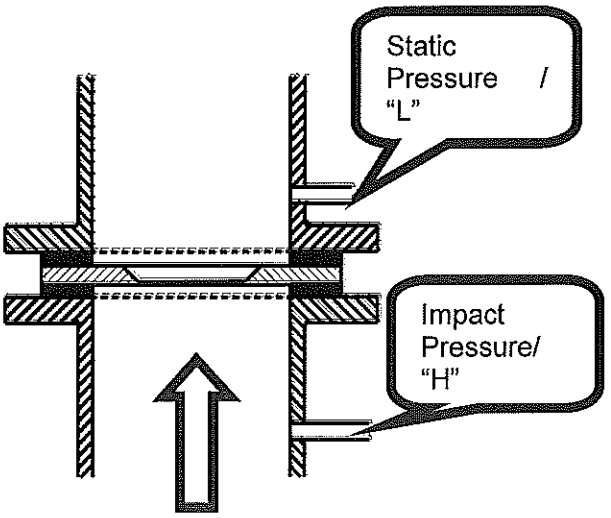


Figure 4 - Orifice Plate (WellSide)



Orifice Plate

Flow Device Name Programmed in GEM	Orientation	Size	System Pressure
ACCU-FLO 1.5V	Vertical	1.5 inch	
ACCU-FLO 1.5H	Horizontal	1.5 inch	
ACCU-FLO 2V	Vertical	2.0 inch	
ACCU-FLO 2H	Horizontal	2.0 inch	
ACCU-FLO 3V	Vertical	3.0 inch	
ACCU-FLO 3H	Horizontal	3.0 inch	
Orifice Plate			
Pitot Tube			
User Input			
Orifice Plate WellSide			
ACCU-FLO-1.5V (System Pressure)	Vertical	1.5 inch	✓
ACCU-FLO-1.5H (System Pressure)	Horizontal	1.5 inch	✓
ACCU-FLO-2V (System Pressure)	Vertical	2.0 inch	✓
ACCU-FLO-2H (System Pressure)	Horizontal	2.0 inch	✓
ACCU-FLO-3V (System Pressure)	Vertical	3.0 inch	✓
ACCU-FLO-3H (System Pressure)	Horizontal	3.0 inch	✓
Orifice Plate-System Side (System Pressure)			✓
Pitot Tube (System Pressure)			✓
User Input (System Pressure)			✓
Orifice Plate WellSide (System Pressure)			✓

Pipe Diameter: The pipe inside diameter (ID) is required for Orifice Plate and Pitot Tube type flow devices.

Orifice Diameter: The field for orifice bore diameter is available for all Orifice Plate flow devices.

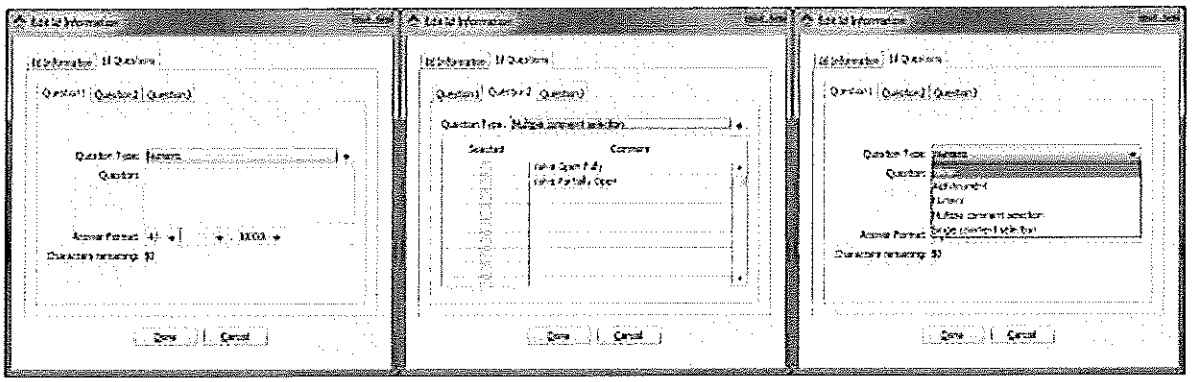
Pump Run Time: Indicates the duration the instrument's pump will run while sampling for the selected ID.

Device Information: Allows the user to enter general information for the device. This will display on the screen of the instrument if the user chooses the ③ View ID Details option from the ID selection screen on the instrument.

ID QUESTIONS

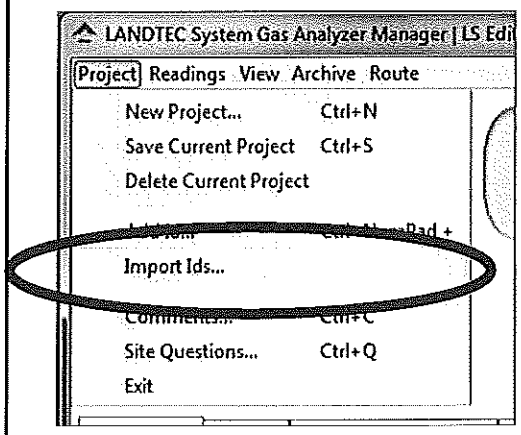
There are 5 Question Types that can be selected:

- **None -** No question will be prompted to the user
- **Alphanumeric -** An alphanumeric answer can be entered when taking a reading
- **Numeric** - A numeric only answer can be entered when taking a reading
- **Multiple Comment selection -** Up to 8 comments that may be appropriate for this device ID can be selected in the ID setup. Then one or all of the comments can be selected when taking a reading.
- **Single comment selection -** Up to 8 comments that may be appropriate for this device ID can be selected in the ID Setup but only one comment can be selected when taking a reading. Comments related to valve position are often used with a Single Comment Selection because the valve can only be in one position.

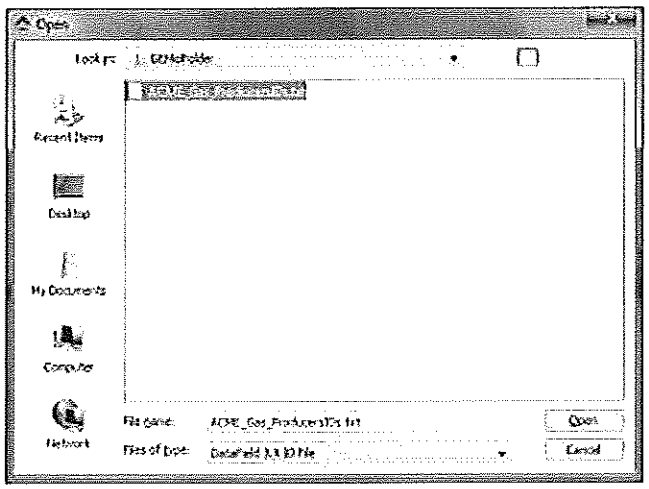


Importing DataField CS IDs

If you have existing ID files from DataField CS v3.2.x, these files can be imported by LSGAM. To begin this operation select the ***Import IDs...*** option from the ***Project*** menu.

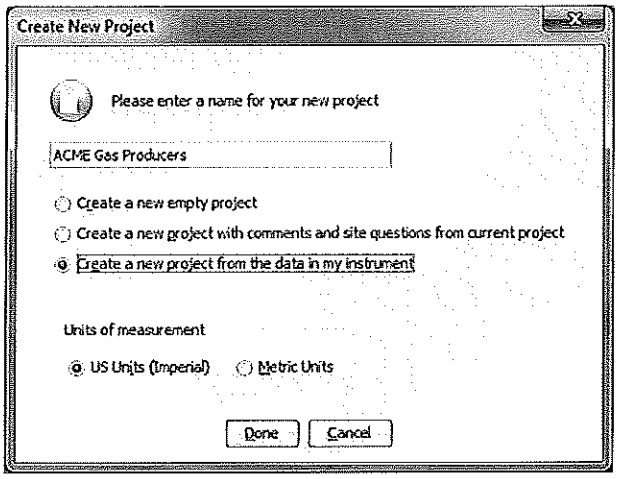


Select an ID file generated by DataField CS v3.2.x.



2.6.3 Create a new project based upon IDs ALREADY IN THE INSTRUMENT:

To create a Project based on the information in the instrument, select ***Create a new project from the data in my instrument***.

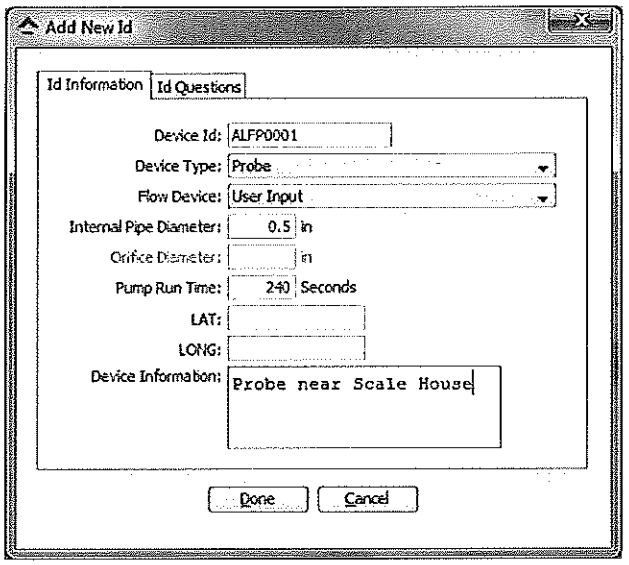


Note: When using the Creating a new project from the data in the instrument option, only IDs NOT associated with other projects will be created into the new project.

Creating a Device ID that does not measure flow Example- Probe or Sample Port

If there is no flow device you will choose User Input. When choosing the User Input option you will need to enter the appropriate pipe inside diameter and pump run time.

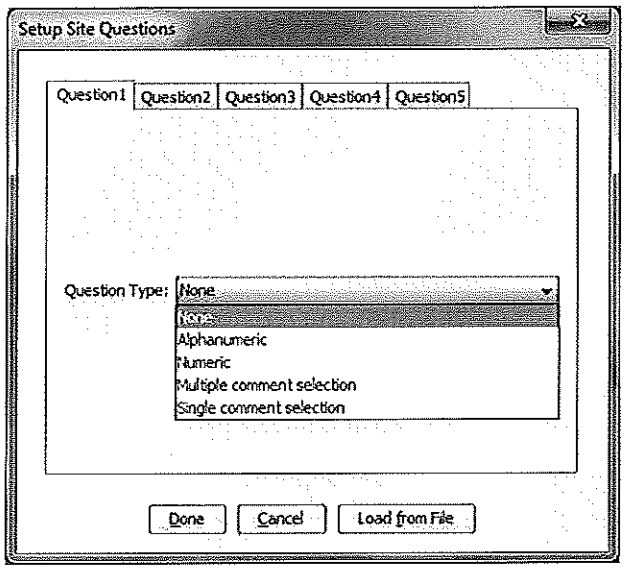
This ID is then generally sent to the GA mode [Landfill Gas Analyzer] of the instrument. Because this mode of the instrument does not read flow will not show the pressure readings screens that are in the GEM mode for vacuum and impact pressures.



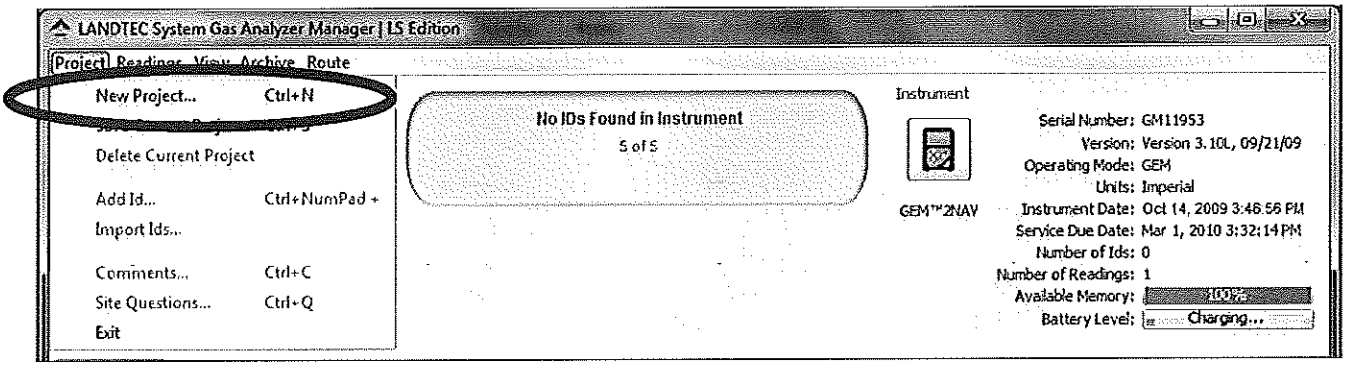
2.7 *Creating your Site Questions*

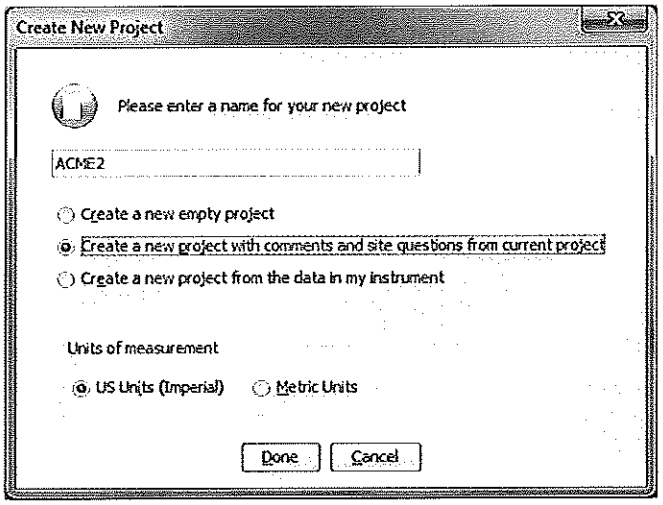
Site questions are setup in the same manner as ID questions however unlike ID questions, the answers for Site questions will apply to all subsequent readings until the site question is updated. A total of 5 site questions can be sent to your instrument. These must be updated each time you use the GEM. This is done by going to the ① Menu selection on the instrument and choosing [Update Site Data]

The options for questions are Alphanumeric – Numeric – Multiple or Single comment selection.



These Site Questions may be used again with another project by selecting the Create New Project and create new project with comments and **site questions** from current project.

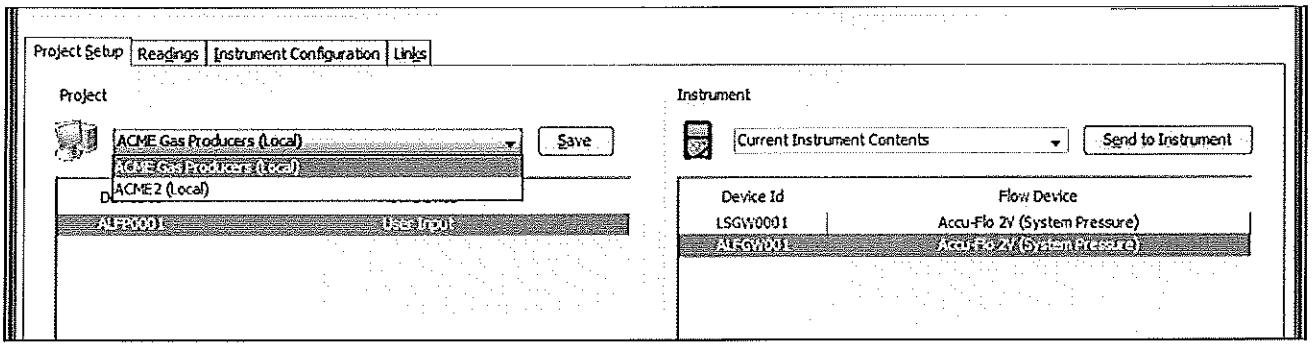




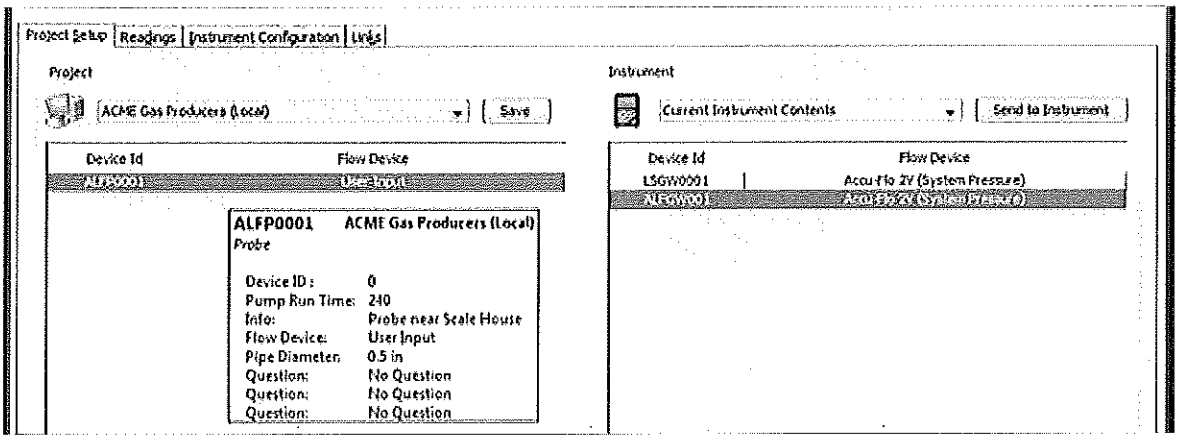
The project will be created and the IDs, Comments, and Site Questions that exist in the instrument will be applied to the new project.

Working with Device IDs

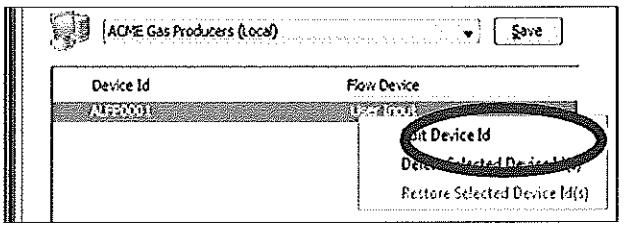
Once some IDs are added to your project you may need to occasionally edit them or reference them. First select the project which you want to work with from the project drop down list.



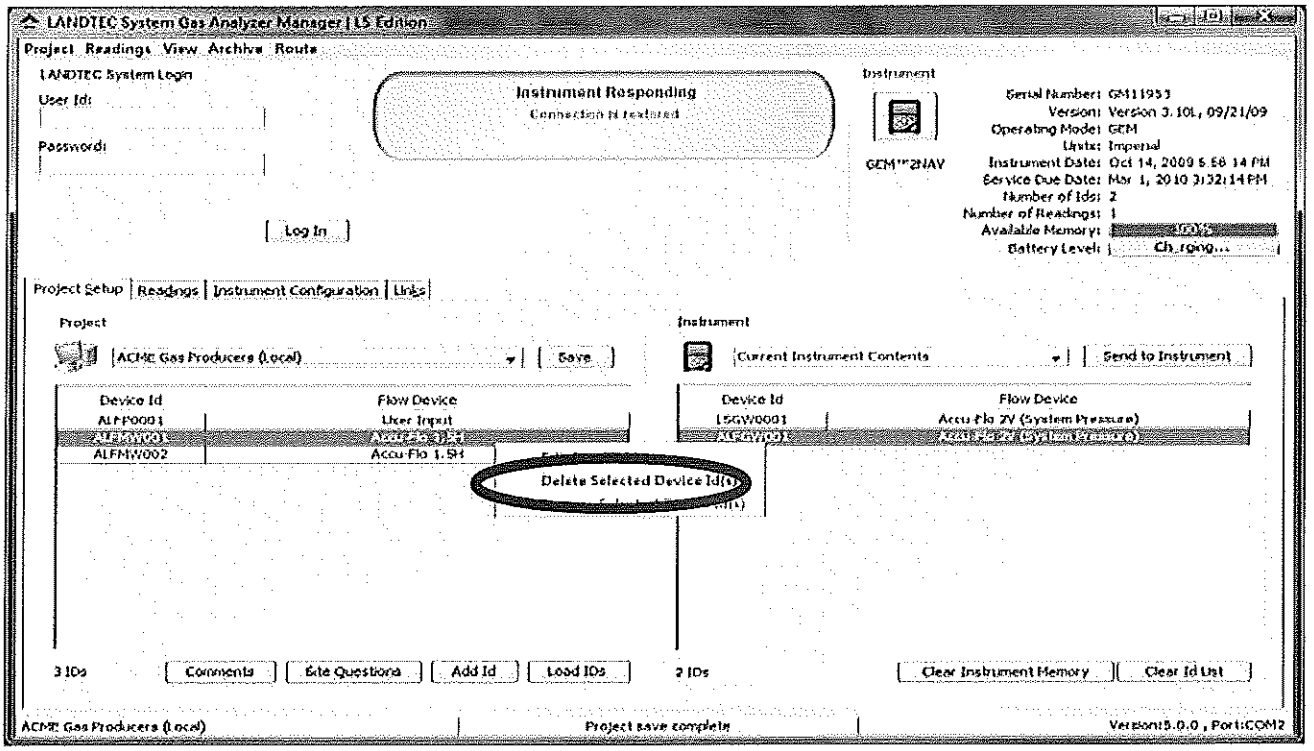
Placing the mouse cursor over a specific device ID will show detailed information about that ID.



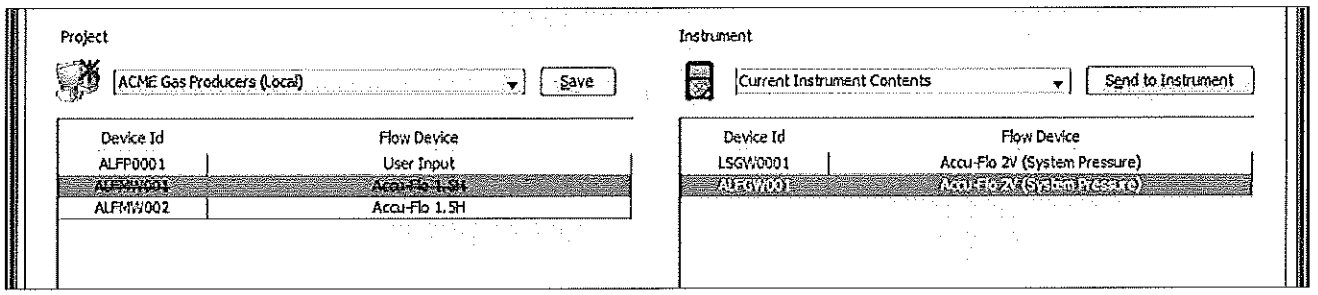
To edit a Device ID, right click on the desired device and select ***Edit Device ID***.



To delete an existing ID, right click on the desired device and select ***Delete Selected Device ID(s)***.



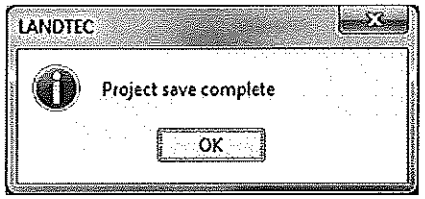
Upon clicking on Delete Selected Device Id(s) you will see the line ~~strikeout~~.



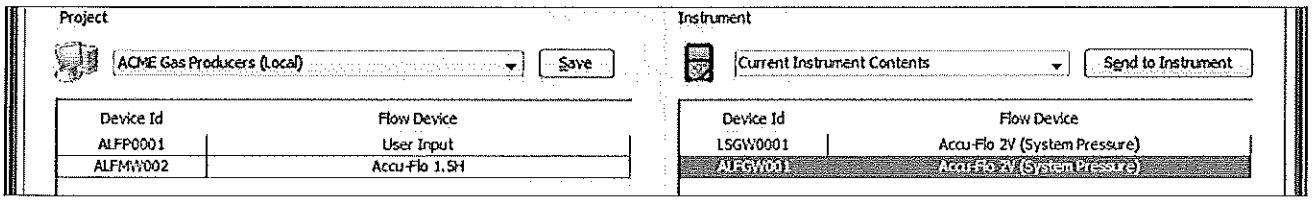
The computer Icon will now display a red * over the image. This indicates that the IDs are NOT saved. Deleted IDs are displayed with a line through the information on the screen. To restore a deleted ID, right click on the ID and click ***Restore Selected Device ID(s).***

Note: Deleted ID's can only be restored while the project state is unsaved. Once saved, the ID changes are saved and restoration cannot be completed.

Once all work with the device ID's is complete, click on the Save button.



After clicking on OK, the device is removed and the computer icon returns to the unaltered state.



2.8 *Sending IDs to the instrument*

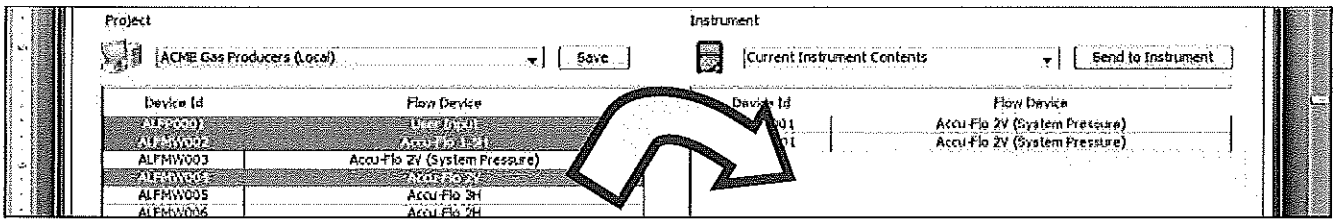
Once IDs have been created in the project, they must be uploaded to the instrument. To perform this operation, select the desired IDs from the left hand table under the Project name (computer side), left click and hold while dragging the IDs to the right hand table and release the mouse button. This is action is know as a "Drag & Drop".

Three basic methods of selecting IDs exist.

- Select Specific ID(s)
- Select a Range of IDs
- Select All IDs

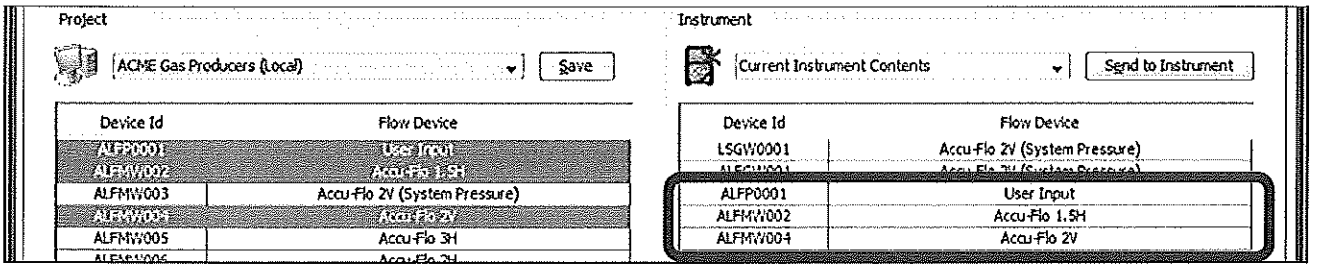
Specific IDs

To Select Specific List of IDs, place the mouse arrow at the edge of the first cell and hold down the left Ctrl key. Now click the next ID cell that you wish to select. Repeat this as many times as necessary.

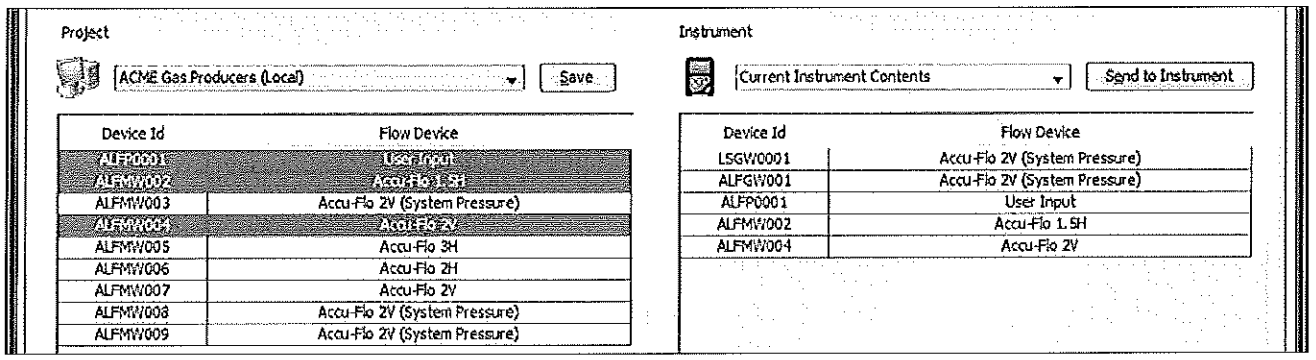


Selected IDs (shown as Highlighted). Arrow depicts "Drag & Drop" action after selection.

Now "Drag & Drop" the IDs from the left (computer window) to the right (instrument window). During the "Drag &Drop" process, the arrow will change to .



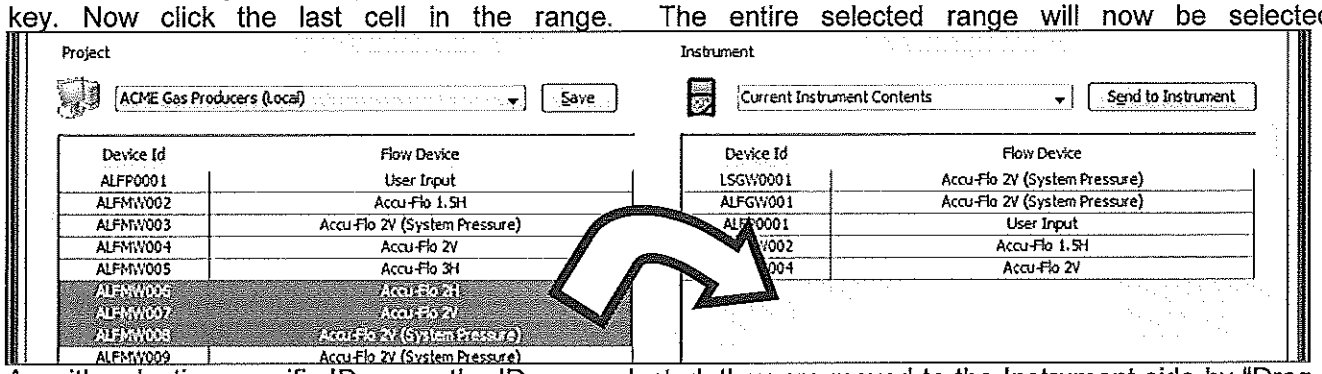
The selected IDs ALFP001, ALFMW002, and ALFMW004 now appear on the Right (Instrument) side. At this point the IDs are on the Instrument side but have NOT been sent to the instrument. The instrument with the red * indicates this unsent ID state. Click on the Send to Instrument button to send these IDs to the instrument.



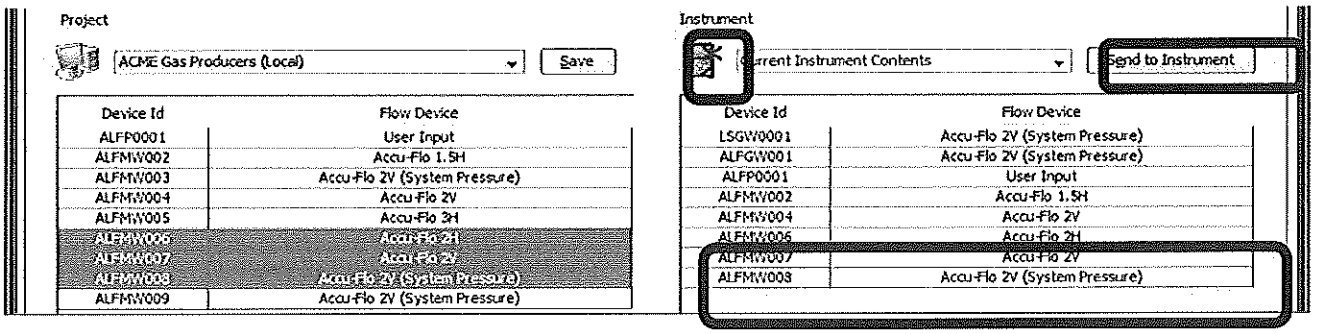
After the IDs are sent to the instrument, the instrument will appear without the red *

Range of IDs

To Select A Range of IDs, place the mouse arrow at the edge of the first cell and hold down the left shift key. Now click the last cell in the range. The entire selected range will now be selected.



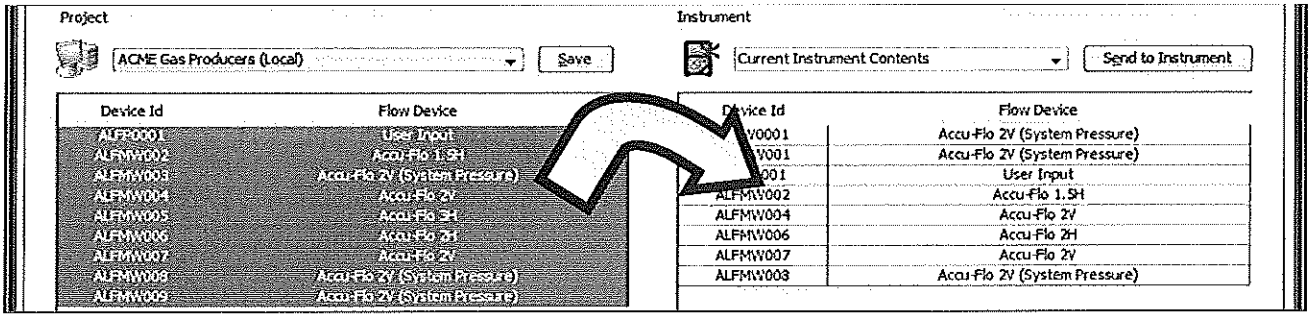
As with selecting specific IDs once the IDs are selected, they are moved to the Instrument side by "Drag & Drop". The Instrument icon will appear with a red * and the ID's will need to be sent to the instrument.



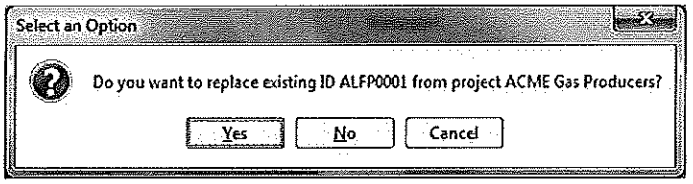
Click on the Send to Instrument button [Send to Instrument] to send these IDs to the instrument.

Selecting All IDs

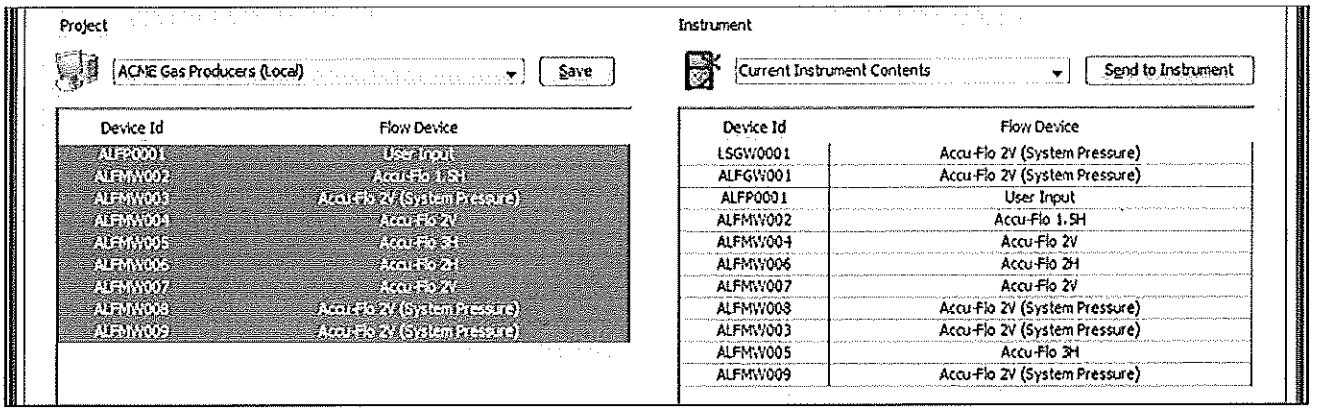
All IDs can be selected by selecting one ID in the Project window and then pressing Ctrl-A.



Now move IDs from the Project Side to the Instrument Side by dragging and dropping them.

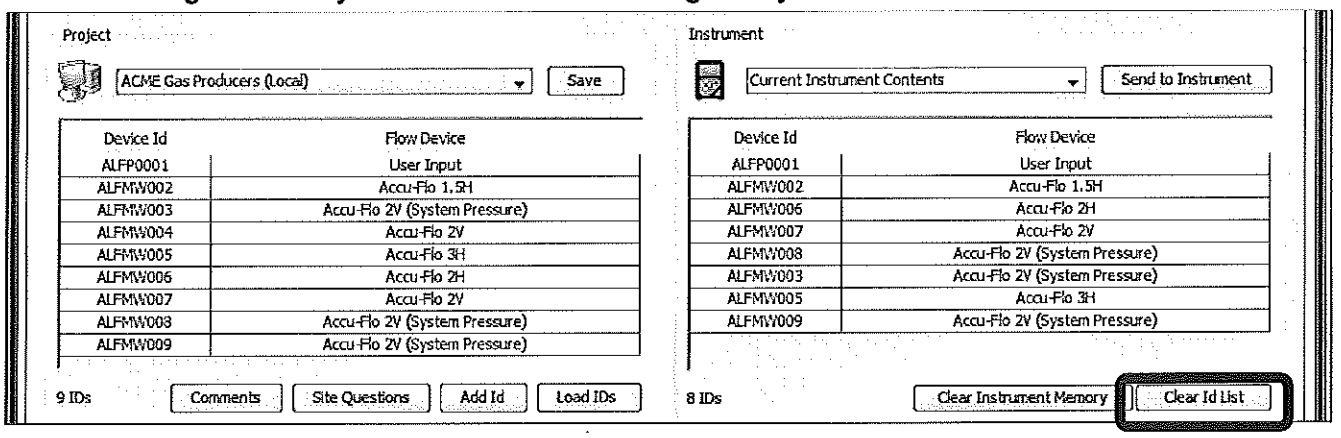


If you are dragging and dropping an ID that is already on the instrument side, you will be prompted with the above message. Answer Yes to update the IDs on the instrument side from those on the computer side. Answer No to ignore IDs that are already in the instrument. Answer Cancel to cancel the action without sending ID's to the instrument side.

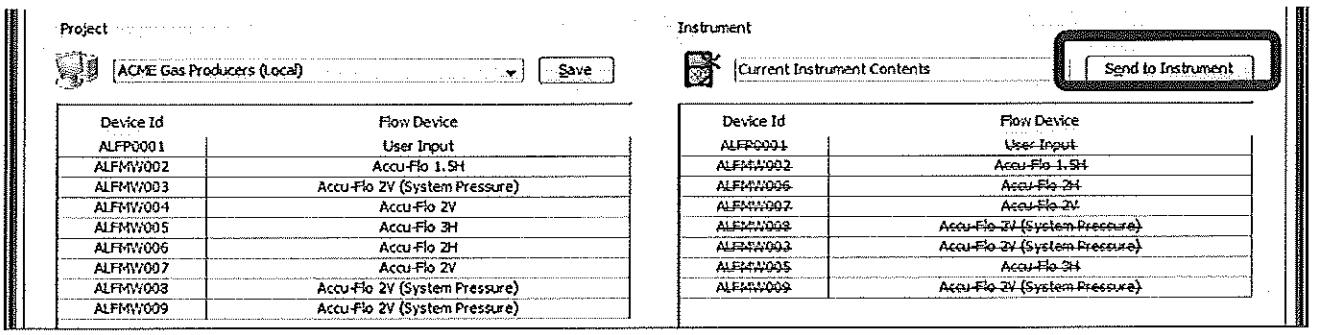


Click on the Send to Instrument button [Send to Instrument] to send these IDs to the instrument.

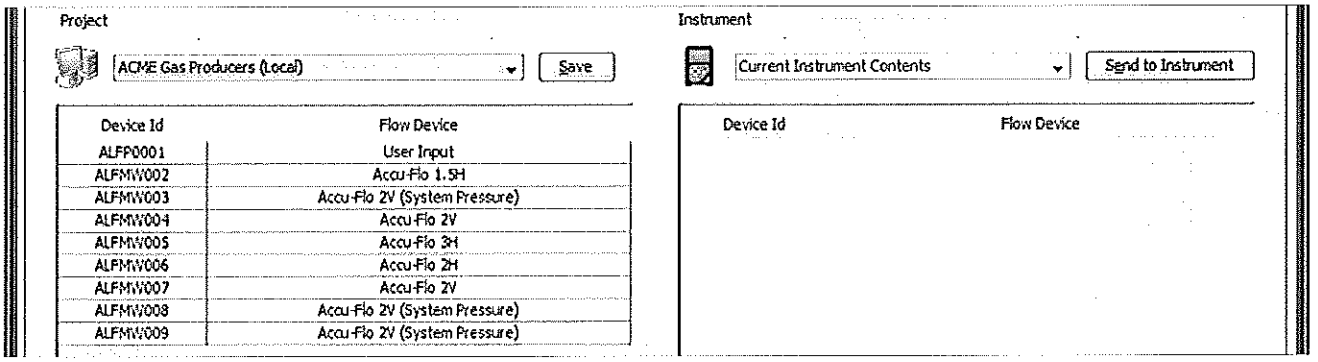
Clearing ID s from your instrument or Deleting a Project



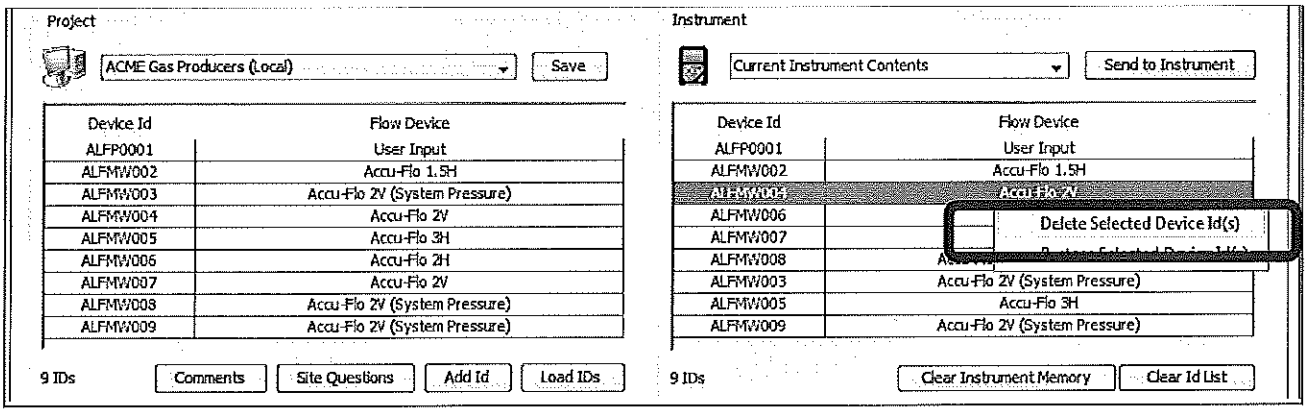
In current instrument contents when selecting the Clear ID List option it will draw lines through the IDS.



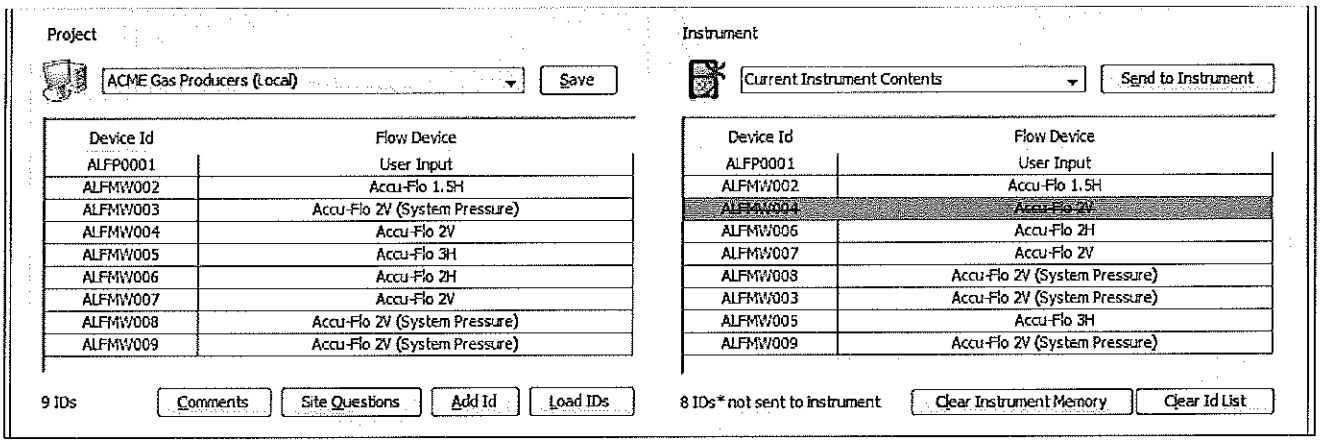
You then need to select ***Send to Instrument***. This will clear all IDs from the GEM2xxx in both the GEM and GA mode.



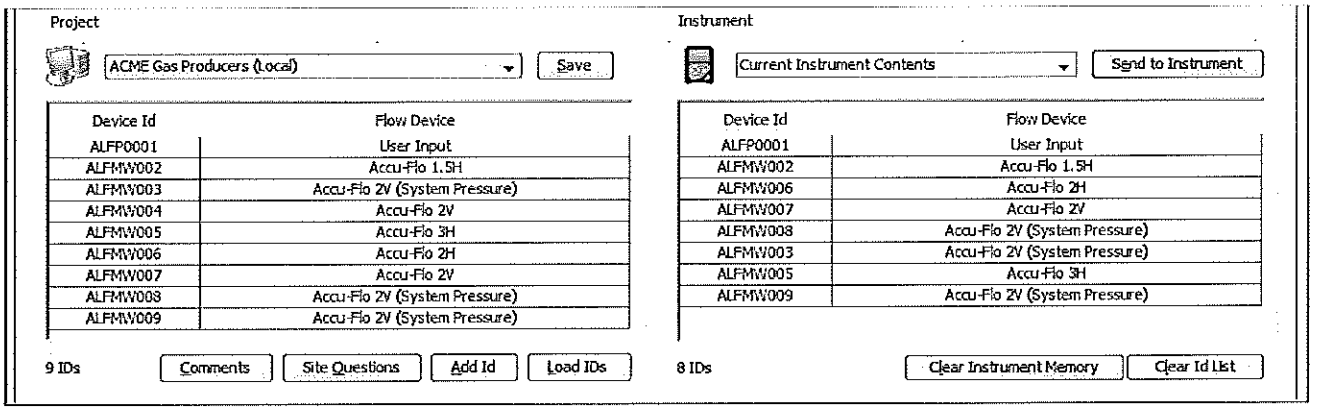
You may also delete one ID from a list by highlighting the ID RIGHT CLICK with your mouse and select the Delete Selected Device option. If you have selected the wrong ID and deleted then you may select the Restore option to return the ID to the list.



Upon selecting Delete Selected Device Id(s) you will see a ~~strikeout~~ line appear through the ID



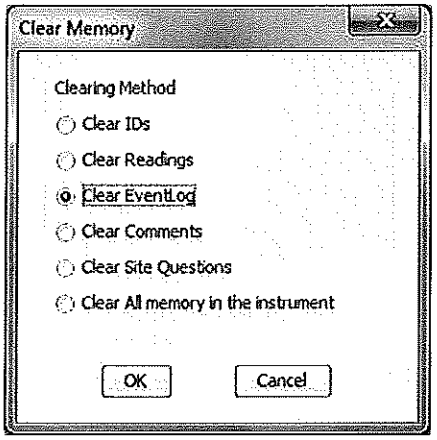
Click on the Send to Instrument button to send the ID corrections to the instrument.



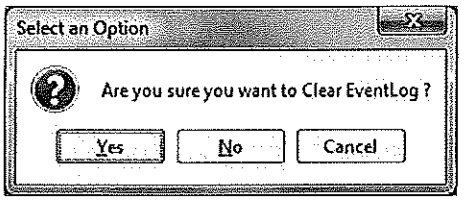
The instrument contents will now be updated and the ALFMW004 ID no longer shows in the instrument side of the list.

Clearing the Instrument Memory

The Clear Instrument Memory function allows various parts of the instrument's memory to be cleared. Upon clicking on the Clear Instrument Memory button the following options are available.



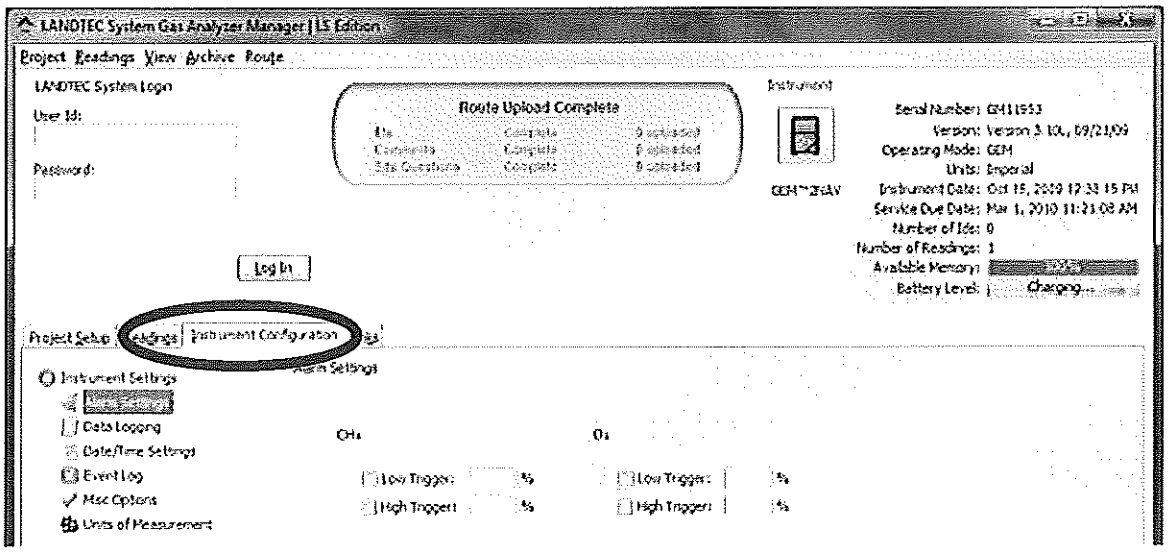
Please Note: Clear functions in the instrument affect both GEM and GA modes of instrument operation.
Upon selecting a memory type to clear, and clicking OK, a prompt will appear to confirm the selected action.



Answer Yes to perform the action.
Answer No or Cancel to return to the clear memory dialog.

2.9 Instrument Settings

The LANDTEC System Gas Analyzer Manager software allows users to change many of the operational settings of the instrument. To view and change the available settings click on the ***Instrument Configuration*** tab.

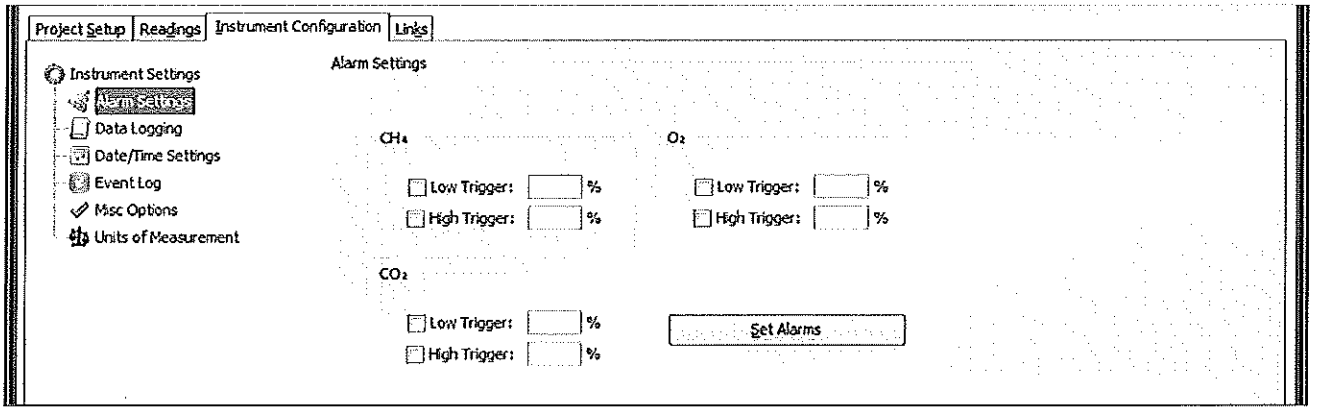


In the Instrument Configuration user interface, there is an Instrument Settings option tree. The Instrument Settings tree allows for easy navigation to the following categories:

- **Alarm Settings**
- **Data Logging**
- **Date/Time Settings**
- **Misc Options**
- **Units of Measurement**

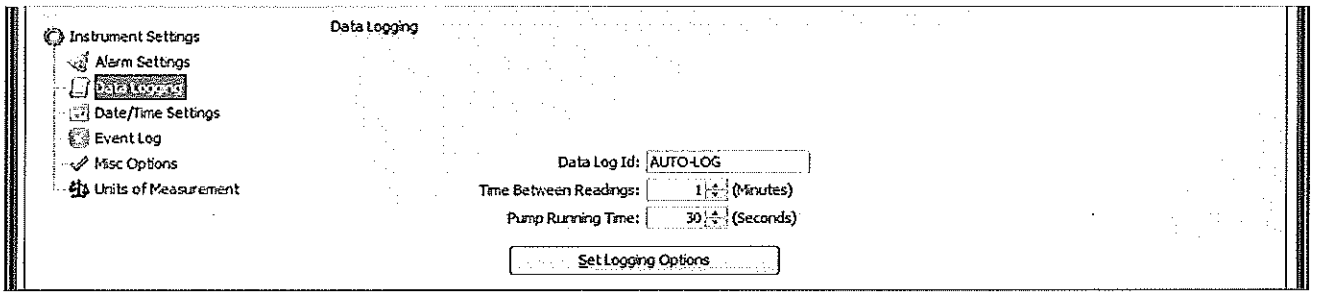
The following sections describe each option category.

2.9.1 Alarm Settings



The Alarm Settings options control the activation and deactivation of the audible alarms in the GEM2xxx instrument. Audible alarms can be configured for CH_4, CO_2, and O_2 parameters. Each parameter can be configured with a Low Trigger and/or High Trigger for the alarm. To activate any specific alarm, click and place a checkmark in the desired box. This will activate the entry field to place the value. The values must be 0 – 100 percent. When alarms are set, the instrument will beep and flash the parameter on the screen if an alarm threshold is surpassed when taking a gas reading.

2.9.2 Data Logging



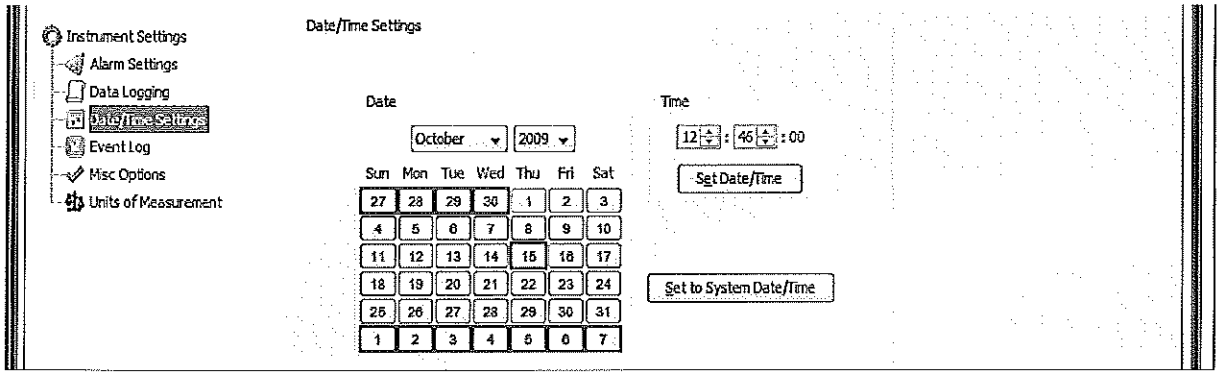
Note: This feature of the instrument is available in GA Operational Mode Only

Data Log ID
The Data Logging option allows the user to specify an ID to be associated to readings taken with the Auto-logging feature of the instrument.

Time Between Readings
This value indicates the time from when the pump stops running until the pump begins sampling.

Pump Running Time
This value indicates the duration the pump will be run for sampling.

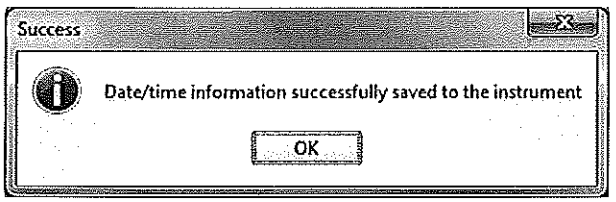
Date/Time Settings



The **Date/Time Settings** screen allows the user to set the date and time of the instrument.

Setting the Computer's Date and Time

To set the instrument's date and time to that of the computer, click on the Set to System Date/Time button.



Answer OK and the instrument's date/time will be set to that of the computer.

Date

Use the calendar options to select the desired date.

Time

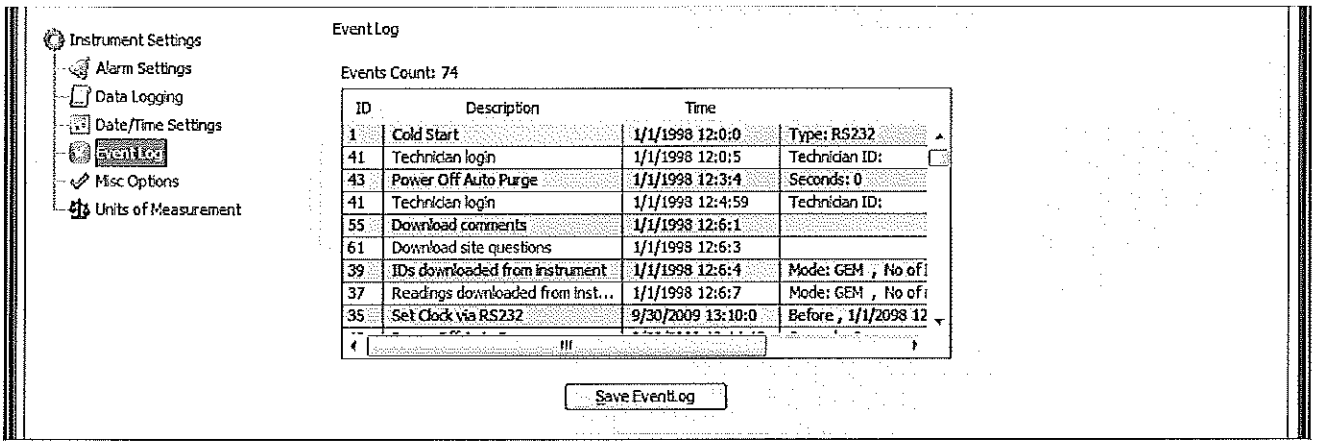
Use the up and down controls to select the desired hour and minutes.

Set Date/Time in the instrument

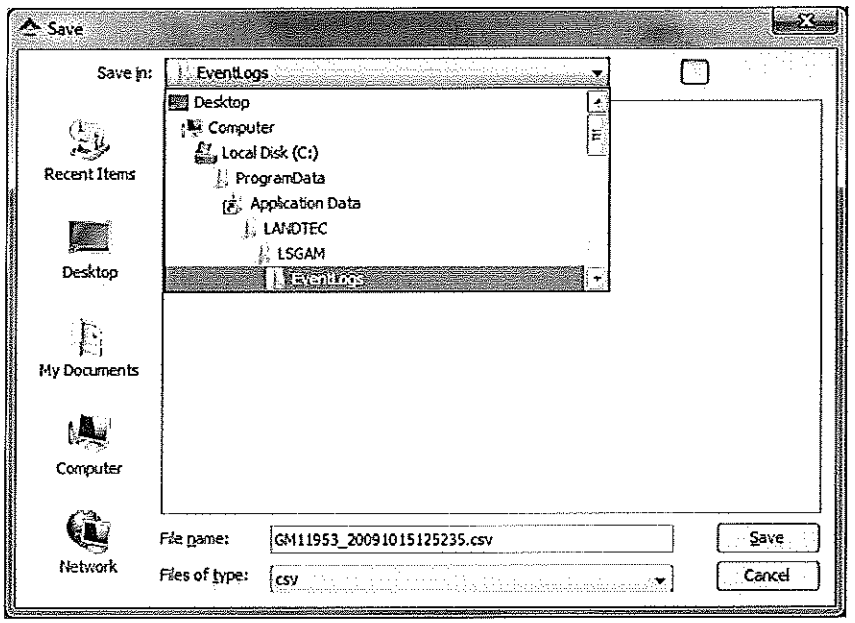
Click the Set Date/Time button to apply the settings to the instrument

Event Log

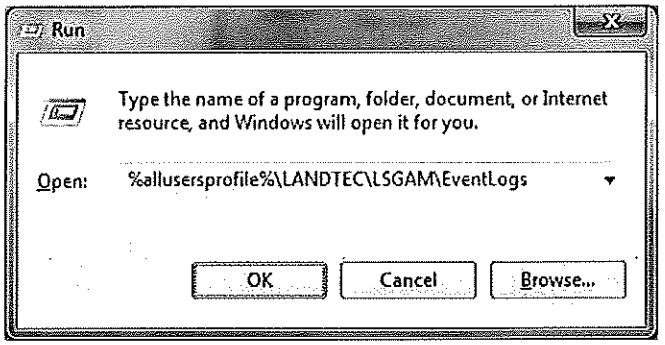
The instrument maintains an event log which records certain events that are not downloaded along with readings, IDs, or comments. In general, these events are useful for LANDTEC Service personnel when assisting in troubleshooting the instrument.



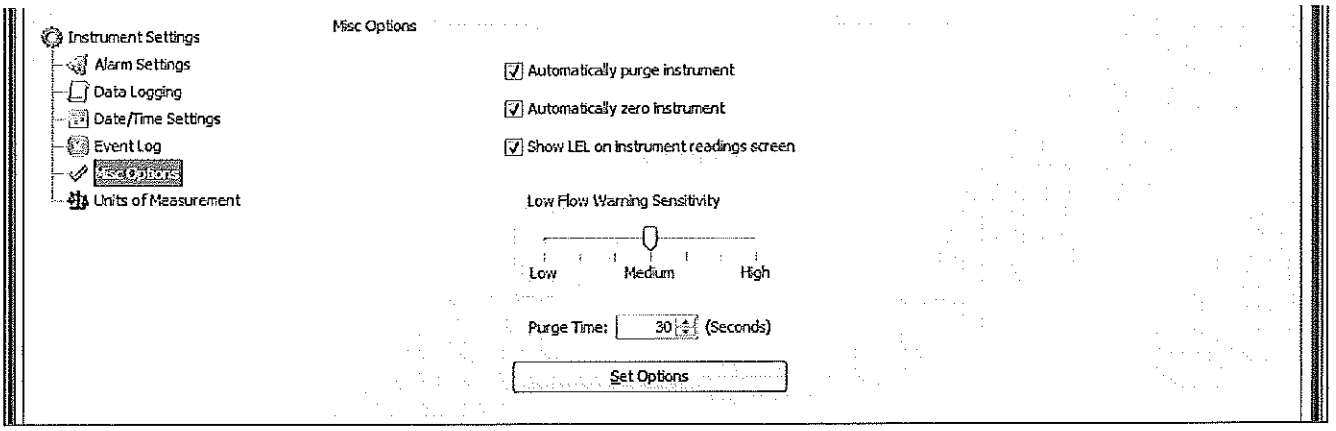
Clicking on the Save EventLog button will allow events to be saved from the instrument.



By default the location of the folder is the EventLogs for the data directory associated to LSGAM. This directory location changes depending upon your operating system but it can be found by typing the following in the Start Menu→Run box from windows.



2.10 Misc Options



Under the miscellaneous options interface the user can change the following instrument settings:

Automatically purge instrument
Activates and deactivates the automatic purge feature in the instrument

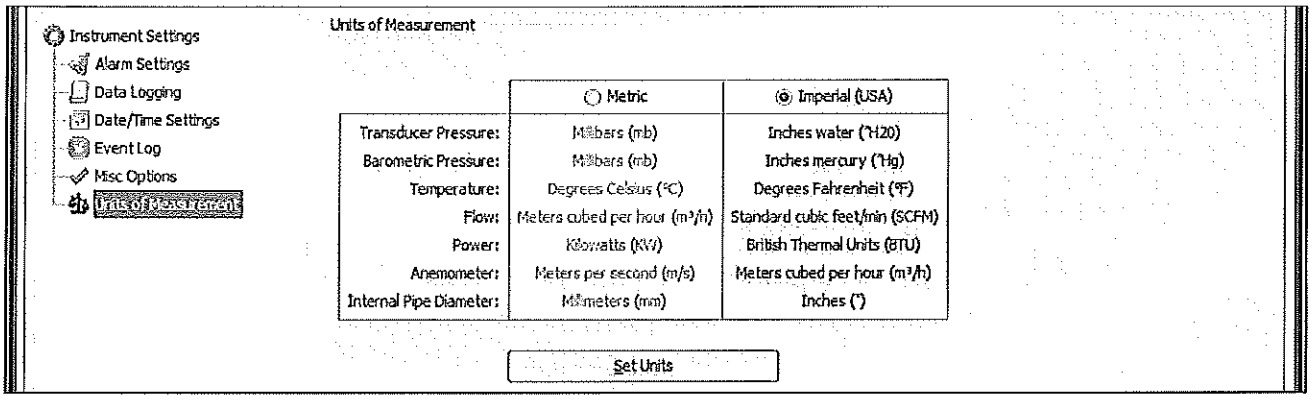
Automatically zero instrument
Activates and deactivates the automatic zero feature in the instrument

Show LEL on Instrument readings screen
Specifies whether or not Lower Explosive Limit (LEL) is displayed on screen, power instrument off and on for change to take effect.

Low Flow Warning
Specifies the point at which the instrument will "Flow Fail". If the instrument detects that it is not able to extract the appropriate gas flow for analysis the word "Flow" will flash in the upper left part of the screen where the pump timer is normally shown. If flow does not increase the pump will automatically be stopped. Adjusting the setting to "Low" will allow the pump to run with less flow going through the instrument. This may help avoid flow fail conditions when sampling from high vacuum systems.

Purge Time
Specifies the duration the pump will run when activated by the purge feature of the instrument.

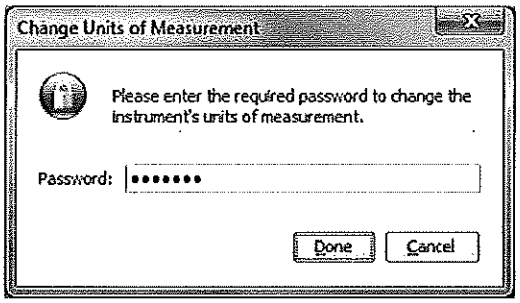
2.11 Units of Measurement



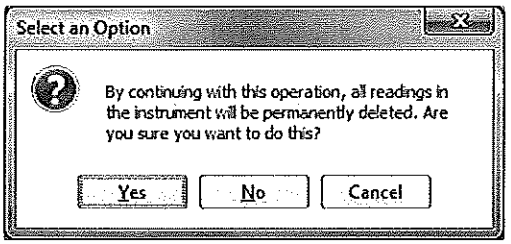
The Units of Measurement interface allows users to select whether to operate the instrument in metric or imperial units. The units for each parameter are displayed on the screen.

WARNING: *Units of Measure are as critical as the values of the readings stored. Be certain to verify the appropriate Units of Measure for your project prior to making a change to this option. Changing the Units of Measure will* ***NOT*** *convert any existing values stored in the instrument. To avoid confusion, download any stored readings prior the changing the Units of Measurement.*

Clicking on the Set Units button will bring up the Change Units Password box. I f you must change the units of measure please call LANDTEC's Software Support for a password.



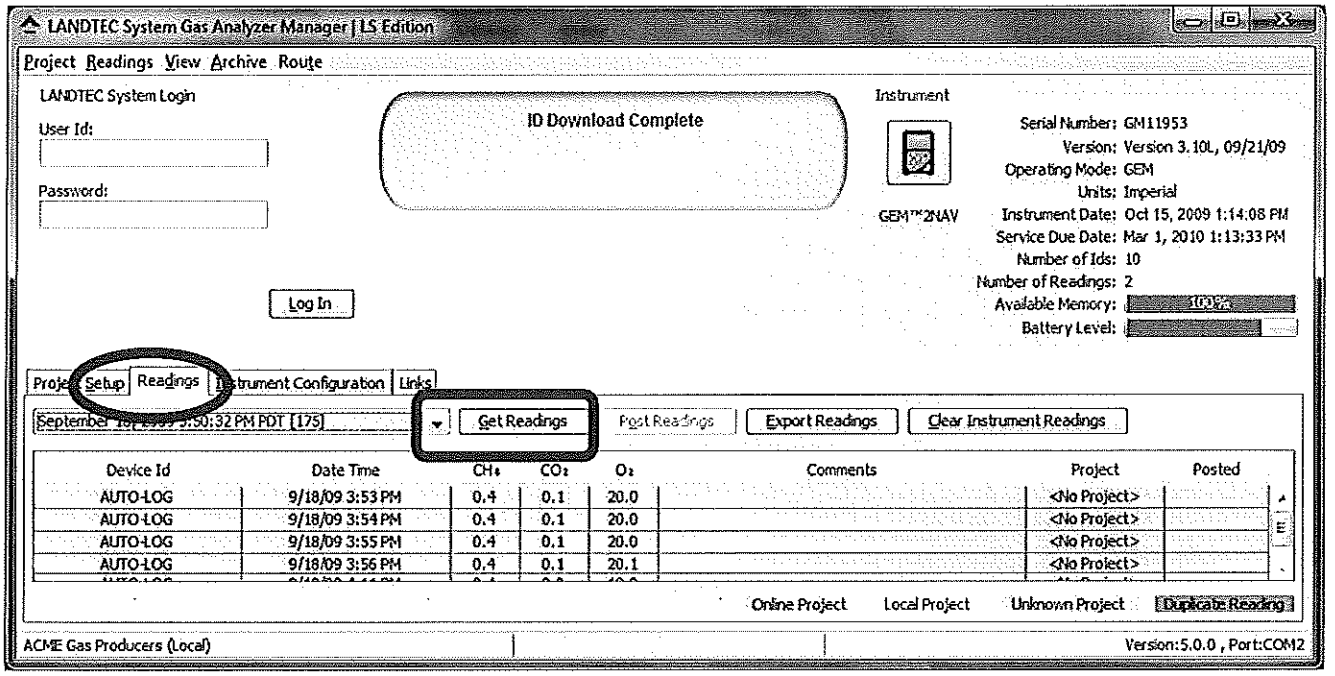
Upon entering the password you'll be prompted one last time to download your data from the instrument. If you have not downloaded your instrument press the No or Cancel buttons. Click Yes only if you have all data from your instrument as changing the units of measure must erase data that is in the instrument to ensure data integrity.



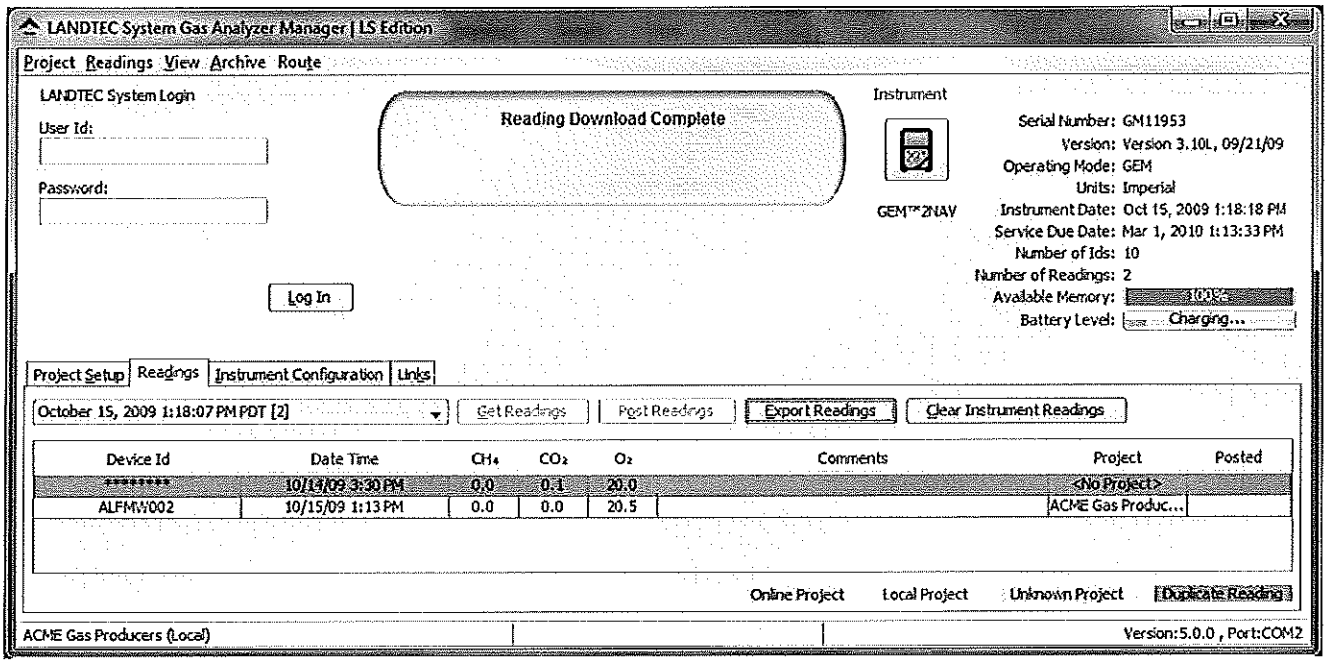
Downloading Readings

After successfully creating projects, IDs, and setting appropriate instrument settings, the instrument is ready for field use. When used in the field, ***readings*** are collected and stored within the instrument's memory. The readings consist of the measured, input, and calculated parameters such as CH_4, CO_2, O_2, Gas Temperature, Flow Rate, etc. These readings must be downloaded from the instrument to be reviewed on the computer and stored for review at a later time. This section of the Operation Manual reviews the process of downloading and storing readings from the instrument.

To view your readings from the instrument, select the Readings tab of the LANDTEC System Gas Analyzer Manager software. Then click on the Get Readings button

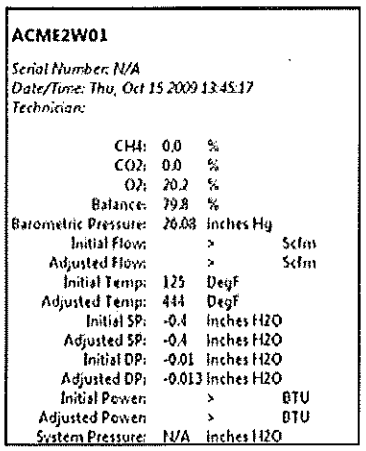


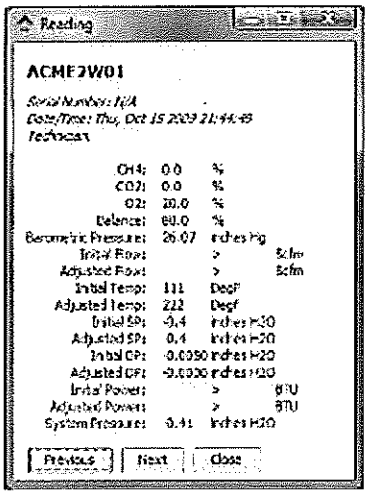
Note: Get Readings function only retrieves readings for the instrument's current mode of operation. If there are readings in both modes of operation (typically Probe Readings in GA mode and Well / Sample Port Readings in GEM mode) then Get Readings button will need to be pressed in each mode of operation to download all of the readings in the instrument.



When the instrument is initially detected by the LSGAM software, the Get Readings button will activate if there are readings in the instrument in the current mode of operation to be downloaded.

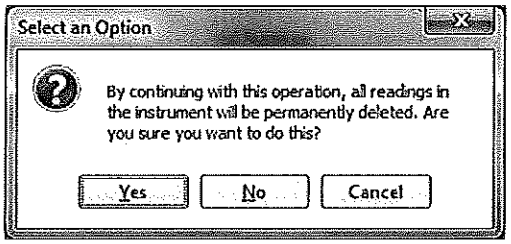
Placing your mouse over a reading will display additional parameters of the reading. As shown below on the left. Clicking on a reading will open a Reading details window and allow you to click through the readings one-by-one in detail by clicking the Previous and Next buttons.





Clear Readings

To clear the readings from your instrument, after the readings are downloaded successfully, click the ***Clear Instrument Readings*** button [Clear Instrument Readings]. A prompt will verify the permanent deletion of the readings from the instrument.

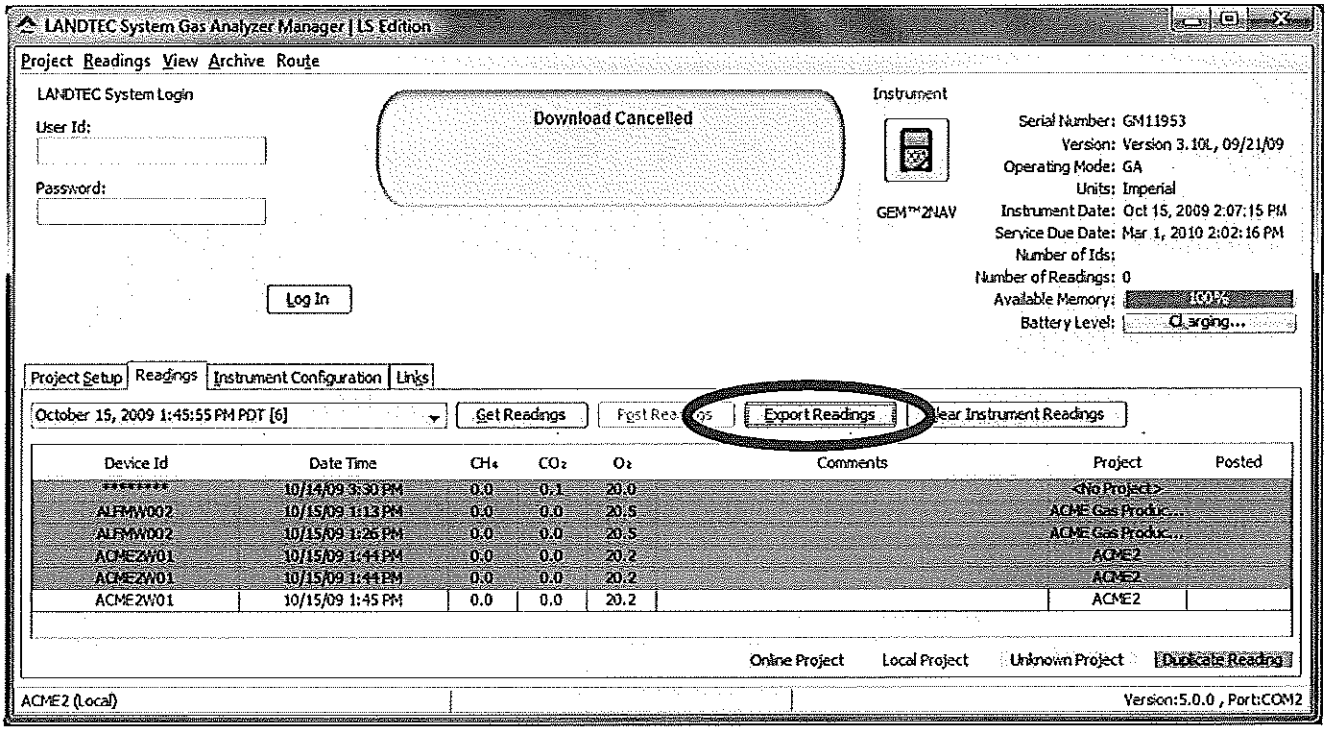


This will clear information within the GEM and GA Mode **simultaneously**.

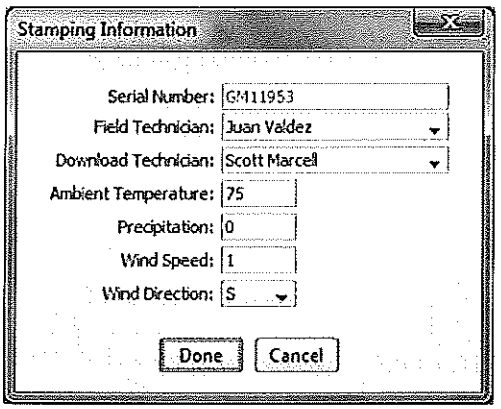
Note: Clicking yes will NOT check to ensure all data is saved from the instrument. If you plug in a GEM2xxx and click the Clear Instrument Readings button without first performing a Get Readings operation, data not previously downloaded will be lost!

Exporting Readings

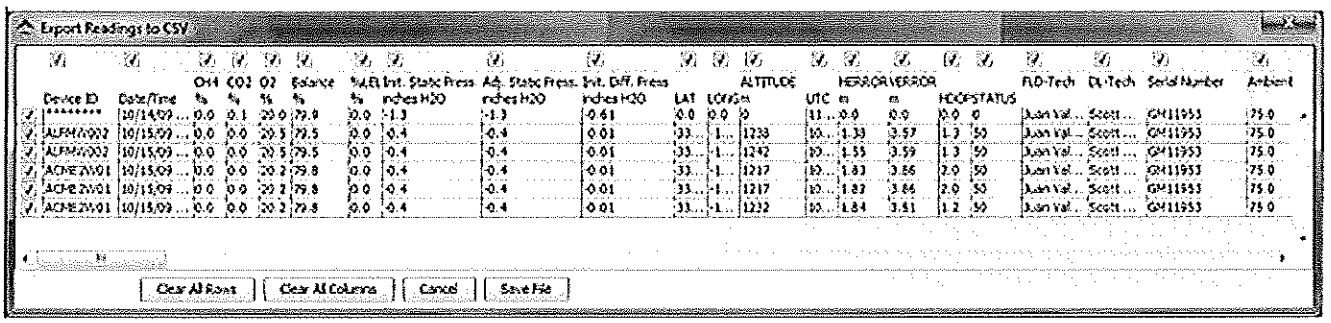
To export readings to a file, click the ***Export Readings*** button.



This will open the Stamping Information Screen. Stamping information are details that are most often stored with the historical data but not directly stored by the instrument. Detailed historical Stamping Information can assist when reviewing the data as atmospheric conditions do impact a gas system's production performance.



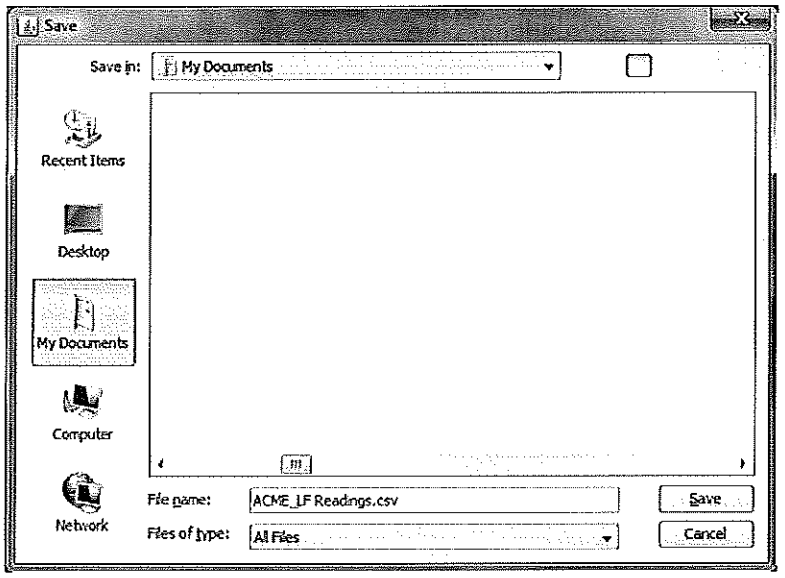
Clicking on Done will open the ***Export Readings to CSV*** screen.



Note: Depending upon your specific GEM2xxx Instrument model you will see additional fields specific to the instrument. For example GEM2NAV has the fields of Latitude, Longitude, Altitude, Herror, Verror, and HDOP Status that the other GEM2xxx models do not have.

This interface provides several options described below.

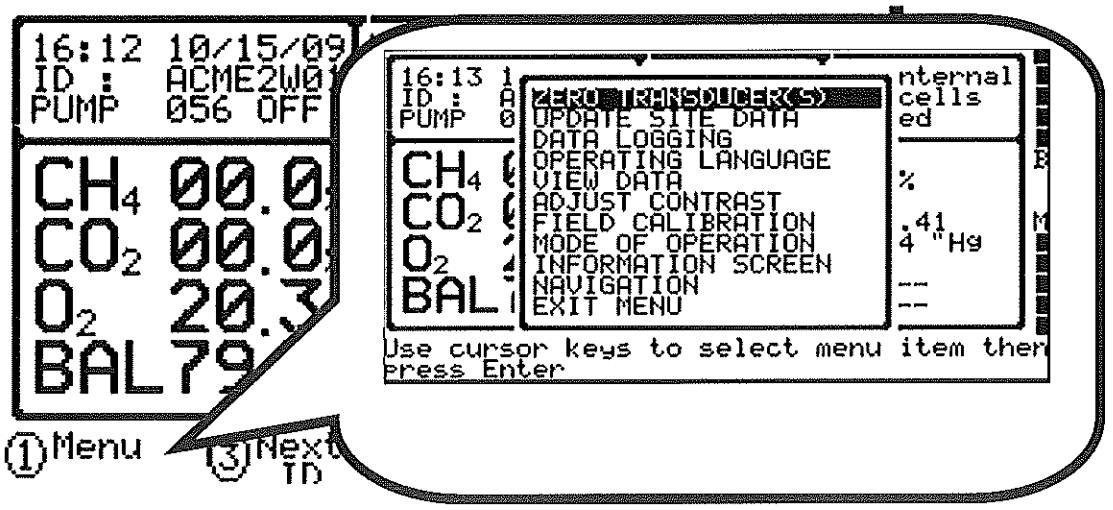
- To add or remove a single reading from export, uncheck the checkbox in the leftmost column.
- To add or remove a specific parameter from export, uncheck the corresponding checkbox across the top.
- To clear all rows click the ***Clear All Rows*** button at the bottom of the screen. After Clearing all Rows you can the button will change and you can ***Set all Rows***
- To clear all column selections, click on the ***Clear All Columns*** button at the bottom of the screen. After Clearing All Columns the button will change and you can then choose ***Set All Columns***
- To exit the operation without saving, click the ***Cancel*** button.
- To specify a filename and save the selection to a file, click the ***Save File*** button. Clicking this button will open a Save window.



The save file dialog will open and default to the My Documents of the user who is currently logged in on the computer. Specify a filename and location then click the Save button. The selected readings will be saved in comma separated value (.CSV) format. The .CSV file may now be opened in another application such as Microsoft Office Excel or Open Office Calc.

General Operations Menu

The following features and functions are selectable from the main menu via key '① **Menu**' from the read gas levels screen. Navigation through the list is via the and cursor keys. Selection of the feature is by pressing the '↵' key.



2.12 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. When zeroing transducers it is important to allow them to stabilize first so an accurate zero is achieved. If ① is pressed the instrument will return to the gas reading screen without zeroing.

NOTE: Zeroing Transducers may take a few extra minutes in the field, but is a recommended step to

ensure the best possible accuracy.

2.13 Update Site Data

Allows the user to answer questions (pre-defined in LSGAM software) relating to the site (e.g. name of operator, weather conditions, etc.). Site Questions are different than ID Questions. Once answered, site answers to site questions will be associated with all subsequent readings until the instrument is turned off or the question answers are updated.

This is covered in detail in section 3.2 of this manual.

2.14 Data Logging (GA mode only)

Enables the user to leave the Instrument unattended to take samples at pre-determined intervals. The reading interval and pump run time may be edited prior to commencing the logging cycle. The ID code may ONLY be set in LSGAM 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 automatically 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 LANDTEC logo will be displayed for a few seconds and the Gas Reading screen will be displayed. This will initiate a 30 second countdown to the next sample being taken unless the operator stops the logging function. The data will be logged against the ID setup through LSGAM for the Data Logging function

2.15 Operating Language

The operating language of the instrument can be set to English, German, Spanish, French, Italian or Brazilian Portuguese through this option.

2.16 View Data

The view data allows the user to see the readings that are in the GEM2xxx memory. Often the amount of data stored is more than can be displayed adequately on one screen so pressing the ⑤ key will allow the user to see additional screens with stored data. The 2 '∧', 4 '<', 6 '>' and 8 '∨' cursor keys will move forward or backwards through the instruments memory. Pressing the ① key will exit to the Gas Reading screen.

2.17 Adjust Contrast

The GEM2xxx automatically adjusts the screen contrast according to the ambient temperature to maintain normal viewing.

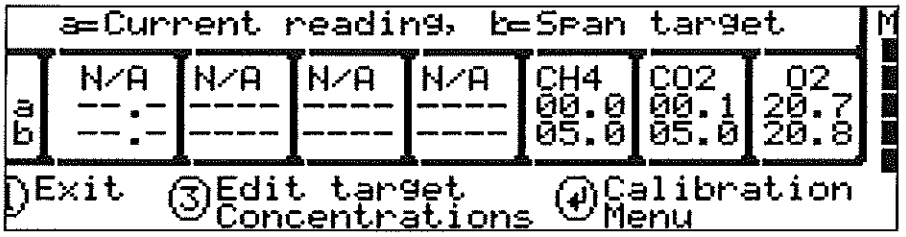
The contrast can be manually adjusted by using the 4 '<' and 6 '>' cursor keys. The manual contrast setting is stored when the '↵' key is pressed.

2.18 Field Calibration

Whenever carrying out a user calibration function it is important to ensure the correct values are entered. Additionally, in the case of a zeroing function, ensure only certified gas or ambient air is used and no connection is made to a probe or wellhead fitting. Additionally, ensure the instrument is purged of any residual gas that may be inside the instrument prior to zeroing. Calibration cylinders are sold by LANDTEC. The regulator, sold by LANDTEC, 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 '**a**') and user span calibration gas values (row '**b**') 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. It is important to confirm the concentration of the calibration gas(es) used and enter the value(s) properly.

The calibration menu has the following menu options:

2.18.1 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_4, and O_2, 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.

2.18.2 Span Channels

Spanning Channels should be carried out prior to use or when the ambient operating temperature changes greater than +/- 20 degrees Fahrenheit. 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_4, CO_2, O_2, (CO & H_2S internally for the Plus) and if an external Gas Pod is fitted (H2S, CO, SO2, H2, NO2, Cl2, or HCN).

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**'.

2.18.3 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_4, CO_2, O_2 (CO & H_2S for the Plus) or Gas Pod (if fitted) and pressure transducers.

2.18.4 Last Field Cal

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

2.19 Mode of Operation

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

2.20 Information Screen

The information screen will automatically display the following information:

```
        INSTRUMENT INFORMATION

   Software Version 3.10L, 09/21/09

Serial Number      : GM11953
Full service due   : 13 Mar 2010
Last Field Cal.    : **:** **/**/**
Language           : English
Communications     : BAUD-38400H
Readings taken     : 0005 of 1800
ID's in use        : 011 of 998
Date format        : MM/dd/yy
```

Navigation

Note: This menu item is specific to GEM2NAV instrument models.

This feature has two options Navigation Screen ON and Navigation Screen OFF. If the Navigation is turned ON, a navigation screen will appear after selecting a well ID. If the Navigation screen is OFF you will skip entering through the navigation screen. If all well locations are known, the user may choose to turn this feature off. Even if this feature is turned off, the GPS will record the related information with readings.

2.21 Exit Menu

The Exit Menu simply exits the main menu screen and returns to the gas reading screen.

3 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), are typically placed on the perimeter of the landfill in natural soil to test for sub-surface gas migration or may be placed next to a building or road to test for the presence of Methane. The GEM2xxx instruments may be configured as a Gas Analyzer (GA mode) for sampling probes. To access this function from the gas read screen press '①' 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.

3.1 Preliminary Checks

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

- All necessary ID codes have been uploaded via LSGAM 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_4, CO_2, and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) readings have been 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. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

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

3.2 Update Site Data

Prior to taking the readings at a particular site, the Site Questions and Technician Login should be updated. This is accessed via the General Menu '①' then **'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 using LSGAM, see Section 3.7. If Site Questions were uploaded to the instrument, they should be answered at this time. The answers are stored and appended to each reading stored thereafter, until the Site Data is updated for another site.

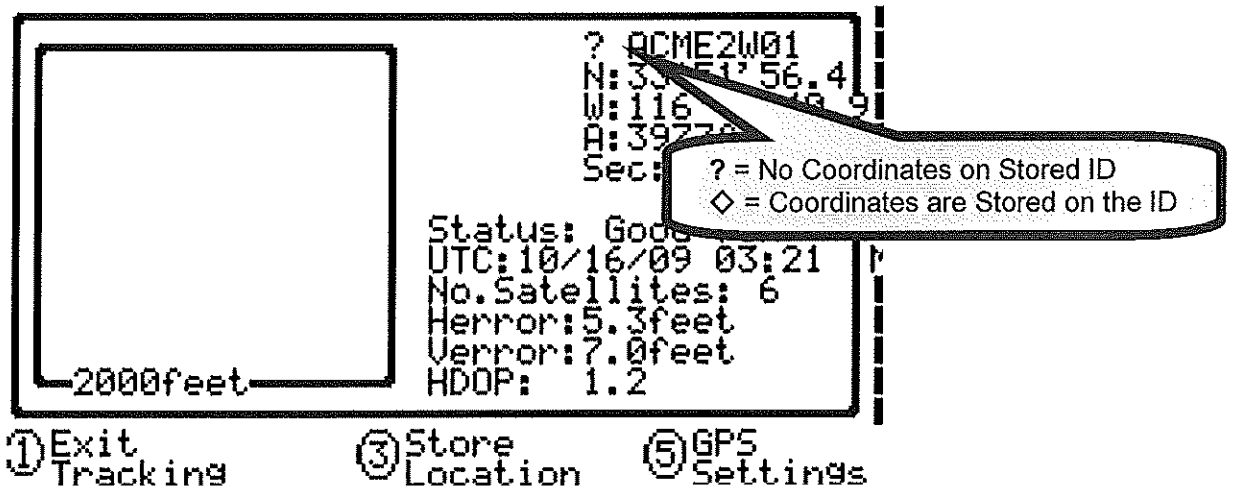
3.3 Taking Readings – With ID

For this function to be used it is essential that the relevant ID be previously uploaded to the Instrument using LSGAM, see Chapter 2 An ID **cannot** be created by the Instrument alone.

1. When the Read Gas Levels screen is displayed, option **'③ 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 '↵ **Select ID**' key. The display may be toggled using the '③ **View ID Details**' to display any relevant ID information available; such as a description of the probe location, etc.

2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (default is 30 seconds). Once the '↵ **Start Purge**' 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 '①**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. On GEM2NAV models a Warning screen may appear before going to the GPS Tracking screen



If coordinates were stored with the ID in LSGAM, then a diamond symbol ('◇') will appear before the ID. In front of the ID, a compass with an arrow will appear indicating the direction of the ID that you have selected. ⑤ **GPS Settings** will allow you to change the GPS Units of measure indicator and scaling values.

Once you have navigated to the well device you can press ① **Exit Tracking** to proceed to the gas reading screen.

5. At this point, connect the sample tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' into place. Then connect the sample tube to the probe sample port. **Do not connect the sample tube 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.**
6. 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. Let the relative pressure reading stabilizes. When the pump starts, the relative/static pressure reading is stored. The relative/static reading will remain displayed as the pressure last taken.
7. 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.
8. 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.
9. Disconnect the sample tubing from the probe and start again at 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_4, CO_2, O_2 (, CO and H_2S for the Plus)).
- LEL CH_4.
- Barometric Pressure.
- Relative Pressure.
- Questions/comments.
- Temperature (if temperature probe is connected).
- Gas Pod (if connected).
- Latitude (for GEM2NAV)
- Longitude (for GEM2NAV)
- Elevation (for GEM2NAV)
- UTC (for GEM2NAV)
- Herror (for GEM2NAV)
- Verror (for GEM2NAV)
- Number of Satellites (for GEM2NAV)

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.

3.4 Taking Readings – Without ID

Gas Readings can be taken without an ID in the instrument by following the instructions below. To create and uploaded IDs to the instrument using LSGAM, see Chapter 2. An ID **cannot** be created by the Instrument alone.

1. From the Gas Reading Screen first select **'③ Next ID'** then press **'⑤ 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 '- - - - - - - -'.
2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (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 **'⓪EXIT'** key.
3. On GEM2NAV instrument models the Tracking screen will appear if the Navigation Menu option is turned on. Since the reading will be taken without an ID you will not have coordinates for the device and the navigation compass will not be displayed. Press **'⓪EXIT Tracking'** key to continue to the gas reading screen.
4. At this point, connect the sample tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' in to place.
5. Now connect the sample tube to the probe sample port. **Do not connect the sample tube 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.**
6. 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.
7. Upon storing the reading, a virtual keyboard will be displayed for any alphanumeric comments to be entered.
8. Disconnect the sample tubing 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.

While taking a reading, 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.

3.5 Temperature Probe Reading

The GEM2xxx has the facility to automatically display and record the probe temperature via an optional Temperature Probe (TP-2000). When the Temperature Probe is fitted to the 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 GEM2xxx UL certification and is therefore certified for use under the same conditions as the instrument.

3.6 Cross-Gas Effects

3.6.1 Methane, Carbon Dioxide and Oxygen

Methane is measured using dual beam infrared absorption. The Methane reading is filtered to an absorption frequency of 3.41μm (nominal). 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 instrument does not read total hydrocarbons. If other hydrocarbons are present in the sample gas a filter should be used to remove them and mitigate the cross gas effects. Typically trace levels of other hydrocarbons (<100ppm) will not induce a cross gas effect and do not require filtering.

The Carbon Dioxide reading is filtered to an infrared absorption frequency of 4.29μm (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 galvanic cell type and suffers virtually no influence from CO_2, CO, H_2S, SO_2 or H_2, unlike many other types of Oxygen cell.

The infrared sensors will not be "poisoned" by cross gas effects. 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.

3.6.2 H_2S, CO and other Optional Gas Pods

The Gas Pods used to measure H_2S 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_2S	SO_2	H_2	CH_4	CO_2
CO	100	<3/~300*	0	<40	0	0
H_2S	<0.5	100	~20	~0.1	0	0

* Indicates reading from pod not fitted with internal filter or after internal filter is saturated.

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. Purge gas pods in the same manner as the instrument to help preserve their life.

NOTE: Cross-gas effects can be mitigated by employing a filter for the gas not being tested.

3.6.3 GEM2xxx Plus Internal Electrochemical Cells for Measuring H_2S and CO

The GEM2xxx Plus employs two internal electrochemical cells to measure Hydrogen Sulfide (H_2S) and Carbon Monoxide (CO). Electrochemical cells which measure CO are typically susceptible to cross gas interference by Hydrogen (H_2) and Hydrogen Sulfide (H_2S). Two components that may be present in the Landfill Gas sample. This means that if H_2 and/or H_2S are/is present in the Landfill Gas sample a normal CO electrochemical cell would give an artificially high reading.

The GEM2xxx Plus uses a 'hydrogen compensated' CO cell to counteract the interference by H_2. This is why the instrument displays an H_2 channel. H_2 is not directly measured, although a rough value, which is shown as LO, MED or HI, can be interpreted. If the H_2 value is displayed as LO or MED the H_2 compensation will mitigate the H_2 effect on the CO reading, however if the H_2 value is shown as high it is possible that there is more H_2 present than the compensation is capable of adjusting for. If that is the case the CO value may be artificially high due to cross gas interference by the H_2. Additionally, if a HI level of H_2 is encountered then a longer than normal purge time will typically be necessary to clear all the H_2 from the electrochemical cell. It is recommended that after encountering a HI level of H_2 the instrument be purged with clean air until the H_2 channel displays LO. This could take as long as five or ten minutes (if the H_2 channel was over ranged) but is necessary to ensure the subsequent readings are accurate.

The CO cell used in the GEM2xxx Plus also utilizes an internal H_2S filter to eliminate H_2S cross gas interference. However, the filter does have a finite capacity. If the filter's capacity is exceeded then the CO cell will be susceptible to cross gas interference by any H_2S that is present in the gas sample. It is quite easy to determine if the capacity of the filter has been exceeded. After all the sample gas has been purged from the instrument, with clean air, and the CO reading is zero, run a certified gas that contains H_2S but not CO (the H_2S calibration gas) through the instrument. If the CO reading remains zero while the H_2S reading increases to the certified value then the internal H_2S filter has remaining capacity. If the CO reading increases with the H_2S reading then the internal filter's capacity has been exceeded and the cell will need to be replaced.

The GEM2xxx Plus was designed to read a maximum H_2S concentration of 500ppm and a maximum CO reading of 2000ppm. If the gas sample contains more than the maximum concentration the instrument will be over ranged and display >>> as the reading. If the instrument is over ranged the readings typically stay artificially high for several minutes and will not go back to zero with a normal purge. While over ranging the instrument is not recommended and will slightly shorten the life span of the electrochemical cells the resulting high readings are not permanent. If one of the channels is over ranged it is recommended to purge the instrument, with clean air, until the reading returns to zero. This may take as long as five or ten minutes. The cell may need to be recalibrated but normally the extra long purge is all that is necessary.

4 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 GEM2xxx instruments 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 '①' 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.

LANDTEC classifies monitoring points on the gas conveyance system not otherwise classified as a Well. Sample ports may have a flow device associated with them. For this reason, Sample ports are monitored in the same manner as well readings.

4.1 Preliminary Checks

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

- All necessary ID codes and readings have been uploaded via LSGAM 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_4, CO_2 and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) 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. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

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

4.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data and technician login should be updated (if programmed). This is accessed via the General Menu '①'. 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 LSGAM 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.

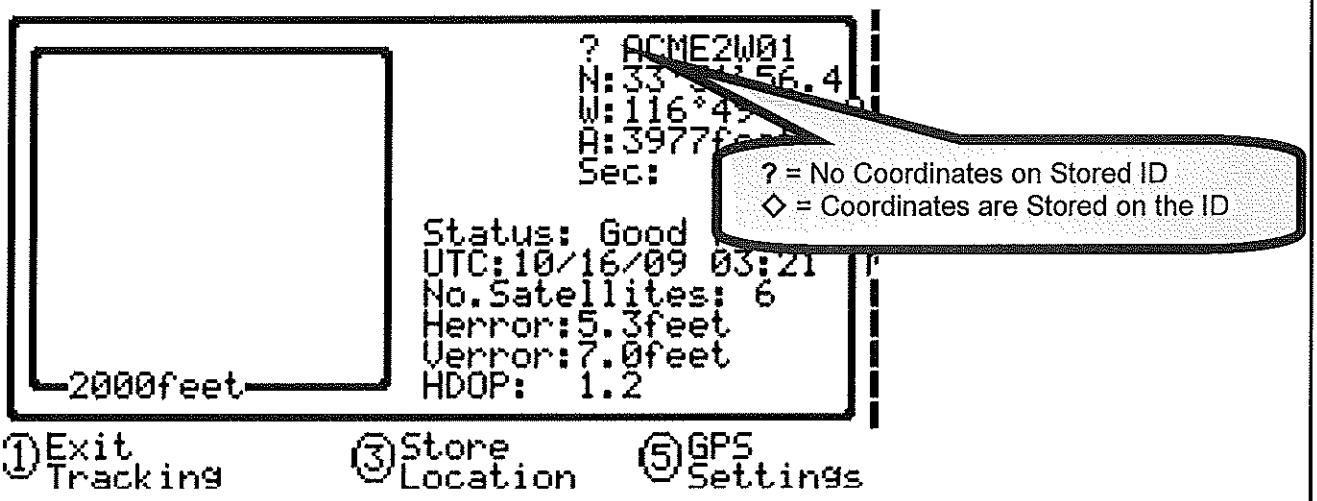
4.3 Taking Gas and Flow Readings (GEM Mode)

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 LSGAM software with the correct 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 '③ **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 tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (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 '①**EXIT**' key.
3. On GEM2NAV models a Warning screen may appear before going to the GPS Tracking screen



If coordinates were stored with the ID in LSGAM, then an diamond symbol ('◇') will appear before the ID. In front of the ID, a compass with an arrow will appear indicating the direction of the ID that you have selected. ⑤ **GPS Settings** will allow you to change the GPS Units of measure indicator and scaling values.

Once you have navigated to the well device you can press ① **Exit Tracking** to proceed to the gas reading screen.

4. Connect the sample tubes (with water trap filter) to the wellhead ensuring the gas sample tube and impact pressure tubes are properly oriented. Insert the temperature probe if used. *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. 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 and any time by pressing the '✂' key. The pump run time is set in LSGAM software. Allow the gas readings to stabilize and press '⑤**Measure Flow**' key, this will store the gas level readings.
6. If a temperature probe is plugged in the temperature will automatically be recorded, otherwise a screen will appear prompting you to enter the gas temperature. Enter in the gas temperature manually if necessary and press the '←**When Complete**' key.
7. If the flow device is set to user input then a screen prompting input of the flow will be displayed. Enter in the flow and then press the '←**When Complete**' key.
8. The '**PRESSURE READINGS**' screen will now appear and prompt the user to disconnect the sample tubes and allow the pressure to stabilize. Once the pressure has stabilized press '↵ **Zero Transducers**'. Press '①' to continue. *Note: if ACCU-FLO wellheads are used this zero function may be performed prior to connecting the sample tubes to the well head by selecting '**① MENU**' and highlighting '**ZERO TRANSDUCERS**'. This eliminates the need to disconnect and re-connect the sample tubes on the same wellhead.*
9. If a temperature probe is not connected, the user is prompted to manually input the gas temperature, press the '↵' key when entry is finished.
10. 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 not previously cleared from the instrument) readings are displayed so modifications may be made to the well if required.

11. If a device is setup containing "system pressure" then the System Pressure Readings screen will appear and prompt you to connect the instrument's static pressure hose to the sample port on the gas system side of the valve. Once the pressure is stored, press then '① **Continue**' key.
12. Pressing '↵ **STORE**' will save the readings to memory.
13. If questions were associated to the device, the questions/comments screen(s) 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.
14. Press '③ **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:

- Device ID code
- Current time/date
- Site Questions and Comments (if entered)
- All gas readings and balance gas (CH_4, CO_2, O_2 (CO & H_2S for the Plus Models))
- Barometric Pressure
- Temperature
- Gas Pod (if connected)
- Gas flow (SCFM)
- Power (BTU)
- Comments, Exclusive comments and Answers to Questions
- For GEM2NAV Models Only Relevant GPS information
    - Latitude
    - Longitude
    - Altitude
    - UTC
    - Herror
    - Verror
    - Number of Satellites

Upon switching the Instrument off, a clean air purge is automatically started for a pre-determined time period. This may be aborted by pressing the '↵' key, although this action is not recommend.

5 Field Operations

5.1 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_4.

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.

5.2 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.

5.3 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.

5.3.1 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.

5.3.2 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.

5.3.3 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.

5.3.4 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_2 and gas temperature and later as increased Oxygen from well over-pull. In time, the Methane will also decline. This is the result of a portion of the landfill, usually at the surface, being driven aerobic. In this portion of the landfill, the Methane-producing bacteria will have been destroyed (due to the presence of Oxygen). With the Methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this

area, and may lead to the operator opening the well or increasing flow.

5.4 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.

5.5 Typical Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily Nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2xxx or magnehelic) or other device(anemometer/velometer)
- Velocity head (P or PT) (from GEM2xxx or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2xxx, or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well's LFG and Methane flow and sum total
- Observations/comments

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

5.6 Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2xxx or magnehelic)
- Velocity head (P or Pt) (from GEM2xxx or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2xxx, 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.

5.7 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 then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
- Type of fill
- Size and shape of refuse mass
- Depth of fill
- Compaction
- Leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and Methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

5.8 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.

5.9 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.

5.10 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.

5.11 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.

6 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. The particulate filter or water trap filter needs replacing.
Readings taken are not what was expected	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. Field calibrate Oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software. 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. Contact Factory Service.
Oxygen readings drift	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.

7 Service & Maintenance

7.1 Factory Service

LANDTEC Facilities are the ONLY authorized service centers for the GEM™ Family of instruments. LANDTEC offers a several service plans to facilitate your bi-annual Factory Servicing of the instrument. Please contact your LANDTEC representative for more information on the service plan that best fits your specific needs. Factory Service includes but is not limited to the following;

General operations
The main functions of the gas analyzers operation are checked to ensure that they are within specification.

Barometric pressure reading
The barometric pressure reading is checked to ensure it is within specification. This is carried out by way of comparing the atmospheric reading against a known standard. If necessary, reprogramming is quoted.

Static and differential pressure readings
The static and differential pressure transducers are checked to ensure they are within specifications. This is carried out by comparing instrument readings to a known standard, applying a known pressure and noting both readings. If necessary, reprogramming will be quoted.

Pump functionality (flow and vacuum)
All flow and vacuum functions of the internal pump are checked to ensure the operation is within specification.

Water ingress/blockage
The internal filters are checked for cleanliness and moisture ingress to ensure they are not contaminated.

Flow fail setting
The flow fail function is checked to ensure proper operation within the specified limits.

Gas pod and Temperature probe connectivity reading
The connectivity of the gas analyzer is checked to ensure correct operation and reading performance with accessories.

Computer controlled gas check
Inward and outward gas checks are carried out by way of connecting the gas analyzer to a custom built computer controlled calibration chamber and proprietary software. At the inward stage, two sets of readings are taken - one using the customer's calibration settings and a second set using factory calibration settings. During this process a range of gases are used that span the reading range of the gas analyzer.

Structural and aesthetics check
The instrument is checked for cracks, scratches and broken or missing pieces.

7.2 Factory Service Facilities

LANDTEC North America
850 S. Via Lata, Suite 112
Colton, CA 92324
USA
Sales Tel: +1 (800) 821-0496 or +1 (909) 783-3636
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Rua Pedroso de Carmargo, 237 - Chácara
Santo Antonio - SP/SP CEP 0417-010
Brazil
Phone: +55(11) 5181-6591
Web: www.landtecbrazil.com.br

7.3 User Maintenance

This instrument is designed to be low maintenance and rugged. However, field calibrations are recommended prior to use or when the ambient operating temperature of the instrument changes more than +/- 20 degrees Fahrenheit. See section 2.18 for further information on field calibrations. Additionally, it may be necessary to change the user accessible filters and o-rings from time to time.

There are two user accessible filters, the particulate filter is located in the back of the instrument, see section 1.1 for location, and the water trap filter which is part of the included hose kit. There are four user changeable o-rings, one on the particulate filter cover, one on the outside of the water trap filter housing, one on the inside of the water trap filter housing, and one on the ends of each male quick connect fitting included on the hose kits.

Note: The o-rings on the male quick connect fittings should be routinely checked as dust and dirt from the various wells they connect to can be abrasive. A damaged or leaky o-ring may allow air intrusion into your gas sample. This intrusion of air may not be noticed when calibrating the instrument because the calibration does not occur under vacuum.

Technical Specifications

7.4 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.

7.5 General

Certifications	UL Certified to Class 1, Zone 1, AEx Ib d IIa T1
Temperature measurement	With optional probe 14°F to 167°F.
Temperature accuracy	±0.4°F (± probe accuracy).
Visual and audible alarm	User selectable CO_2, CH_4 and O_2 Min/Max levels via LSGAM CS software.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

7.6 Power supply

Battery type	Rechargeable Nickel Metal Hydride battery pack containing six 4AH cells. **Not user replaceable**. 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.

7.7 Gas Ranges

Detection principle	CO_2 and CH_4 by dual wavelength infrared cell with reference channel. O_2 (and CO & H_2S in Plus) by internal electrochemical cell. The gas sample is not dried or adjusted for Gas Humidity and therefore is on a wet basis.
Oxygen cell lifetime	Approximately 18 months in air.

Typical Accuracy 0 - Full Scale	**Gas**	**0-5% volume**	**5-15% volume**	**15%-FS**
	CH_4	±0.3%	±1%	±3%
	CO_2	±0.3%	±1%	±3%
	O_2	±1%	±1%	±1%
	H_2S in Plus Instruments ±10%FS from 0-Full Scale			
	CO in Plus Instruments ±10% of reading or 15ppm whichever is greater			
Response time, T90	CH_4 ≤20 seconds CO_2 ≤20 seconds O_2 ≤20 seconds			
Range	CH_4 0-100% reading. CO_2 0-100% reading. O_2 0-25% CO (in Plus Instruments) 0-2000ppm H_2S (in Plus Instruments) 0-500ppm			

7.8 Pump

Typical flow	300 cc/min.
Flow fail point	Adjustable, approximately 50 – 250 cc/min.
Flow with 200 mbar vacuum	250 cc/min approximately.
Vacuum	100 inches H_20.

7.9 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.

7.10 Optional Gas Pods

Typical Accuracy (Subject to User calibration).	**Gas**	**0-Full Scale**
	CO	±10% FS
	H_2S	±10% FS
	SO_2	±10% FS
	H_2	±10% FS
	HCN	±10% FS
Response time, T90	CO	≤60 seconds
	H_2S	≤60 seconds
	SO_2	≤60 seconds
	H_2	≤60 seconds
	HCN	≤60 seconds

Range	CO	0-500ppm
	H_2S	0-50 or 0-200ppm
	SO_2	0-20 or 0-100ppm
	H_2	0-1000ppm
	HCN	0-100ppm

7.11 Regulatory Compliance Labels and Statements

The device has the following safety and non-hazardous parameters:

Terminal Nos	Ui	Ii
Connector A:	6V	
Connector B	14 V	100 mA
or	11 V	2.25 A

Underwriters Laboratories Inc. (UL) has not tested the performance or reliability of the Global Positioning System (GPS) hardware, GPS operating software or other GPS-related aspects of this product. UL has only tested for the explosion, fire, shock and casualty hazards required by the applicable hazardous locations standards. UL certification does not cover the performance or reliability of the GPS hardware, GPS operating software or other GPS-related aspects of this product.

UL MAKES NO REPRESENTATIONS, WARRANTIES OR CERTIFICATIONS WHATSOEVER REGARDING THE PERFORMANCE OR RELIABILITY OF ANY GPS RELATED FUNCTIONS OF THIS PRODUCT